

Aphelion™ Imaging Software Suite

User Guide

Version 4.6

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1. INTRODUCTION

IMPORTANT NOTE TO THE READER: Most sections of this User Guide are common to both the Aphelion Lab and Aphelion Dev products. In the common sections, the product referenced is simply Aphelion. In those sections not common to both products, the product referenced is either Aphelion Lab (or simply Lab) or Aphelion Dev (or simply Dev). The sections also related to Aphelion SDK are from 1 *Introduction* (i.e., this section) through 2.4.5 *Aphelion Installation*, and also section 8. *Programming examples (Dev and SDK only)*.

This User Guide provides basic information about using Aphelion™ products, from installing its software to processing images and printing your results.

Throughout this guide, you will find references to additional information contained on the Aphelion DVD.

Aphelion's Online Help can be accessed from the **Menu bar** by choosing **Help→Help Contents**. This User Guide will open as an HTML Help.

Note: You can access all Aphelion documentation without installing the software; just look at the files in the *Help* folders on the DVD.

2. FINDING YOUR WAY AROUND

This chapter describes the installation of the Aphelion Imaging Software Suite products. It also gives a detailed description of the Graphical User Interface.

2.1. *Using Windows*

To use Aphelion, you should be familiar with the Windows® operating system installed on your computer (i.e., 7, 8.1 or 10) and basic Windows features such as clicking, double-clicking, and drag-and-drop editing.

Note: Unless otherwise specified, when we talk about Windows® environments in this document, we mean the Microsoft® operating systems known as 7, 8.1 and 10. Specific behaviors of these Windows® versions are explained if necessary. Aphelion Dev is available for both the 32-bit and 64-bit versions of Microsoft® Windows operating systems. Use of the 64-bit version of Aphelion is recommended if very large and/or 3D images are to be processed.

2.2. *Our notations*

In this document, some shortcuts are used to simplify the text. The following describes those shortcuts.

Installation Path – Installation path names will vary depending on whether a 32-bit or 64-bit installation has been performed. Many times, the only difference in a path name is the designation of either *Program Files* or *Program Files (x86)*. To avoid needless repetition, we will write <Aphelion Installation Path> instead of "C:\Program Files\ADCIS" or "C:\Program Files (x86)\ADCIS."

2.3. *Product Support*

Problem reports, comments, and enhancement requests should be submitted via the Technical Information Request form on our website as described below:

<https://www.adcis.net/en/contact-us/>

License Code requests should be submitted via the Code Request form of our website as described below:

<https://www.adcis.net/en/code-request/>

Note: Technical support is handled only in an electronic way. Support messages must include 1) the name of the company or organization to which the software license is granted, 2) the email address of the person requesting support, 3) a phone number that can be called by our customer support team to ask for more technical information about the problem, 4) the License Code and version number of the software, 5) the version of the Windows operating system, and 6) a detailed description of the problem with the list of operations to call to demonstrate the problem.

Support is available at the following locations:

In France:

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France

Phone: +33 (0)2-31-06-23-00

Contact: <https://www.adcis.net/en/contact-us/>

In the USA:

Adcis, Inc.

P.O. Box 25971

Woodbury, MN 55125-0971 USA

USA

Phone: +1 609-944-8855

Contact: <https://www.adcis.net/en/contact-us/>

For other locations, please contact your Aphelion representative. A list of official representatives is available on our website at:

<https://www.adcis.net/en/where-to-buy/>

2.4. Installing Aphelion

2.4.1. System Requirements

Aphelion requires the following minimum system configuration:

- ✓ Windows® 7, 8.1, or 10 operating system;
- ✓ Windows® 32-bit or 64-bit operating system;
- ✓ SXGA monitor (1280x1024 resolution, 65,536 colors);
- ✓ Intel® Core i3 processor, or equivalent;
- ✓ 8 GB of RAM;
- ✓ Hard drive with at least 1.5 GB free space;
- ✓ A network interface adapter supporting the Ethernet® protocol and compatible with NetBIOS®;
- ✓ A local or network DVD drive (for software installation).

2.4.2. Aphelion Licensing

The licensing mechanism is based on the network adapter of the computer on which Aphelion software is being installed. Refer to the sections *2.4.3 Aphelion Installation Prerequisites* and *2.4.5 Aphelion Installation* to learn more about the installation procedure.

An evaluation version of Aphelion is time limited. The evaluation license expires 30 days from the date of the email containing the License Code. If Aphelion has not been installed or issues have arisen during the 30 days period please contact your Aphelion software supplier or ADCIS S.A.. To install the evaluation version, follow the instructions provided in the sections *2.4.3 Aphelion Installation Prerequisites* and *2.4.5 Aphelion Installation*.

No code is required to install Aphelion. The Aphelion software requires an activation to be used whatever the version (Evaluation or permanent). The activation involves two coded character strings:

- a) an Identification Code that pops up the first time the user is running Aphelion, which is sent by the user to ADCIS and
- b) a License Code which is returned by ADCIS to the user that is copied in the Registration window.

Please be sure that your computer system meets the conditions described in sections *2.4.1 System Requirements* and *2.4.3 Aphelion Installation Prerequisites*. If it does, then follow the instructions given in section *2.4.5 Aphelion Installation* to install Aphelion on your system.

2.4.3. Aphelion Installation Prerequisites

Aphelion can only be installed on a computer equipped with either a properly configured network adapter (non-virtual adapter) or with an optional Aphelion USB dongle. If your computer does not have an appropriate network adapter, please contact your Aphelion supplier for information about purchasing an Aphelion USB dongle.

2.4.4. Installing the USB Dongle

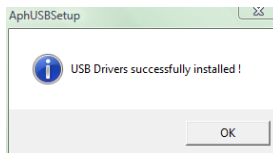
The Aphelion USB dongle is an optional device that provides users with two capabilities. The dongle enables installation of Aphelion on a computer that does not have a suitable network adapter (see the section immediately above). The dongle can also be used to enable non-concurrent execution of Aphelion on multiple computers simply by moving the dongle from one computer to another.

Note: Only a single copy of the software can be used at a time; the dongle must always be connected to the computer on which the Aphelion license is used.

DO NOT perform the following procedure unless your Aphelion installation will be using an Aphelion USB dongle.

1. **DO NOT** connect the dongle to the USB port until Step 5 (i.e., not before the complete installation of the USB dongle driver).
2. Open a Windows session with Administrator rights.

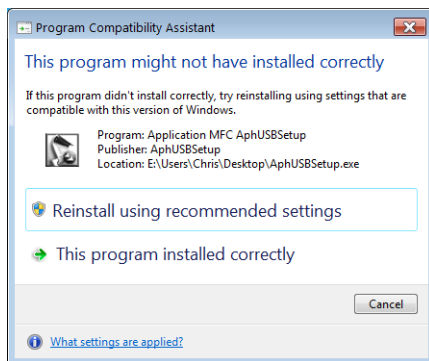
3. If your computer has an active internet connection, skip this step and go to the step 4. Run the program **Device Drivers\DongleAphUSBSetup.exe** which can be found on the Aphelion DVD. This step will install the dongle's driver and end by displaying the window shown below.



Click the **OK** button to close this window.

4. Connect the dongle to your computer.

Windows 7: The message “Installing device driver software” pops up in the Notification area. After a few moments, the Program compatibility assistant window opens. Select the option “*This program installed correctly,*” then click the **OK** button to complete the installation.



Windows 10: The icon “Device installation” appears in the Windows task bar. This icon vanishes after the driver installation.

5. Restart your computer.
6. Once the computer has restarted, open the **Windows Device Manager**.
7. Double click on the **Universal Serial Bus controllers** so that all connected USB devices are displayed.

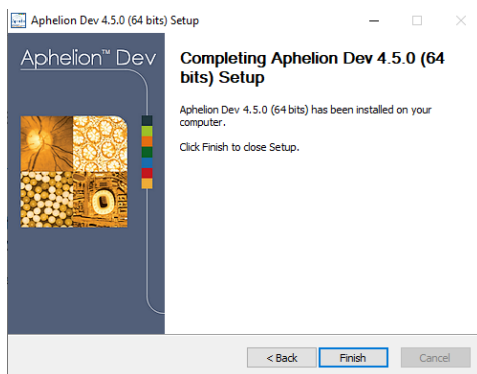
8. Check the entry *CBUSB Ver 2.0* is displayed with no warning.

In case of trouble, refer to *APPENDIX C. 1 - Troubleshooting for the dongle*.

2.4.5. Aphelion Installation

Important note: Be sure to use a Windows session with Administrator rights to install the software. If you have doubt about your rights, contact your local system administrator.

1. If you received the Aphelion software on a DVD, please ensure that the DVD is in the DVD drive.
2. Run the installation program ***AphelionDev Setup 4.x.y (32 bits).exe*** or ***AphelionDev Setup 4.x.y (64 bits).exe*** for Dev or ***AphelionLab Setup 4.x.y (32 bits).exe*** or ***AphelionLab Setup 4.x.y (64 bits).exe*** for Lab. This file can be found in the corresponding folders of the DVD if you received the software on a DVD, or on your hard drive if it was downloaded from the website of ADCIS SA or Adcis, Inc.
3. Follow the instructions as they appear on the screen during the installation.
4. After you have read and accepted the End User License Agreement, the Choose Install Location window appears. Then click on the **Next** button.
5. Continue the installation until the window Completing the Aphelion Dev 4.x.y Setup Wizard for Dev or Completing the Aphelion Lab 4.x.y Setup Wizard for Lab pops up, and then click on the **Finish** button to complete the installation.



2.4.6. Camera interface installation

For any Aphelion interface to an acquisition device, note that the driver to this device should be installed. The driver setup program and the procedure to complete the installation of the Aphelion interface to your acquisition device are available in the *Device Drivers* folder which can be found on the Aphelion DVD.

Note: If you do not have the Aphelion DVD, please contact us to get information about the driver to be installed.

Check the Aphelion interface to verify your acquisition device is licensed in the Extensions tab of the Options window (menu **Tools→Options**), otherwise see <https://www.adcis.net/en/applications/image-acquisition-device-interfaces/> or contact your Aphelion representative (<https://www.adcis.net/en/where-to-buy/>).

DirectShow Compatible Cameras

Aphelion can also control a DirectShow compatible camera. The following procedure checks that the camera interface is working properly:

1. If Aphelion is running, you must exit from Aphelion before

connecting the camera. After Aphelion has been closed, connect the camera to the computer using the cable provided with the camera. Windows automatically installs the driver associated with the camera.

2. Open the Windows Device Manager applet.
3. Open the *Imaging devices* group and verify that the camera is listed in this group. The driver installation may take a few minutes.
4. Run the **Aphelion** software. The camera settings are automatically loaded and camera functions can be controlled from the Aphelion interface.

Third party cameras

Extension interfaces for third party cameras are available in Aphelion Dev. To install one of the camera drivers, refer to the associated installation guide located in the \Device Drivers folder that can be found on the Aphelion Imaging Software Suite DVD.

2.4.7. Software required to use Aphelion

Microsoft Visual C++ 2013 Redistributable Package, Microsoft Visual C++ 2017 Redistributable Package and Microsoft .NET Framework 4.0 are required to run Aphelion software. If not already installed on your computer, these packages will be installed automatically during the Aphelion installation process. The absence of either of these Microsoft packages will prevent Aphelion from executing properly.

Note: Future versions of Aphelion software may require newer versions of these required Microsoft products. Be sure to install the newer versions when asked to do so during the Aphelion software installation process.

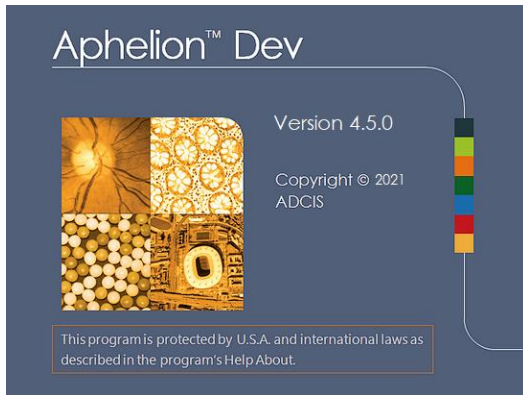
Software capable of executing AVI files is required to run the multimedia demonstrations that show how to use Aphelion. These demonstration files are included on the Aphelion DVD in the folder, *Multimedia Demos*.

2.5. *Activating/Starting Aphelion*

Once Aphelion is installed, start the application by clicking on the appropriate **Aphelion** icon (Dev or Lab) located on the desktop, or by clicking on **Start→All Programs→Aphelion Dev (or Lab) 4.x.y**.

2.5.1. *Starting Aphelion*

If the Aphelion license has been activated, then the application is loading, and a splash screen pops up and displays the copyright information and the software version number.

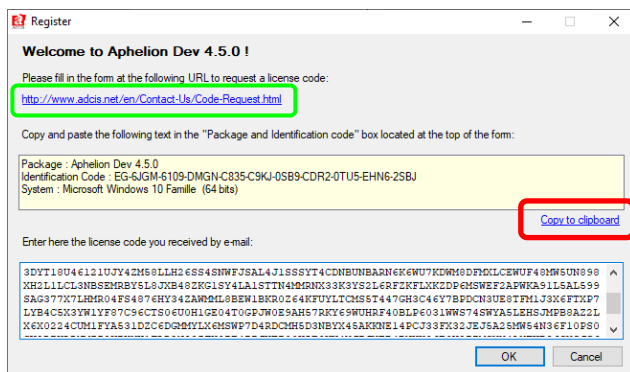


After a few seconds, the splash screen vanishes and Aphelion's main graphical user interface ("GUI") opens.

2.5.2. *Activating Aphelion*

If you run Aphelion for the first time, you should activate its license by following the instructions below:

1. The Register window appears on the screen as shown below.
2. Click on the **Copy to clipboard** (encircled in red in the figure above) to copy the identification data in the clipboard. This information will be required to generate the license code.

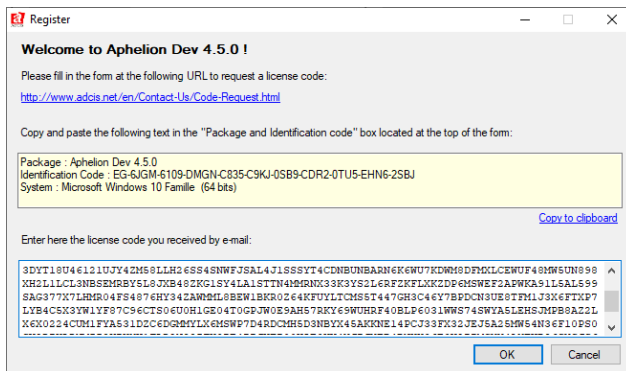


3. Click on the web link in the Register window (encircled in green in the figure above) to open the Code request form from the website of ADCIS S.A. or Adcis, Inc.
4. Paste the Identification Code (**Ctrl+V**) in the Package and Identification window of the Request code form and complete the Code Request.

Note: If you purchased the Aphelion license then select *Permanent code* as *License type* and enter the order and delivery slip references in the Questions window at the bottom of the Code request form.

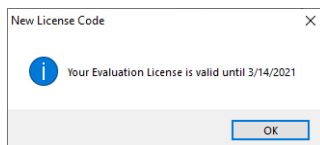
5. Enter the text shown in the image in the bottom of the Code request webpage then click on the **Submit** button to send the Code request form to the Aphelion Support Team.
6. Within one business day, the Aphelion Support Team will send you an email with the License Code needed to register your Aphelion license.
7. Copy (**Ctrl+C**) the license code you receive by email. Click on the **Aphelion** icon (Dev or Lab) located on the desktop, or use **Start→All Programs→Aphelion Dev (or Lab) 4.x.y** to launch **Aphelion Dev** or **Lab** program and paste it (**Ctrl+V**) at the bottom of the Register window then click **OK** to complete the product

registration. Note the code is a string of characters that may occupied all the window box.

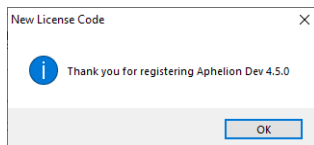


- The New License Code message box is displayed. The type of license and the date of validity of the installed license are shown in this window.

For an evaluation version:



For a permanent version

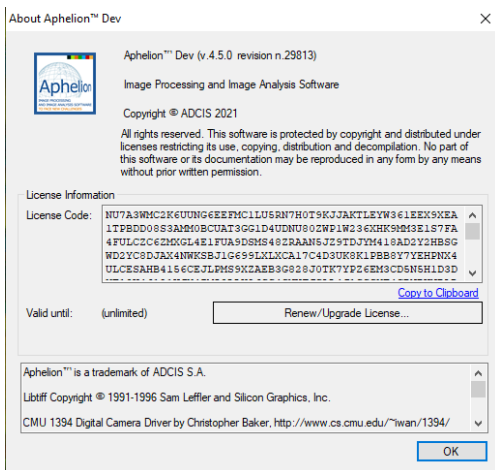


Note: The License Code depends on the computer configuration, the licensed components, and the Aphelion version. If you try to install an update version of Aphelion on the same computer as a previous installation and the License Code is not accepted, then contact your Aphelion representative or the Aphelion Support Team at <https://www.adcis.net/en/code-request/> and select the License type **Update** to request a License Code for this newer version.

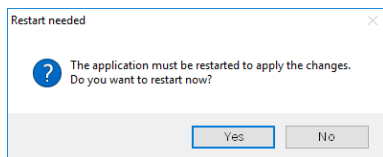
2.6. *Updating the Aphelion license*

After purchasing the license of an Aphelion extension, you can add this license to your current Aphelion license by updating the license code. The following instructions describe how to update your license.

1. Open the *ContactUs/CodeRequestForm* page on our websites (see section 2.3 *Product Support*).
2. Start the application by clicking on the appropriate **Aphelion** icon (Dev or Lab) located on the desktop, or by clicking on **Start→All Programs→Aphelion Dev (or Lab) 4.x.y**.
3. Select **Help→About Aphelion....** The About Aphelion window opens as shown below.



4. Click on the **Renew/Upgrade license...** button.
5. Follow the instructions given in *2.5.2 Activating Aphelion* to complete the license upgrade.
6. The Restart needed message box opens. Click **Yes** to apply the changes.



2.7. Exiting Aphelion

To quit Aphelion, select **File→Exit**. If loaded images have been modified during the work session, or if new images have been created, then a Save Files dialog box opens. The user selects the images and ObjectSets to be saved, then clicks on the **Save** button. If no files should be saved, the user clicks on the **Don't save** button.

2.8. Terminology

To facilitate your use of Aphelion, please become familiar with the following terms. You may find it helpful to refer to *Figure 2.9-1* in the following section.

Graphical User Interface (“GUI”) – The Aphelion GUI is divided into two regions: the **Workspace** and the **Menu Bar** plus toolbars. Each of these is further divided into sub regions, and is described in more detail below. *Figure 2.9-1* shows the **Workspace** sub regions (i.e., windows) as rectangles outlined in blue and the menu plus toolbars sub regions as rectangles outlined in red.

Menu Bar plus Toolbars – This GUI region contains two rectangular areas in which the **Menu Bar** and various toolbars are displayed. The **Menu Bar** and its associated toolbar appear in the rectangular area at the top of the GUI. The rectangular area at the far right of the GUI contains the selected task's **Contextual toolbar** (see detailed explained below).

Workspace – The **Workspace** is a fixed region of the Aphelion GUI that contains multiple windows. The number of windows and their functions is determined by the current step in the image analysis process (i.e., the **Active Task**). While each window has a default size and location within the GUI, their sizes and locations can be altered by the user. An example of the default **Workspace** layout is shown in *Figure 2.9-1*.

Windows – The **Workspace** windows are user interface structures that provide information and controls used in the image analysis process. There are two categories of such interfaces: display interfaces and control interfaces.

Display Interface – This interface type provides on-screen representations of image and ObjectSet data. Image data includes full images and thumbnail images displayed as pixels arrays. ObjectSet data (information extracted from a source image) consists of spatial attributes (e.g., Bitmap, Chain, Line) and a set of numeric attributes

(e.g., area, length, max and min pixel intensity) for each object in the ObjectSet. Each object's spatial attribute is rendered in a graphics overlay in the Visualization window, generally on top of the ObjectSet's source image, although another image can be selected. ObjectSet data can also be displayed in the form of grids (row-column arrays) and charts (histograms and scatter plots). When needed, these ObjectSet representations can be viewed concurrently in different Display Interfaces (i.e., Visualization, Grid, and Chart).

Control Interface – This interface type is the means by which a user selects functions and specifies parametric values that apply to an image, graphic object, measurement, or image capture device.

Task – Aphelion divides the image analysis process into six distinct steps for Lab and seven steps for Dev called tasks. These are named **Camera settings**, **Calibration settings**, **Image Acquisition**, **Object Extraction**, **Object Editing**, **Measurements**, and **Report Generation**. A task named **Developer** is available in the Dev version. A task is selected by clicking its icon on the **Task Bar**. The first two tasks are only available to users with administrator rights. When the user selects a task, the Workspace is automatically reconfigured to provide the Display and Control Interfaces appropriate for the selected task, including the corresponding **Contextual Toolbar** displayed on the right side of the GUI.

Task Bar Control Interface – This control interface displays the icons for the tasks used to perform an image analysis and to define the settings.

Visualization window – This window contains the Visualization Display Interface, the vehicle through which images and ObjectSets can be displayed. The user can choose to display either one image (i.e., a 1x1 array) or multiple images as an MxN array of images, where M and N are Administrator defined parameters via Tools→Options→Advanced→Images (see section 2.9.4 *Main Toolbar*). A set of image manipulation tools exists on the **Main Toolbar** to perform image zooming and panning. These include **Fit to Window**, zoom to Actual

Size, **Zoom in area of interest**, **Zoom In**, **Zoom Out**, and **Pan**. Tools are also provided for drawing or deleting graphic objects in a graphics overlay. This window can also concurrently display an ObjectSet as an overlay on the image from which it was extracted. The Visualization window has some unique properties not present with the other Workspace windows (e.g., it is always visible).

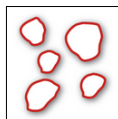
Image Gallery – The Image Gallery displays a thumbnail version of each image currently open in a work session, along with the image's name. Selecting (double-clicking on) a thumbnail image in the Image Gallery makes it the Active Image by displaying it in the Visualization window.

Active Image – Any open image that appears in the Visualization window and that has the focus as noted by the image's icon being highlighted in the Image Gallery. The Active Image is always the default target image for image processing functions executed from the **Main Toolbar**, a **Contextual Toolbar**, or the **Developer Task**.

Object – An object is a grouping of adjacent pixels in an image (e.g., blob, line, chain). The objects derived from a single, source image compose an ObjectSet. A list of object types is specified in the Tools→Options→Measurements window. More information is provided about objects in subsequent sections.

ObjectSet – A set of objects derived from a single, source image. Four tasks can be used to create objects: the **Object Extraction Task**, the **Object Editing Task**'s interactive editing tools, the **Measurements Task**'s interactive drawing tools, and the **Developer Task**'s segmentation tools (Dev version only). When measurements are computed for an object's attributes, they are stored with their respective object in its ObjectSet. An ObjectSet is visualized as a graphics overlay on its source image. ObjectSets can be saved as .aso (recommended) or .tks (for backwards compatibility with previous versions of Aphelion).

ObjectSet Gallery – For each ObjectSet currently opened in a work session, the ObjectSet Gallery displays a



common thumbnail (see adjacent) labeled with the ObjectSet's name. A newly created ObjectSet appears in the ObjectSet Gallery with a default name that is the source image name appended with the text (n) in case of multiple instances of the same ObjectSet, (e.g., SourceImageName (2)) when there are multiple ObjectSets derived from the same image. If these ObjectSets are saved to storage media, the extension .aso is appended to the default name (e.g., SourceImageName (2).aso). The user is also given the option to rename the ObjectSet file before it is saved.

Interactive shapes are also represented in the ObjectSet Gallery as if they were an ObjectSet. The default name of a set of interactive shapes is the text string “I_” followed by the source image name.

Note that only the **Developer** Task enables the user to specify ObjectSet names when the ObjectSet is created. Double-clicking on an ObjectSet thumbnail displays the ObjectSet in the Visualization window.

Active ObjectSet – The ObjectSet that is visible in the Visualization window that lies on top of all other ObjectSets concurrently displayed in the Visualization window. ObjectSets displayed in the Visualization window are layered (i.e., one on top of the other) such that the most recently opened ObjectSet lies on top of the stack of displayed ObjectSets (i.e., is the Active ObjectSet). This ObjectSet will also have its icon highlighted in the ObjectSet Gallery.

Note: For all tasks except the **Developer** Task, the Active ObjectSet is the only ObjectSet displayed in the Visualization window.

Any open ObjectSet can be made the Active ObjectSet by double-clicking its icon in the ObjectSet Gallery. This action brings the ObjectSet on top of all the others. If any ObjectSet measurements grids exist for the Active ObjectSet, those grids will be opened and displayed in the **Measurement** and **Report Generation** Tasks. Repeated double-clicking of an ObjectSet icon alternately turns on and then off its status as the Active ObjectSet and the display of its objects and

measurements grids. However, its icon in the ObjectSet Gallery will remain highlighted until a different ObjectSet icon is clicked or double-clicked.

Attribute – A text or numeric data element describing some aspect of an image or object. Images and objects can have multiple attributes. In Aphelion, we define two types of attributes: spatial and numeric. Spatial attributes are descriptors that provide shape and other geometric information about objects in the form of text (e.g., Bitmap, Line, Circle, Rectangle, Chain, and Point). The shape types (spatial attribute values) are specified in the Tools→Options→Measurements window.

Numeric attributes have measurable, scalar values that describe some aspect of an image (e.g., max pixel value, average pixel value) or an object (e.g., area, length, width, elongation). For each numeric attribute, there is a defined mathematical measurement. A list of the measurements provided in Aphelion is specified for each object shape type in the Tools→Options→Measurements window.

Measurement – A function that computes the value of an attribute defined for an image or ObjectSet. Sometimes, the value itself is also referred to as a measurement.

Grid – A grid displays the attribute measurement values computed for a specific ObjectSet, a set of shape objects, or a set of global measurements computed for an ObjectSet or a set of shape objects. A grid looks very much like a spreadsheet, having one or more columns and one or more rows. A grid row holds the attribute measurement values for one object of the ObjectSet. A column holds the measurement values for a specific attribute for all objects in an ObjectSet. This structure also describes the grid for interactive shapes and for global measurements.

Since the grid for an image displays measurements based on all pixels in the image, the grid is said to contain global measurements. Such grids also include object feature measurements aggregated for all objects in an ObjectSet (Object Global Measurements grid) or for all

interactive shapes (Interactive Shape Global Measurements grid). Consequently, a single row in a global measurements grid will contain global measurements for one ObjectSet. Multiple rows can be used to compute global measurements for multiple ObjectSets.

Grids are initially displayed in window B (see *Figure 2.9-1*) of the Aphelion Workspace. Four grid types are provided: Object Measurements, Interactive Shape Measurements, Object Global Measurements, and Interactive Shape Global Measurements. The latter two are considered measurements on the Active Image. For more information about the four grid types, see *Contextual Toolbar – Compute Tools* in section 2.10.5 *Measurements Task*.


Message Passing – A very useful software feature that responds to a user action in one display interface by initiating a corresponding action in one or more other display interfaces. Message passing, also called Image Synchronization, is implemented for four combinations of display interfaces:

- between an ObjectSet and its measurement grid;
- between an ObjectSet, its measurement grid, and a 1D or 2D histograms computed from one or two attributes of the ObjectSet;
- between multiple images displayed in the Visualization window;
- between a Profile graph in the Chart window and the corresponding line shape drawn on an image; and
- between a Histogram plot and the corresponding line or closed shape drawn on an image.

Between ObjectSet and Grid – With an ObjectSet displayed in the Visualization window and its measured attribute values displayed in a measurements grid, selecting an object in the Visualization window will cause that object's row to be selected simultaneously in the grid. Conversely, selecting an object row in a grid will cause the simultaneous selection of that object in the Visualization window. Handles will appear around the object. Message passing also works when the user selects multiple objects or rows. Clicking anywhere

outside a selected object or object row will deselect all previously selected objects or object rows.

Between Images – Message passing between images is a method by which changes in zoom and pan in one image cause the same zoom and pan operations to occur simultaneously in other selected images. Message passing is available in either One image or Multiple Images modes. Enabling message passing is essentially the same for both modes.

To activate message passing, the user selects those images for which message passing should be active. This is done by clicking on the window banner of each of image while depressing the **Ctrl** key. An icon with opposite-facing arrows  is displayed in the window banner of each selected image. The presence of this icon indicates the image is active for message passing. In the One image mode, since the images are stacked, it may be necessary to first click on an image's tab in order to display the image and access its window banner.

ROI (Dev version only) – Image processing operations are usually performed either on an entire image or on a portion of an image referred to as a region of interest (ROI). ROIs let you focus on selected areas of an image. Regions of interest are useful to enhance a part of an image, provide faster processing since only a subset of the whole image is processed, or produce a count of objects for a selected region. Two ways to create ROIs in an image are 1) using the mouse to draw one or more ROIs or 2) convert the spatial attributes of an ObjectSet to ROIs. ROIs can have any shape and any size (rectangle, polygon, ellipse, or freehand contour).

Connectivity – Pixel connectivity defines the number of adjacent neighbors a pixel has. A pixel with 4-connectivity is defined to have only four nearest neighbor pixels—the adjacent pixels directly above, below, left, and right. A pixel with 8-connectivity also includes the four pixels diagonally adjacent. Connectivity is often used to determine if two adjacent pixels are part of the same object. With 4-connectivity, two adjacent pixels are said to be in the same object if

they are adjacent vertically or horizontally. With 8-connectivity, two pixels are said to be in the same object if they are adjacent vertically, horizontally, or diagonally.

Docking panel – The Workspace of the Aphelion GUI is a docking panel. This means that the Workspace is subdivided into areas in which windows can be docked. Docked windows are fixed in location while docked. Undocked windows can be moved to virtually any location inside or outside the Workspace. By default, a window is docked until the user undocks it. Note that the Visualization window is always docked. Further details on docking are provided in section *2.9.1 Workspace and windows*.

Calibration – Calibration is a process that defines the size of an image pixel in real-world unit (e.g., inches, microns). This pixel size is called Resolution. The mathematics to compute the resolution is contained in the **Calibration settings** Task. However, the user must provide the real-world measurement of a known object (e.g., gauge, optical micrometer) whose image is captured and displayed on the computer screen and is used to calibrate the image acquisition system.

Resolution – Measurement of the smallest object that can be seen, i.e., the measurement in real-world units of an object represented by a pixel. The resolution depends on the acquisition system (camera and optical system) configuration and the distance between the object and the acquisition system. The resolution is defined by a calibration process for each acquisition system configuration and camera-object distance.

Important note: The calibration process must be performed each time an element of the acquisition system is changed (e.g., camera, lens, distance from the scene or sample to the camera sensor, etc.).

2.9. Graphical User Interface (GUI)

This section describes in detail the Aphelion graphical user interface (“GUI”), the different windows comprising the GUI, and the behavior of each specific window and the user interface it provides. The software rigorously implements the new capabilities of Visual Studio .NET, such as user control of window sizes, functionality, and docking states.

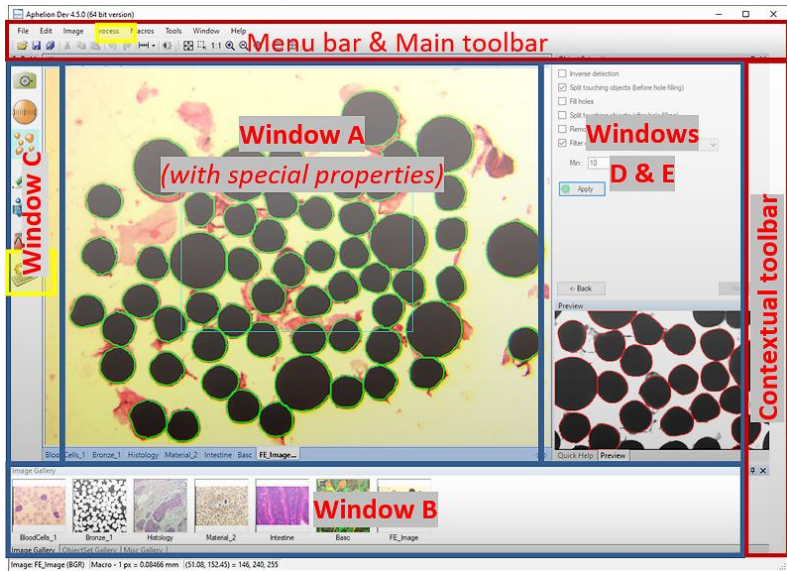


Figure 2.9-1: Aphelion GUI Example – **Object Extraction** Task configuration, showing its GUI subdivisions. Features highlighted in yellow are only available in the Dev version

The Aphelion GUI contains a **Menu Bar**, **Main Toolbar**, task **Contextual Toolbar** (red rectangles in above figure), and a Workspace with four or five windows in a pre-defined layout based on the Active Task (see blue rectangles in above figure). Tasks with only four windows will have window E removed and window D expanded downward.

The following table shows the initial windows configuration for each task. Names in the window columns are descriptive of the user interface function provided by the corresponding window.

Table 2.9-1: Initial windows configuration for each task at start-up. Shaded windows are Control Interfaces, unshaded are Display Interfaces.

PRIMARY TASKS	W I N D O W				
	A	B	C	D	E
<i>Acquisition</i>	Visualization	Image & ObjSet Galleries	Task Bar	Camera settings	Histogram & Quick Help
<i>Extraction</i>	Visualization	Image & ObjSet Galleries	Task Bar	Object Extraction	Preview & Quick Help
<i>Object Editing</i>	Visualization	Image & ObjSet Galleries	Task Bar	Quick Help	
<i>Measurements</i>	Visualization	Image & ObjSet Galleries, Grids	Task Bar	Quick Help	Chart
<i>Report Generation</i>	Visualization	Image & ObjSet Galleries, Grids	Task Bar	Quick Help	
<i>Developer (Dev version only)</i>	Visualization	Image & ObjSet Galleries, Output, BasicScript Cmd Window, Python Cmd Window	Task Bar	Functions, C# coding, BasicScript coding, Python coding	Chart & Quick Help
SETTINGS TASK	Administrator mode only				
<i>Camera settings</i>	Visualization	Image & ObjSet Galleries	Task Bar	Camera settings & Options	Histogram & Quick Help
<i>Calibration settings</i>	Visualization	Image & ObjSet Galleries	Task Bar	Calibration settings	Quick Help

Image and ObjectSet galleries, measurement grids, output values, and command prompt interfaces all coexist at various times in window B as stacked windows (see Stacked pad topic in next section).

When Aphelion is started, the initial Active Task is the **Acquisition** Task (in User mode) or the **Camera settings** Task (in Administrator mode) so that the user can capture an image by just clicking the **Snap** icon on the task's **Contextual Toolbar**.

2.9.1. Workspace and windows

The Workspace is divided into a number of rectangular windows that always fill the entire Workspace area and are predefined for each task. The size and proportions of a window can be changed by the user dragging a window's boundary to a new position. This change in the window causes the adjacent window(s) to gain or lose area accordingly. Window sizes may also change automatically. When a docked window is undocked, adjacent windows will expand to systematically fill the Workspace area previously occupied by the newly undocked window. Similarly, if an undocked window is docked into the Workspace, adjacent windows will shrink in a systematic way to accommodate the newly docked window.

For descriptive convenience, we define two windows types: Visualization window, of which there is only one, and task windows which vary in number depending on the Active Task. All task windows exhibit identical behaviors. The following table describes the major differences between the two window types.

Table 2.9-2: Differences between Visualization and task-specific windows

FUNCTION	VISUALIZATION WINDOW	TASK-SPECIFIC WINDOWS
When displayed	Always	Depends on Task
Docked or Undocked	Always docked	Yes
Dockable with Auto-Hide	No	Yes
Dockable with Stacking	No	Yes

Docked Window mode

A docked window can be moved to a new location in the Workspace by use of the standard Windows' technique of dragging and dropping. This method undocks the window from the Workspace and then docks it in any dockable location in the Workspace. Dockable locations are indicated by the appearance of docking pads when an undocked window is passed over another docked window.

Note: While a docked task window will always shrink to provide space for another task window being docked adjacent to it, the Visualization window never shrinks to accommodate a newly docked task window unless that task window is being docked on a docking pad that is pointing to a boundary shared between the Visualization window and the Workspace.

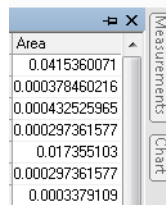
Auto-Hide mode



There are two methods for hiding a docked task window in the Workspace: *Auto-Hide* mode and *Stacked*. *Auto-Hide* is described in this section, while the *Stacked* method is described in the *Moving a window* section below.

A docked window can be placed in *Auto-Hide* mode by clicking on the pushpin icon in its window banner. When *Auto-Hide* mode is activated, three changes occur on screen:

- The pushpin rotates to a horizontal position (see graphic on right);
- The window expands to the full length of the boundary it shares with the Workspace, overlaying adjacent windows; and
- An access tab appears aligned along that Workspace boundary.



Clicking in a different window causes the auto-hide window to collapse (i.e., hide) into the Workspace boundary, enabling the overlaid windows to be visible again. There are two ways to reveal hidden auto-hide window: a) simply move the cursor over the window's tab or b) click on the window's tab. In both cases, the hidden window will be displayed. However, in the first case, the displayed auto-hide window will hide again once the cursor is moved into an adjacent window. In the second case, the window won't hide until one clicks in a different window.

The *Auto-Hide* feature can be used to hide any docked task window along any border of the Workspace so that it is easily accessible when needed. This allows the user to make more Workspace area available to view other windows. For example, the Visualization window can be made to fill the entire Workspace by auto-hiding all other windows.

To remove a window from *Auto-Hide* mode, simply click on the window's pushpin. The window will be restored to its prior docked, non-auto-hide state.

Undocked windows

An undocked window is said to be floating in that it can be moved to any location on the computer's display screen that is not a docking pad (see next section, *Moving a window*). Its size and proportions (aspect ratio) can be freely adjusted by the user within the operating system's constraints.

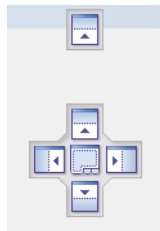
A docked task window (i.e., not the Visualization window) can be undocked in two ways. If the user double-clicks on its banner, the window will become undocked and repositioned to its last undocked location, and conversely. A task window also becomes undocked when the user drags it from its docked position.

An undocked window can be docked in two ways. Double-clicking its banner will cause it to become re-docked at its last docked location. Alternatively, an undocked window can be dragged/dropped on a docking pad.

Help: A set of multimedia demonstrations is available on the Aphelion DVD showing how to use the software.

Moving a window

When a window is dragged to a new Workspace location, a docking control (see graphic at right) appears as the mouse pointer passes over a docked window. The docking control will have one or more pads (small boxes). The symbol on a docking pad



indicates where the undocked window will become docked relative to the already docked window (above, below, left, right, or stacked) after the windows are reconfigured to fit in the space previously occupied only by the docked window(s). When the mouse pointer is positioned over one of the docking control pads, a preview of the reconfigured windows appears showing their locations and proportions if the undocked window is dropped on that pad.

Arrowhead pads – In the case where the undocked window is dropped on an arrowhead pad belonging to a task window, the undocked window and the underlying docked window will be reconfigured to share equally the Workspace area formerly occupied only by the previously docked window. The position of the newly docked window will be dependent on which of the available pads is used (above, below, left, and right).

Stacked pad – If the undocked window is dropped on the **Stacked** pad (center icon of the docking control), the undocked window will be reconfigured to the same dimensions as the underlying docked window(s) and the undocked window will be stacked on top of the docked window(s) (similar to an up-turned deck of playing cards). For each undocked window dropped on the **Stacked** pad of a window, the stack in that window area will increase by one and a corresponding tab will be added at the bottom edge of the stack. Clicking on a tab will cause its window to be displayed (to rise to the top of the stack). The value of stacking windows is that the window size is not decreased as new windows are added to the stack.

When an area of the Workspace is vacant as a result of a docked window being moved, the adjacent window(s) will systematically expand to fill the area vacated by the relocated window.

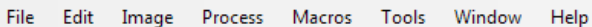
Note: A group of stacked windows can be undocked as a group and can be moved as a group in the same manner as for a single docked window. A window in a stack of windows can be removed from its stack by dragging its tab to a new location or by double-clicking its tab. In the latter case, the window becomes undocked and located where it last existed as undocked.

2.9.2. Task and work context

Use of Aphelion is accomplished through a set of tasks. A predefined work context is associated with each task and is comprised of a set of control and display interfaces, each represented in window form on the screen. A task's work context also includes a contextual toolbar that displays along the right-hand border of the GUI. *Table 2.9-1* gives a list of all window interfaces provided for each task.

Note: A window that was moved to a new location or reconfigured in the work context of a given task will cause the corresponding window in all subsequent tasks to be identically moved or reconfigured. For instance, moving the Histogram/Quick Help window of the **Acquisition** Task (i.e. Window E) will have the same effect on the Preview/Quick Help window of the **Object Extraction** Task and the Chart window of the **Measurements** Task. (See *Table 2.9-1* for these correspondences.)

2.9.3. Menu Bar

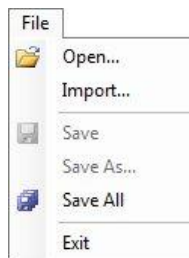


The **Menu Bar** provides user access to the **File**, **Edit**, **Image**, **Process**, **Macros**, **Tools**, **Window**, and **Help** menus. Each menu contains a list of entries that perform specific operations, as described below. A menu entry can be exercised by a single mouse click.

Note: Some menu entries also can be exercised by clicking on a shortcut found on the **Main Toolbar**. An entry that has a toolbar shortcut will have that shortcut's icon displayed at the left of the entry.

File Menu

Open: Opens a Windows files browser and lets the user select a file to load. The filter in the files browser adapts to the context, and to the highlighted window (with the focus) in the Aphelion GUI. For example, in a C# Macro window, Open only displays .cs macro files. The value of the filter can be changed to display other files or all files present in the current folder.



If the user chooses to open a 2-D image file, the image is loaded into the Image Gallery as a thumbnail and displayed in the Visualization window as the Active Image.

A 3-D image is also loaded into the Image Gallery as a thumbnail, but with a 3D frame overlaid on it (see example adjacent). However, a 3D image cannot be displayed in the Visualization window until a rendering method has been chosen and there are two ways to do this.

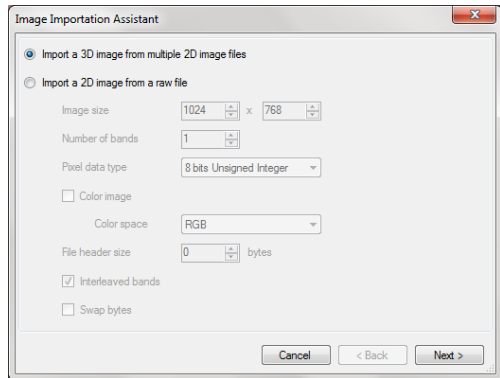


If the parameter `DisplayThreeDImagesOnOpen` is set to `False`, a 3D image will not automatically open in the Visualization window. In this case, to display the 3-D image in the Visualization window, the user right clicks on the 3D image's thumbnail and, from the dropdown menu, chooses the `Show` entry and then selects from the next dropdown menu, the desired rendering method: *Isosurface*, *Volume*, or *Section*.

A 3D rendering method can also be specified as a default condition by going to the Options→Advanced→Appearance→Images window and then setting the parameter `DisplayThreeDImagesOnOpen` to `True` and the parameter `DefaultThreeDViewer` to the desired rendering method: *IsoSurface*, *Volume*, or *Section*. In this configuration, all 3D images will be opened automatically in the Visualization window using the default rendering method.



While multiple copies of a 3D image rendered using different methods can be open concurrently in the Visualization window as stacked windows, they can also be opened concurrently in a single window. To do this, drag and drop the 3D image thumbnail into the desired window. This causes the thumbnail's contextual menu to open. From this menu choose Show and then select a rendering method (*Iso*surface, *Volume*, or *Section*) from the next dropdown menu.

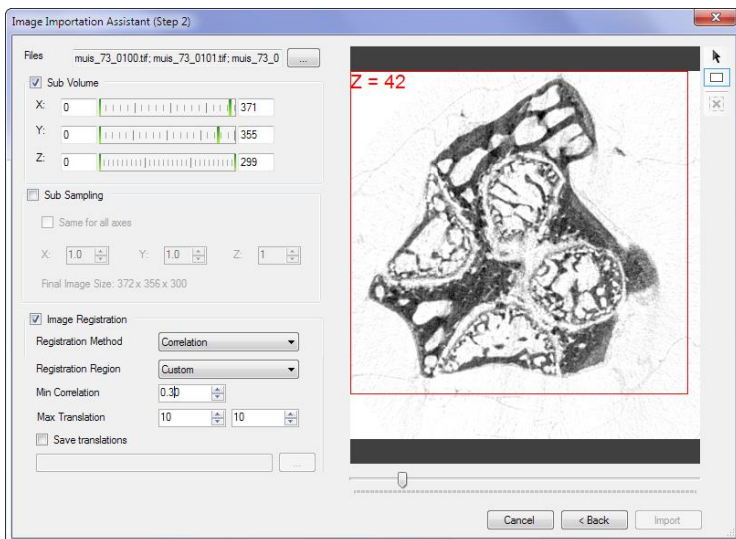
Import: If image data is in a non-standard 2D format or a 3D image, the **Import** feature enables the user to specify the key parameters and storage location of the image so that it can be read and processed by Aphelion. This feature can be configured to generate a 3D image from a set of grey-scale 2D images of successive



sections, or to import a raw 2D file consisting of one or more bands. The *Import* process consists of two successive steps. **Next** and **Back** buttons are used to switch between these two steps.

The first step is used to specify whether the file is 2D or 3D and, to specify key parameters of the imported image format. If a 3D image is to be imported, a set of windows pops up to let the user specifying the series of 2D images and key parameters. First, select the image series by clicking on the [...] button. A new window pops up with four icons in the right toolbar. Click first on the + icon to load a series of images. Then click on the first image of the series when the filer opens. To load the whole set of images, and in the case there is a logic in the file naming convention, click the **Yes** button, else manually select each image of the series. If needed, move images in the list using the ↑ and ↓ icons, or delete an image by clicking on the × icon. A sub volume can be defined specifying the X, Y, and Z

coordinates of the volume. In case of large images, select the subsampling parameters to speed up the display and the processing of the 3D volume that is generated. If the sections in the image series are not perfectly aligned, click on the *Image Registration* check box, and specify the associated parameters. The *Registration Method* parameter is either *Correlation* or *Used saved Translations*. The *Registration Region* can be *Entire*, *Subvolume*, or *Custom*. In this latter case, click on the  rectangle icon in the right toolbar to specify a rectangular region of interest in one of the sections. The *Max Translation* parameter defines the maximum translation that is accepted between two consecutive sections defined in pixel units. Once all parameters have been defined, click on the  button to import the set of sections and define a 3D image.



If the user selects a 2D image to be imported, the user also specifies the *Image size* (in pixels), the *Number of bands*, the *Pixel data type*, and the *File header size*.

When the *Number of bands* selected is greater than 1, the *Interleaved bands* checkbox is made available for selection. If the *Number of bands* selected is 3 or 4, the user is provided a checkbox to indicate that the

imported image is a color image. In this case, the user also identifies the appropriate color space from a dropdown list of applicable color spaces. For *Pixel data type*, the user selects from a dropdown list consisting of thirteen data types. If the user selects a data type containing of more than eight bits, the *Swap bytes* checkbox is made available for selection.

Clicking on the **Next** button switches window to the second step in the *Import* process. This step's sole purpose is to enable the user to specify the file path for each image to be imported. Clicking on the **Open File** icon opens a file browser. For a 2D image, simply select or enter the path to the file to be imported.

For a 3D image, the path for each 2D section or slice must be provided in image sequence order. The file names must use the following convention: *[filename][index].[ext]*, where *filename* is any valid Windows name, *index* is an integer indicating the sequence order position of the image, and *ext* is the file type extension and must be one of the file types supported by Aphelion.

Save: Saves the objects with the focus in the highlighted window. The **Save** entry is only enable if the objects with the focus have been modified. If there is more than one object in the window (e.g. an image and an ObjectSet), the menu changes to reflect the modified objects displayed in the window. Typically, the menu entry can be:

Save Image *ImageName*

Save ObjectSet *ObjectSetName*

Save *Multiple Objects...*

In case of multiple objects, a window pops up letting the user select the objects to be saved. The names of the output files are the names of the objects and the extensions are the default ones (defined in the **Tools→Options→Files** menu for the images and ObjectSets – see *Files Options* in this section for more details).

Tip: To save multiple images/ObjectSets, select the corresponding thumbnails in the Image/ObjectSet Gallery, and then click on the **Save** entry.

Save As...: Saves the unmodified entities with the focus in the highlighted window. In case there are more than one object in the window (e.g., an image and an ObjectSet), the menu changes to reflect the objects displayed in the window. Typically, the menu entry can be:

Save Image *ImageName* As...

Save ObjectSet *ObjectSetName* As...

Save *Multiple Objects* As...

In case of multiple objects, a window pops up letting the user select the objects to be saved. The names and extensions of the output files can be edited if desired.

Note: In case multiple images are selected in the Image Gallery window or multiple ObjectSets are selected in the ObjectSet Gallery window, then the last selected entity is the one with the focus. It means the save operation will affect this object.

Save All: Saves all modified objects available in the Aphelion GUI, including images, ObjectSets, color palette, etc. The list of objects that will be saved can be customized in the **Tools→Options→Advanced** menu. In case multiple objects are to be saved, a window pops up letting the user select the objects to be saved. The names and extensions of the output files can be edited if desired.

Note: Image resolution is only saved with .tif and .asi file formats. Since the .asi (Aphelion serialized image) format is proprietary to the Aphelion Imaging Software Suite products and is not compatible with any other imaging software or devices, it is recommended that images be saved in TIFF format if they may have to be imported into a third party software product.

Note: The .aso file format is an Aphelion 4.x proprietary format for saving ObjectSets. It includes and extends the capabilities of the .tks format which was used for the Aphelion 3.2 software products. It is recommended that the .aso format be used for most Aphelion situations. The .tks format should be used only when working with ObjectSet files generated by an Aphelion 3.2 software product.

Note: The icon is grayed out if no object can be saved in the highlighted window.

Exit: Ends the current project work session and frees all memory that was being used, and closes the Aphelion program. During this closing process, the user is given the chance to save any unsaved image and ObjectSet data.

Edit Menu

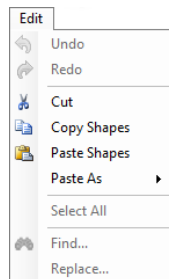
The **Edit** menu provides tools that enable the user to edit selected entities depending on the context, such as text in a Macro window or a graphic object displayed in the Visualization window.

Undo: Undoes only the last editing operation.

Redo: Redoes only the last Undo operation.

Cut, Copy, Paste: Standard object editing behavior.

Paste As...: Creates an image that contains the data copied in the clipboard if the Image option is selected, or paste one or more selected objects in an Aphelion ObjectSet in a graphic or an ROI.



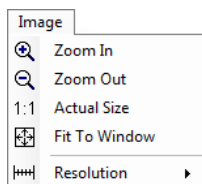
Note: To quickly convert selected objects in an ObjectSet into graphic objects or ROIs, select the **Developer** or **Measurement** tasks, select the objects and copy them in the clipboard, then select the **Developer** Task, click on **Edit→Paste As...** menu and choose Graphic or ROI to paste the objects in the active image respectively as a graphic overlay or a ROI.

Select All: Selects all image or ObjectSet thumbnails displayed in the Image or ObjectSet gallery. Selected objects can then be closed by right-clicking on the **Close** entry in the contextual menu.

Find: Finds a character string specified by the user in the active macro window.

Replace: Finds a character string specified by the user and replace it with a new character string in the active macro window.

Image Menu



The **Image** menu provides tools that enable the user to alter the display of the Active Image in the Visualization window. Shortcut buttons for these functions are provided on the **Main Toolbar**.

Zoom In: Zooms into the Active Image. The zooming factor is times $\sqrt{2}$. One click on **Zoom In** increases the inter-pixel distance by a factor of 1.414; clicking twice doubles the inter-pixel distance.

Zoom Out: Zooms out from the Active Image. The zooming factor is times $1 \div \sqrt{2}$. One click on **Zoom Out** decreases the inter-pixel distance by a factor of 0.707; clicking twice halves the inter-pixel distance.

Note: The zooming factor can also be altered by turning the mouse wheel.

Actual Size: Displays the Active Image so that image pixels are in a 1:1 relationship with screen dots (i.e., no zooming applied). Scrolling or panning may be necessary to view all areas of the Active Image.

Fit To Window: Zooms the Active Image so that the entire image is displayed as large as possible in the Visualization window. The zoom factor applied is identical for both the X and Y axes in order to preserve the image's aspect ratio.

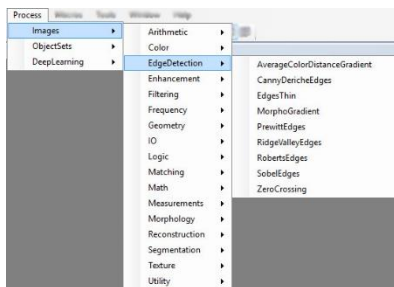
Important note: When **Fit To Window** is selected, as denoted by its menu icon turning blue and its toolbar button gaining a blue outline, all other zoom tools are disabled. To gain access to the other zoom tools, unselect **Fit To Window** by clicking again its menu entry or its toolbar button.

Resolution: Selects a predefined resolution to be associated with the current image. If no resolution has been defined, then the menu entry is **None**.

Process Menu (Dev version only)

All Image and ObjectSet functions can be invoked from this menu. The menu has three or four panels (see below), the first providing three major function groupings: Images, ObjectSets, and DeepLearning functions (there can be more depending on the additional plugins installed within your Aphelion Dev distribution). The second panel divides these major groupings into sub-groups of related functions. The third panel lists either an additional level of sub-grouping or the individual functions contained in the selected group or sub-group. If a fourth panel is provided, it lists the functions contained in the second level sub-group. When the mouse pointer is hovered over a function, a tooltip appears providing a brief explanation of the function. The selection of any function from the **Process** menu's third or fourth panel will automatically activate the **Developer** Task and initialize the functions window in the window D location of the user interface.

An additional fourth entry in the first panel, Compatibility 3.2, provides access to all of the Aphelion 3.2 functions laid out in the hierarchy of that version. This menu entry is hidden by default and can be activated by selecting **True** for the option found at:

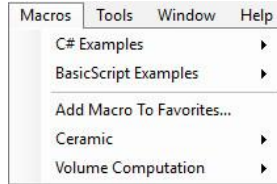


Tools→Options→Advanced→Developer→ShowCompatibilityGroups.

Note that Aphelion 4.x contains functions that were not available in version 3.2.

Macros Menu (Dev version only)

The **Macros** Menu lets the user add a list of macros in this menu, to allow a quick run or edit of a macro. Example macros distributed with Aphelion Dev are already available in this menu (options “C# Examples” and “BasicScript Examples”).



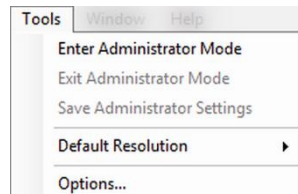
Note: To define macro sub-menus, edit with Notepad or a similar program the user.config file located in the C:\Users\<User>\AppData\Roaming\ADCIS\Aphelion Dev\4.x.x folder, and add or edit a MacroShortcut XML entry as shown in the example below:

```
<Project>
  <MacroShortcuts>
    <MacroShortcut Type="Aphelion4.Scripting.MacroShortcut">
      <MacroShortcut Name="MyMacros.Ceramic"
        FileName="C:\Program Files\ADCIS\Aphelion
        4.x.y\Dev\Examples\Macros\CSharp\Processing\Ceramic.cs"
        Arguments="" ID="0" ParentID="0" />
    </MacroShortcut>
  </MacroShortcuts>
</Project>
```

The AphUserMacroAdd BasicScript command can also be used to add an entry in the Macros menu. This command allows defining sub-menus in this menu.

Tools Menu

The **Tools** Menu contains a variable number of entries depending on which



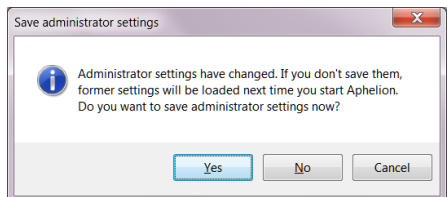
Aphelion Extensions are installed. If none are installed, the menu will be as pictured to the right with five basic entries. When certain Extensions are installed, they will have an entry in this menu to enable a user to call or start the Extension (e.g., Classifier Builder).

Note: In some cases, the Extension may start in the background of the Aphelion Dev program. Click on the Extension icon in the Windows Task bar usually located at the bottom of the screen to activate the Extension.

Enter Administrator Mode: Clicking on this menu entry will cause the Aphelion system to immediately activate Administrator Mode. If a password was previously created, then a password entry box is displayed before entering Administrator Mode. When Aphelion is in Administrator Mode, the user has access to all of Aphelion's settings. These settings enable an Administrator to configure Aphelion for optimal performance of the user's projects and are accessed via the Options menu entry (see below). Note that settings for cameras and settings for calibrating the acquisition system and images coming from another source are accessed via entry on the Task Bar that only displays when the Administrator Mode is active (see section 2.10 Tasks).

Note: If no password has been defined, and if the *AutoEnterAdministratorMode* parameter is set to *True* in the *Identification* options of the Advanced settings (**Tools→Options→Advanced**), then Aphelion starts in Administrator mode for all types of users. This parameter is set to *True* by default. However, the *True* setting is ignored if a password is defined.

Exit Administrator Mode: Clicking this entry deactivates the Administrator Mode. If any Options settings were changed since the last time settings were saved, the adjacent Save window appears giving the user a chance to save any changed



settings prior to deactivating Administrator Mode. If the user clicks on the No button at this time, then settings changes are retained for the current work session but are not saved for future work sessions. In this case, when the user ends the current Aphelion work session (terminates Aphelion execution), if the changed settings have not previously been saved, the same Save window appears to provide a last opportunity to save the changes for the next Aphelion work session. If the user clicks on the Yes button, then the settings changes are saved. If there are any unsaved settings changes when the user terminates the Aphelion work session, the Save window appears, providing a last chance to save changed settings.

Save Administrator Settings: Saves the changed settings, but Aphelion remains in Administrator Mode. This operation is only available in Administrator Mode.

Default Resolution: Clicking on the Default Resolution menu entry displays a list of all resolutions previously created and named by an Administrator using the Calibration Task. By selecting the appropriate named resolution from this list, the user causes that resolution to be attached to the Active Image for use in computing measurements



on this image. For more information on calibration and resolution, please see Section 2.8 *Terminology*.

When an image opened from storage media includes a resolution that corresponds to none of the resolutions that were defined using the **Calibration settings** Task, then this imported resolution appears in Aphelion's status bar.

Note: If a resolution is attached to the current camera configuration (refer to *2.10.1 Administrator Settings Tasks*), then this resolution is applied to the captured image, over-riding the selected **Default Resolution**.

Options...: This entry on the Tools menu provides access to most of the settings available for configuring the Aphelion software. The remaining settings are accessed via the Taskbar and its Camera Settings and Calibration Settings tasks. Non-Administrator users do not have access to the Camera Settings task. Instead, such users have access to the Image Acquisition task which has limited settings.

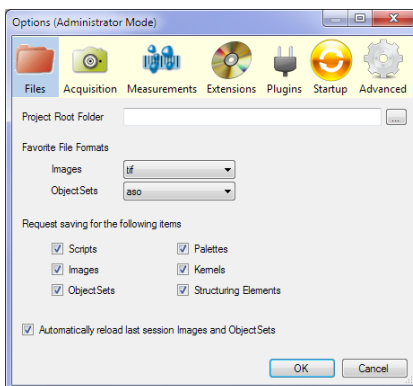
Administrator settings include parameters for image acquisition, project data, measurements, and Advanced settings. Advanced settings include specification of interface colors, the separator in the grid, the compatibility with previous versions of Aphelion, and other settings that typically do not need to be updated frequently.

The Options window is organized into groups of functionally or operationally related settings. These groupings are selectable by clicking on an icon located along the top edge of the window, as is shown below.



Files Options

Selection of **Tools→Options→Files** opens the Files control interface containing settings specific to how files are managed by Aphelion. From this interface, the user can specify the *Project Root Folder* into which data and measurements files will be stored. This interface is also used for specifying the default formats for images and ObjectSets and the types of data that are to be saved. The user



can also specify which Aphelion objects can be saved when exiting the program (e.g. Aphelion macros or scripts, images, ObjectSets, kernels, structuring elements, and color palettes). If the last checkbox is selected, the last user session will be reloaded when Aphelion starts, including images and ObjectSets that were open in the Galleries in the previous session.

Tip: If the *Project Root Folder* is not specified by the user, then the default folder for storing the user's images and ObjectSets is:

	Aphelion Lab	Aphelion Dev
7, 8, & 10	"C:\Users\User name\Documents\... ...Aphelion Lab"	...Aphelion Dev"

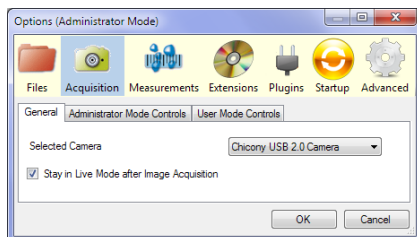
Using these default folder names ensures that data saved by one user are kept separate from data saved by other users.

Acquisition Options

The Acquisition Options are divided into three groups, each group having its own tab: General, Administrator Mode Controls, and User Mode Controls. The contents of the three tabs are described in the following paragraphs.

General: Cameras that have previously been registered with the Aphelion system will appear in the Selected Camera dropdown list. (The camera registration process is described in the section titled “Administrator Mode Controls” following below.) The user selects the camera that will be used in the current work session to capture images or video.

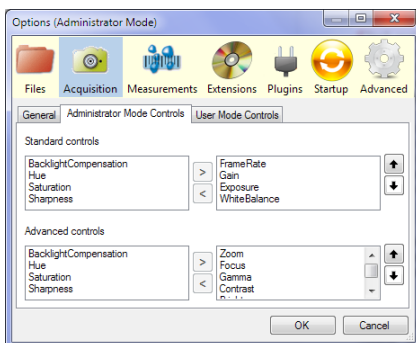
Check-marking the *Stay in Live Mode after image acquisition* box under the General tab specifies that after an image is acquired (i.e., **Snap** button was pressed), the live image remains displayed in the Visualization window. If the box is not check-marked, the live image is replaced by the acquired image in the Visualization window. The *Select Camera* box is used to select the acquisition device to be used to receive live video and to snap images.



Note: Only administrators can select the acquisition device.

Administrator Mode Controls: This interface is used by an Administrator to specify those camera controls that only an Administrator can change. Changing these controls is accomplished with the **Camera settings** Task.

The Administrator Mode Controls dialog box divides camera controls into two categories, *Standard controls* and *Advanced controls*. Camera controls that are displayed in the window depend on the driver interfaced to Aphelion and the manufacturer specifications. They are automatically registered with Aphelion when the camera is connected to the computer while it is running Aphelion. When registered, all of the controls initially appear listed in the left box of both Administrator Mode Controls and User Mode Controls dialog boxes, and the right box of those dialog boxes remain blank until an Administrator moves controls from the left box to the right box. An Administrator can then move any listed control between the left and right boxes by selecting a control and then clicking on the < and > direction buttons as needed. Moving a control from the left window to the right window will cause that control to be visible in the Camera settings control interface visible when the **Camera settings** Task is selected in Administrator Mode.

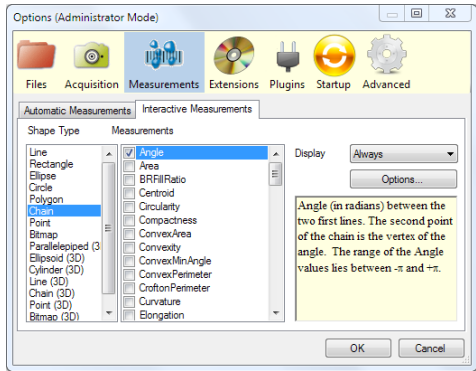


User Mode Controls: This interface is used by an Administrator to specify those camera controls, both standard and advanced, that a non-administrator user will be allowed to change when using the **Image Acquisition** Task in the User Mode. Moving a control from the left box to the right box will cause this control to be accessible by non-Administrator users. This enables the Administrator to limit what changes can be made by non-Administrator users.

Note: To learn more about the selected camera's modes and controls, please refer to the camera manufacturer's documentation.

Measurements Options

Selection of the **Tools→Options→Measurements** option enables an Administrator to specify the measurements that will be computed on objects extracted from images or manually drawn or edited by the user. The Measurements control interface lists each Shape Type available in Aphelion and a check box menu of Measurements available for each Shape Type. The **Measurements** Task will compute the check-marked measurements for each object in an ObjectSet based on the object's Shape.



Object types are divided into two categories: Automatic and Interactive.

- Automatic: Measurements computed on these object types are generated in the **Developer**, **Object Extraction**, or **Object Editing** Tasks, and are displayed in a grid in the Object Measurement Tab found in the Gallery. The Automatic Measurements panel enables the user to select the measurements to be automatically computed for each shape type in this category.
- Interactive: Measurements computed on these object types are generated in the **Measurements** Task using the interactive drawing tools available in the Task, and are displayed in a grid in the Interactive Shape Measurements Tab found in the Gallery. As an option, interactive Measurements values may also be displayed in the image overlay. The Interactive Measurements panel enables the user to select the measurements to be computed in real-time for each shape type in this category.

Available shape types are: Line, Rectangle, Ellipse, Circle, Polygon, Chain, Point, Bitmap, and 3D shapes (Parallelepiped, Ellipsoid, Cylinder, Line, Chain, Point, Bitmap), only available when the 3D Image Processing extension is licensed and loaded.

Bitmap is a shape only available for objects generated either in the **Developer**, **Object Extraction**, or **Object Editing** Task.

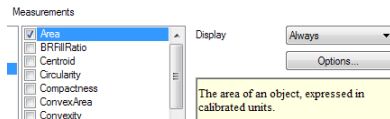
Line, Polygon, and Chain are shapes available for objects generated either in the **Developer** or **Measurements** Task.

Rectangle, Ellipse, and Circle are shapes available in objects generated in the **Measurements** Task.

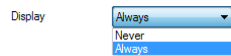
Available measurements depend on the shape that is computed or drawn.

Note: All graphic objects drawn by the user in the **Measurements** Task are assigned a *Shape* type.

When a measurement is highlighted by the user, a brief description of that measurement appears in the help box at the right-side of the Measurements panel. If a measurement is both selected and highlighted, two display settings are enabled immediately above the help box, as shown beside.



Display: Defines whether the measurement is “Always” or “Never” displayed in the image overlay.



Options: Provides a pop-up menu of display parameters that enable the user to define the location and format of the displayed measurement.

Style: Specifies the text displayed as a string or in a tooltip. Currently, only a *Text* string default is available.

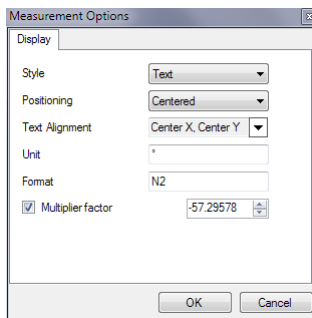
Positioning: Specifies the default position of the text relative to the object. Currently, only a *Centered* default is available.

Text Alignment: Defines the text alignment.

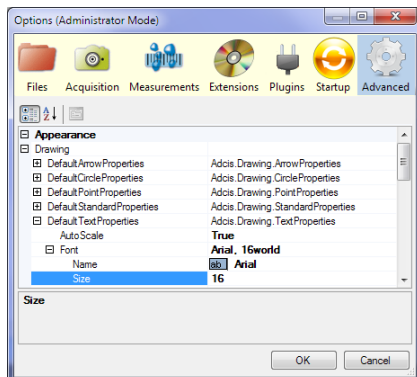
Unit: Specifies the text to add after a measurement value to identify applicable units (e.g., μm , pixel).

Format: Specifies the format of the text. The available formats are *Numeric (N)*, *Fixed-Point (F)*, *Exponential (E)*, and *General (G)*. The digit after the letter specifies the number of decimal digits except for G. For this latter case, it gives the number of significant digits.

Multiplier factor: Specifies a constant as a multiplier of measurement results. This is useful for rescaling or converting to a different unit. For example, the number 57.296 (i.e. $180/\pi$) can be set as the Multiplier factor to display in degrees angle measurements that were computed in radians




Tip: To change the size of the font, open the Tools→Options... →Advanced window, select Drawing→DefaultTextProperties →Font, and then update parameter values there.



Automatic Measurements

Measurements selected in the Automatic Measurements panel are automatically computed on the objects generated in the **Object**

Extraction and/or **Object Editing** Tasks when the  button is clicked.

Interactive Measurements

The measurements selected in the Interactive Measurements panel are computed on the fly when a shape is drawn using the drawing tools available in the **Measurements** Task. The drawing tools used to create geometric shapes are: Line, Circle, Polyline, Polygon, Caliper (Line with start and end bars) and Angle (Polyline made of three points). Their shape types are then, respectively, Lines, Circles, Chains, Polygons, Line, and Polyline, and the measurements selected for these types will be computed in the **Measurements** Task as soon as the shape is drawn.

Extensions *(Administrator mode only)*

An Aphelion extension is a set of tools that is usually used in the Aphelion GUI. However, note that some extensions are stand-alone applications that can be used outside Aphelion. Typically, a specific license code is required to be able to use one or more Aphelion extensions, although some extensions do not need a specific license code (i.e. C#, BasicScript and Python scripting languages, camera emulation using AVI files).

Note: Aphelion includes a set of default camera drivers to control most common cameras. Drivers for certain other cameras are available as extensions of Aphelion.

Selection of **Tools→Options→Extensions** opens the **Extensions** control interface. It displays the list of all of the Aphelion extensions, not including standalone extensions, that were available for purchase at the time Aphelion was installed on the current computer. Extensions that are licensed on the current computer are

denoted by the word “*Licensed*” in the *Status* field. If the text “(loaded)” appears adjacent to “*Licensed*”, then the necessary libraries and driver(s) were loaded for that extension when the current execution of Aphelion was started. If the *Status* field of a listed extension shows only “*Licensed*”, then one or more necessary drivers or libraries were not included when the current execution of Aphelion was started.

The text “*Licensed*”, with or without the text “(loaded)” appended to it, only appears for the extensions included in the License Code that was used when Aphelion was last installed on the computer.

The checkbox for each extension has four states: Checked+notGreyed

(CnG), Checked+Greyed (CG), NotChecked+Greyed (nCG), and NotChecked&NotGreyed (nCnG). These states have the following meanings:

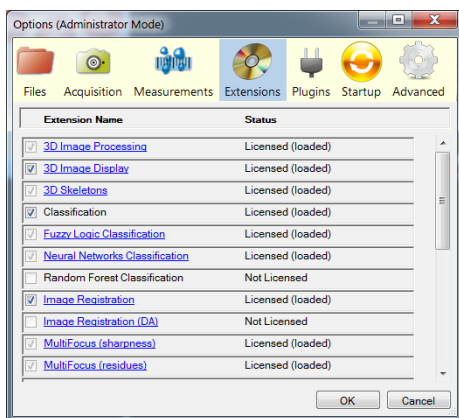
CG Extension is always loaded and cannot be unloaded by user

CnG Extension is licensed & loaded and can be unloaded by user

nCG Extension is not licensed

nCnG Extension is licensed and can be loaded by user

The first time Aphelion is started after an installation, all licensed extensions are configured to be loaded into main memory. By unchecking a licensed extension whose checkbox is not greyed, the user is able to prevent the extension’s software from being loaded into main memory. This can have a positive impact on Aphelion start-up time and free up a portion of main memory. It can also prevent



warning messages that may occur if the extension requires the presence of non-Aphelion software that has not been loaded or absent external device. An example of this situation is presented in the following Note.

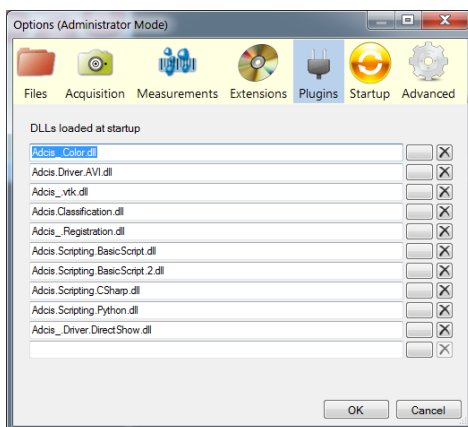
Note: It is recommended to not load a camera driver if the camera is not connected to the computer. Some drivers make calls to software that is provided only by the camera manufacturer to enable communication between the computer and the camera. Such a situation may result in troublesome warning messages or in unpredictable behaviors by the camera.

Plugins (*Administrator mode only*)




A plugin is a DLL or a programming library that is included in Aphelion Dev. At startup, Aphelion can load one or more plugins. Some Aphelion extensions may need to load a set of plugins, while other extensions do not (i.e., 3D Image Processing, 3D Skeletonization, Image Registration, and MultiFocus). Note an Aphelion user can create his/her own plugin. New user functions are usually loaded in Aphelion through the use of a plugin, although a C# script can also be loaded to add new image processing functions in the Aphelion GUI.

Selection of **Tools**→**Options**→**Plugins** opens the **Plugins** control interface. It lists the plugins that are loaded when starting Aphelion. To unload a plugin, click on the ☒ checkbox to clear it and then click the **OK** button. In the Save administrator settings window that appears, click on the **Yes** button to



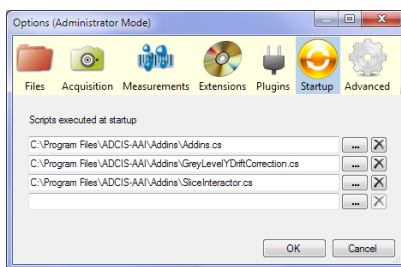
save the Administration Settings and to restart Aphelion. When Aphelion restarts, the plugin is not loaded and does not appear in the *Plugins* list. Remember that since the plugin is no longer loaded, any extensions that use it will no longer function.

To load a plugin that was not loaded (i.e., not in the *Plugins* list) when Aphelion was last started, locate the blank entry (i.e., last entry) in the list and click on its  button. This causes the file browser to open to the directory containing all of the Aphelion plugins provided with the current Aphelion installation. From there, the user can choose an Aphelion plugin or navigate to any directory containing the plugin the user wishes to install. Select (highlight) the desired plugin (a .dll file) and click the **Open** button. Next, click the **OK** button in the Plugins list (DLL loaded at startup) window. This causes opening of the same Save administrator settings window that opens when a Plugin is unloaded. Click the **OK** button and then, in the window that appears, click on the **Yes** button to close Aphelion and have it automatically restart. Be sure to check to see that the desired plugin is now loaded. If you know what extensions require the newly loaded driver, check the extensions list to see that those extensions now show that they are loaded.

Startup (Administrator mode only)



This menu lets the user define the list of macros /scripts executed when starting the program. These scripts can be a mix of C#, BasicScript or other scripts developed in the supported languages.



Advanced Options (Administrator mode only)



Advanced options can be configured in this panel. The five main parameter categories are:

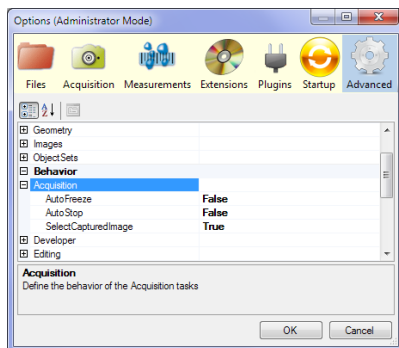
Appearance: Displays/Changes image and ObjectSet appearance settings.

Behavior: Displays/Changes settings for **Image Acquisition**, Object Extraction, and **Developer Tasks**.

Files: Specifies the Save action settings for files.


General: Specifies administrator password, user name, language of the user interface, license code, and other system information.

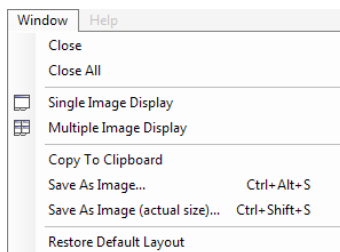
Misc: Displays/Changes the graphical user interface location, size, status (maximized, minimized, normal).



Refer to *APPENDIX H - Options→Advanced Menu* to get a detailed description of each parameter available in the Options→Advanced window.

Window Menu

Close: Closes the Active Image and free the memory space used by the image data. Note that clicking on the Visualization window's  button will also close the image displayed in the corresponding window. This operation is not available if there is no Active image.



Note: ObjectSets can be individually closed by right-clicking on an ObjectSet's icon in the ObjectSet Gallery window, then clicking **Close**.

Close All: Closes all images and ObjectSets currently opened respectively in the Image Gallery and in the ObjectSet Gallery window.

A window pops up prompting the user which images and ObjectSets need to be saved before being closed. This operation is not available if there is no loaded image and no loaded ObjectSet.

Single Image Display: Displays one image in the Visualization window.

Multiple Image Display: Displays multiple images in the Visualization window as an array specified by the MIVTColumnCount and MIVTRowCount parameters in the Advanced Options (2x2 images by default).

CopyToClipboard: Copies the displayed part of the active image to the clipboard.

Save As Image...: Saves the entire contents of the Active Image window (i.e., Window A) as a TIFF image. The saved image will have the same zoom factor, size, and visible non-image border (if any) as appeared in the Active Image window.

Save As Image (actual size)...: Saves the entire image and overlay (if any) displayed in the Active Image window as a Tiff file, preserving the actual size and aspect ratio (i.e., zoom value of one) of the image.

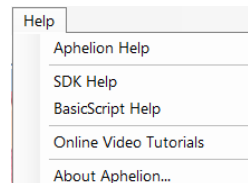
Restore Default Layout: Restores the default Aphelion Graphical User Interface layout, as it appears in *Figure 2.9-1* earlier in the document.

Help Menu

Help Contents: Opens the online Aphelion User Guide.

SDK Help: Opens the online Aphelion Image and ObjectSet Processing Function Guide.

BasicScript Help: Opens the online BasicScript macro language Guide.



Online Video Tutorials: Lets the user play the video tutorials explaining the use of the software. It opens a web interface that displays the list of available videos.

Note: An internet connection must be available to play these tutorials.

About Aphelion: Displays a window containing software version and legal information about Aphelion (i.e., Aphelion version, release number, Identification Code, License Code, and copyrights).

2.9.4. Main Toolbar


The **Main Toolbar** provides shortcuts for many of the operations provided by the menus on the **Menu bar**. See section 2.9.3 *Menu Bar* for a detailed description of these operations. The **Main Toolbar** also contains some operations not available on the **Menu bar**. These are described below.

File Menu Shortcuts: 

Open, Save Image, and Save All: see section 2.9.3 *Menu Bar*.

Edit Menu Shortcuts: 


Cut, Copy, Paste, Undo, and Redo, see section 2.9.3 *Menu Bar*.


Resolution:  Used to select a resolution that is only applied to the Active Image.


Help: The resolution associated with an image is saved with the image if the format is either TIFF (.tif or .tiff) or Aphelion Serialized Image (.asi). In these cases, the resolution will be applied automatically when loading the image. However, the resolution will be lost if the image is saved in a format other than .tif, tiff, or .asi.


Image Menu Shortcuts: 

Fit to Window, Zoom in area of interest, Actual Size, Zoom In, and Zoom Out, see section 2.9.3 *Menu Bar*.


Zoom area of interest:  Enables use of the mouse to draw a rectangular area of interest in the Visualization window, which then results in that area is being expanded to optimally fill the window. This button is highlighted in blue when active and it remains active until it is clicked again.

Pan:  Enables use of the mouse to move the image in the horizontal and vertical directions. Press the left button and move the image while pressing the button.

One Image:  Displays one image in the Visualization window (i.e., the Active Image). This is the default mode when starting Aphelion. All images open in the Image Gallery will be open in this mode as a stack of images with the Active Image on top of the stack. If the One Image button is clicked when the Visualization window is in *Multiple image* mode, the multiple images will be reconfigured into a stack of images, with the Active Image on top and the image tabs in the order in which the images existed in the image array. Any image in the stack can be displayed (moved to the top) by clicking on its tab.

Multiple Images:  Displays multiple images in the Visualization window as an MxN array where M and N are specified by the MIVTRowCount (i.e., M) and MIVTColumnCount (i.e., N) parameters of the Tools→Options→Advanced→Images window (2x2 array by default). The first K images open in the Image Gallery will be used to populate the MxN array. This array will be displayed as a single panel of images having a tab at the bottom labeled Panel 1. If the number of images open in the Image Gallery exceeds K, additional panels will be created as needed.


Note: The message passing feature is available in both the One image and Multiple images modes.


Developer tools:  These tools are used in the **Developer** Task to create histograms, profiles, and regions of interest. Please see following section, *2.9.5 Profile – Histogram – ROI Toolbar (Dev version only)*.


2.9.5. Profile – Histogram – ROI Toolbar (Dev version only)

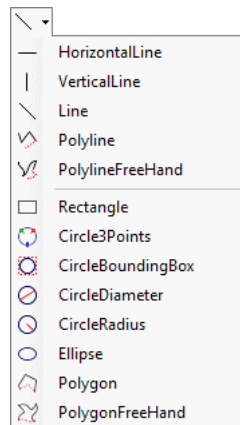


This toolbar is enabled only when the **Developer** Task is selected. It is used to compute profiles and histograms, and to define a Region of Interest ("ROI") or multiple ROIs drawn in the graphics overlay. An ROI is a structure that enables execution of an image processing function on a sub-region (aka, sub-image) of an image. While some functions can only process rectangular regions, ROIs can be defined as virtually any shape using drawing tools provided on the toolbar. A profile or histogram is displayed in real-time in window E for the selected (i.e., highlighted) line or region.

Selection button : Used to select shapes previously drawn with one of the shape tools found on the toolbar. The selection is indicated by the appearance of handles (small white boxes) on the shape's bounding rectangle (for a circle or ellipse) or on the shape's boundary line.

Select a shape by left clicking on it. To select multiple shapes, hold the **Shift** or **Ctrl** key down while left clicking the shapes. Left clicking outside the selected shapes without holding down the **Ctrl** key will cause all selected shapes to become unselected. Any single shape can be individually unselected by left clicking on it. Unselected shapes can be selected as a group by using the selection tool  and tracing a rectangle around the target shapes.

Shape button : Used to choose the shape type to be drawn (see shapes list in adjacent graphic). Straight lines can be drawn in any direction and have any length. Geometric shapes can be drawn to any size. Refer to section 2.9.5 Measurement Task, Contextual Toolbar – Interactive Drawing Tools to get a detailed description of each shape.

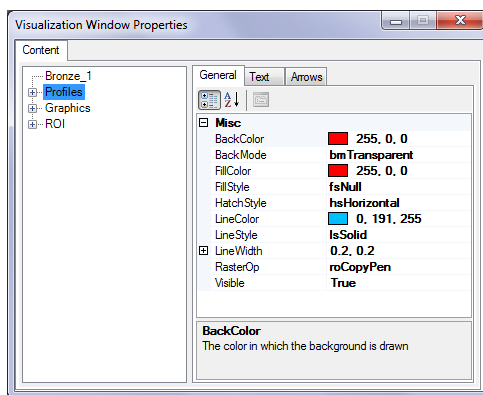


Select the shape type by clicking on the shape button as described in the paragraph below.


When a shape is drawn, it is immediately selected and its handles appear, and the action corresponding to the selected operation mode (i.e., Profile or Histogram) is automatically performed. To alter the shape drawing, drag any of its handles. The angle of a line shape can be changed by dragging either one of its handles as needed. Any shape can be moved by grabbing its interior and dragging it to the desired location.


Note: The **Shape** button has to be clicked each time a shape is to be drawn, as the **Selection** button is automatically selected after a shape is drawn.


Each individual graphic object property can be altered. Select a graphic object and right-mouse click to open the Visualization Window Properties. To enable transparency, select the FillStyle as Solid, and add an alpha value (0 to 255) in front of the three default values of FillColor. For example, if the color is red and fully opaque, no alpha value is needed (255,0,0). If the color is red and 50% transparency is desired, insert alpha = 128 in front resulting in (128, 255, 0, 0). The alpha value affects all color channels equally.

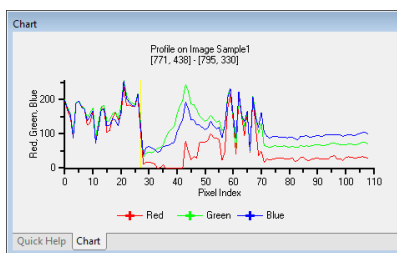



Note: The color of a drawn shape depends on the mode that was enabled when the shape was drawn. The four modes (i.e., Graphic, Profile, Histogram, and ROI) are mutually exclusive.

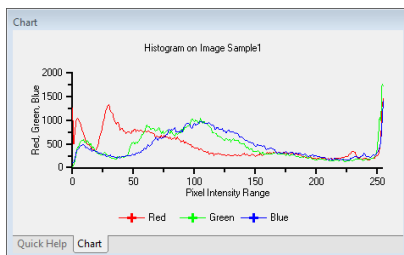
Delete button : Used to delete any shape or ROI or set of shapes or ROIs drawn in the graphics overlay using the **Shape** drawing tools. A shape or ROI must be selected before it can be deleted. Note that a shape and an ROI cannot be concurrently selected. Thus, selecting a shape will cause any selected ROIs to become unselected, and vice versa.

Graphic button : A click on this button enables the Graphic mode. All shapes drawn when Graphic mode is enabled are converted into a graphic overlay.

Profile button : Enables the **Profile** mode, which is used to compute and display in the Chart window a graph of the pixel intensity values along a straight line drawn in the Active Image. When the Profile mode is enabled, each time the user draws a new line shape or selects or modifies an existing Profile line shape in the Active Window, the profile of that line is updated in real-time in the Chart window. When the **Profile** mode is enabled, a blue box appears around the **Profile** icon on the **Menu bar**. Right clicking in the chart window displays a contextual menu that lets the user zoom in and out of a user defined region of interest in the Chart window. Message passing is active between the chart and the image. Select a range of values on the chart by pressing the mouse on the chart and holding down to define a range of intensity values. The corresponding section on the profile is highlighted with two vertical lines defining the two extremities of the section manually defined. Zoom in the chart to help refining the segment selection.




Histogram button : Enables the **Histogram** mode, which is used to compute and display in the Chart window a plot of the *number-of-pixels* versus the color or gray-scale *intensities* for pixels contained in a closed shape or along a line. When



the Histogram mode is enabled, each time the user draws a new line or closed shape or selects or modifies an existing Histogram line or closed shape in the Active Window, the histogram of that line or closed shape is updated in real-time in the Chart window. When the **Histogram** mode is enabled, a blue box appears around the **Histogram** icon on the **Menu bar**. Right clicking in the chart window displays a contextual menu that lets the user zoom in and out of a user defined region of interest in the Chart window.

Note: Clicking on one of the color band labels at the bottom of the chart window results in display of a graph only for the selected color band. Clicking outside these labels restores the concurrent display of graphs for all three color bands. Also, the chart window's contextual menu allows the user to concurrently display any combination of the available bands.

ROI button : A click on this button enables the ROI mode. Each closed shape drawn when the ROI mode is enabled is converted to a region of interest (ROI). When the **ROI** mode is active, a blue box appears around the **ROI** icon in the **Main Toolbar**.

Multiple ROIs of various shapes and sizes can be defined in an image. To add another ROI to an image, make sure the **ROI** mode is enabled. If it is not, click on the **ROI** button. Next, select the desired shape from the **Main Toolbar** and draw the ROI. ROIs are automatically saved with an image if the image is saved in TIFF or ASI format. However, ROIs are lost when an image is saved in all other formats.

Note: Any shape can be copied from one image (source) and pasted into another (target) image and converted into any mode (i.e., Graphic, Profile, Histogram, or ROI). Begin by selecting the desired shape in the source image and use the Ctrl+C sequence to copy that shape to the Windows clipboard. Next, make the target image the Active Image and then enable the desired mode for the target image. Finally, use the Ctrl+V sequence to paste the selected shape onto the new Active Image. When the desired shape appears after a few seconds, it will have the characteristics of the mode enabled for the target image and, if appropriate, the Chart window will be updated.

Help: An ROI can be used to create a new image from a portion of the Active Image. First draw the ROI on the Active Image, then use the *SubCopy* function in the *Process→Image→Utility* group to transform the ROI's contents into an image.

2.9.6. Task interface

The **Task Bar** lets the user select a task to be performed. The tasks are listed in a sequential order typical for accomplishing an image processing or analysis project. A user would typically execute them from top to bottom. But, depending on the user's needs, tasks may be skipped, repeated, or performed in a different ordering.

When a task is activated, a task-specific workspace is displayed that is composed of various interfaces. These interfaces are designed to facilitate the user's work for the imaging project step addressed by the task. Refer to section 2.10 *Tasks* for more information on the tasks available in Aphelion.

A typical work session will usually involve the following tasks:

Administrator Mode Only Tasks

- **Camera settings** to set up the acquisition system, display a live image, and capture still images (only in Administrator mode);



- **Calibration settings** to define the resolutions (only in Administrator mode);





General Tasks

- **Image Acquisition** to receive a live image stream from a camera, during which one or more still images can be snapped and captured. When no camera device is available, Aphelion can receive images stored on local or network storage media;
- **Object Extraction** to quickly filter and segment the Active Image and generate objects;
- **Object Editing** to manually amend the **Object Extraction** results using the object editing tools provided;
- **Measurements** to compute a set of measurements for objects previously extracted (see note following);
- **Report Generation** to generate user-modifiable reports in MS Excel format and to export images to the Windows clipboard; and
- **Developer** (Dev version only) to provide the user with a wide range of image and ObjectSet processing functions. ObjectSets generated in this task can be edited in the **Object Editing** Task and can have attributes computed for their objects using the **Measurements** Task.




Note: The **Measurements** Task also provides tools for drawing interactively shapes in the graphics overlay. These enable the user to create and compute ad hoc measurements for the image and for extracted and drawn objects. For complex images where the **Object Extraction** process fails, it is possible to skip the two preceding tasks (**Object Extraction** and **Object Editing**) and immediately draw objects and compute associated measurements. The interactively drawn shape objects are independent of the objects created using the **Object Extraction**, **Object Editing**, and **Developer** Tasks.

2.9.7. Visualization Window

The Visualization window is used to display and manipulate images. This window has two image array mode buttons on the **Main Toolbar**:  for the *One image* mode, which displays a single image (i.e., 1x1 array) and  for the *Multiple Images* mode, which displays multiple images as an array of images. When the *Multiple Images* mode is selected, the Visualization window is automatically reconfigured into one or more panels, each configured to display M time N images. Sufficient panels will be created so that all of the 2D images in the Image Gallery will be displayed in sequence, beginning with the left-most image. Multiple panels are stacked in the Visualization window with reference Tabs appearing in the Status bar at the bottom of the window. Any panel can be displayed by clicking on its Tab or by double clicking on one of its images in the Image Gallery.

The banner of an open image window provides the name of its image at the far left end of the banner. If an open image is also an Active Image, the letter A is inserted to the left of the image name and its banner is highlighted.

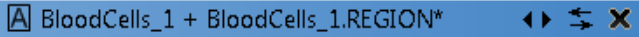
A close button is provided at the far right end of the banner. Clicking on the close button closes the image window in the **Visualization** window and removes its thumbnail from the Image Gallery. However, the image remains in Aphelion's active memory (i.e., RAM).

If there are multiple Active Images, then the banner for each of these image windows will also have a pair of opposite-pointing, horizontal arrows  displayed adjacent to the close button. These arrows indicate that the Active Images will be synchronized with respect to zooming and panning operations.

In addition to the above, the banner of a color image will have two, juxtaposed arrowhead buttons pointing left and right. These can be used to display any single color channel of that image. As these arrowheads are clicked, the name of the displayed color band appears in parentheses to the right of the image name.

If one or more ObjectSets are open in the graphics overlay and were derived from an image open in the Visualization window, the name(s) of such ObjectSets will appear in the banner of that image.

Following is an example image widow banner for a color image having one open ObjectSet.



From left to right, the listed information is:

- Boxed letter A indicates an Active Image.
- Name of the image (BloodCells_1).
- Name of an associated ObjectSet with its spatial attribute appended (BloodCells_1.REGION*). If more than one ObjectSet is named, the last named ObjectSet is always the Active ObjectSet.
- Icons used to sequence through the bands (channels) of a multi-band image. For a color image (Red), (Green), or (Blue).
- Icon showing image synchronization is active.
- Icon to close the image.

Visualization Window Contextual Menu

Right clicking in the Visualization window opens a pop-up menu. The entries in this menu vary depending on what Task is active on the Task Bar (window C). The following table specifies the contents of this pop up menu. These entries are described in the following table.

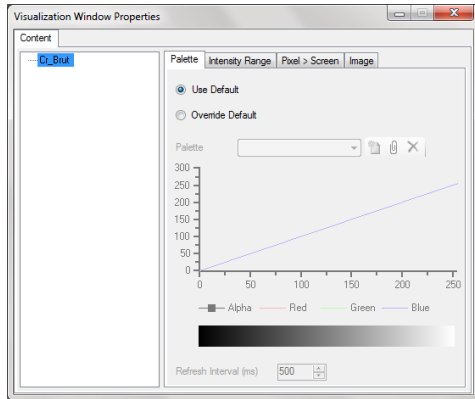
TASKS	Histogram	Statistics	Properties
Camera Settings	✓		✓
Calibration Settings			✓
Object Extraction			✓
Object Editing			✓
Measurements	✓		✓
Report Generator			✓
Developer	✓	✓	✓

Histogram – This entry computes the pixel intensity histogram for the Active Image and displays it in window E.

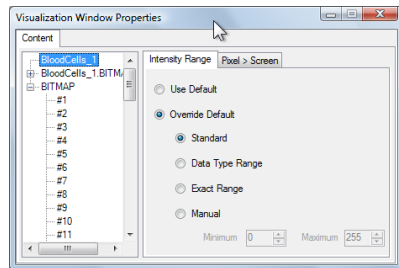
Statistics – This entry computes the minimum, maximum, mean, skewness, and kurtosis values for the Active Image and displays them in the Output window located in window B. The Output window can be cleared of prior computations and other data by right-clicking the window and choosing Clear.

Properties – This entry displays a pop-up window that provides various display settings for the Visualization window, specifically for the Active Image and any Active ObjectSets displayed in the Visualization window.

To change the display properties of the items displayed in the Visualization window, right-click in the Visualization window. Select Properties. The Visualization Window Properties window opens (see example at right). This window's left panel lists the items currently displayed in the Visualization window (e.g., images, ObjectSets).



For a 2D image, only the Active Image and its displayed ObjectSets are listed. The example shows the Active Image, one ObjectSet, with an indexed list of its objects.



For a 3D image, since more than one rendering of the 3D image can be displayed concurrently, the items list will include all renderings concurrently displayed in the Active Image window. (For an

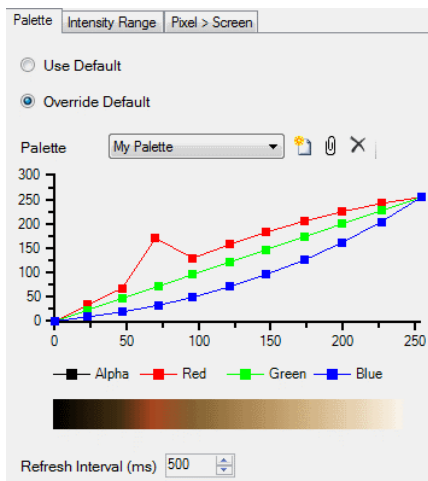
explanation on how to display multiple 3D renderings in the same window and how to change their display settings, see the 3D Image Display Extension manual.

If an ObjectSet is listed (<filename>.bitmap), double-click on its name or click on its plus sign to see its contents. A numbered list corresponding to all of the objects in the ObjectSet is displayed. Display attributes for individual objects can be changed in the General tab of the right panel. To close the ObjectSet list, double-click on the on its name or click on its minus sign.

The contents of the right panels of the Visualization Window Properties window varies depending on the type of the item selected in the left panel (e.g., monochrome image, color image, 3D image, or ObjectSet).

Palette Tab

When the selected Image is a monochrome Image, the right panel has three, stacked panels with tabs labeled: Palette, Intensity Range, and Pixel > Screen. Click on the Palette tab, and select Overwrite Default. The Palette dropdown list provides seven predefined palettes: Grey Scale, Inverse Grey Scale, Sepia, Rainbow, Saturation, Label, and Binary. To add a new palette to the list, click on the new palette button just to the right of the dropdown list. The New Palette dialog box opens. Enter a new name in the *Name* field. Any existing palette can be selected from the Copy From dropdown list and used as a template for the new palette. Next, click **OK**.

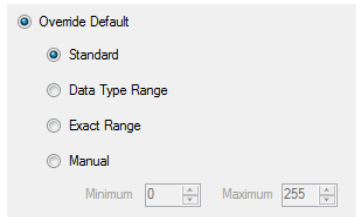


The selected palette template can be modified by repositioning control points along the graph lines for each color band. A graph line is formed by one or more straight line segments connected by control points, which are represented as small squares on the graph line. Control points can be added, deleted, or repositioned in the graphing area. To create a control point, position the mouse pointer in the graphing area, then right-click and select Add from the dropdown list, and then select the target color band. A small square appears on that color band's graph line directly above or below the pointer position. The control points can be individually dragged to form the desired graph shape. To delete a control point, right-click on the control point and select Remove, and then select the color band from which the control point should be removed.

Intensity Range Tab

The tab labeled *Intensity Range* provides various methods for determining which pixels will be displayed and what values will be assigned to the displayed pixels.

Intensity Range limits the display of pixels to those pixels whose intensity values fall within a specified range of values.

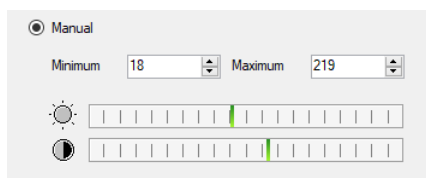


Standard is the default behavior for most common imaging software products. Pixels having an intensity value of 0 are displayed in black and pixels having an intensity value of 255 are displayed in white. Values in-between produce more or less bright shades of gray. However if the range of the intensity values exceeds [0, 255] then the Exact Range strategy is applied (see below).

Data Type Range is based on the pixel intensity values data type. For example, if intensity values are specified as unsigned, 8-bit integer numbers, the intensity range will be 0 to 255; if as unsigned, 16-bit integer numbers, 0 to 65,535.

Exact Range stretches the image histogram by assigning an intensity value of zero (black) to the pixels having the minimum intensity value in the image, a value of 255 (white) to the pixels having the maximum intensity value, and proportionately equivalent values to the remaining pixels. This yields a gray-scale image having high contrast.

Manual option lets select which intensity value will be displayed in black (minimum), and which intensity value will be displayed in white (maximum).



The two sliders available at the bottom of the window let the user adjust the image brightness and contrast. Moving the sliders updates the display in real-time. Clicking on the associated icons resets the two parameters.

Note: The brightness and contrast sliders are enabled if the *Manual* option is selected.

The *Pixel > Screen* operation, sometimes called “transfer function,” maps pixel intensities found in the image file to new values specified in a Look Up Table (or LUT). For example, pixels in an image file having intensity values less than 50 might be displayed as having intensities equal to zero. For each pixel value in an image (input value), a LUT will specify an output value for that pixel, which values may or may not be equal. Aphelion provides four transfer functions: Linear, Logarithmic, Gamma, and Modulo. The Gamma value can be adjusted if the Gamma function is selected. The Modulo function is used to display Label images.

Image Tab

If an image is selected in the left panel of this window, a list of image parameters is displayed in the Image Tab panel on the right. Some of these parameters can be modified here, while the others are only informational.

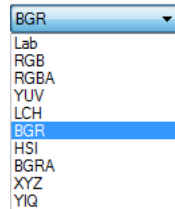
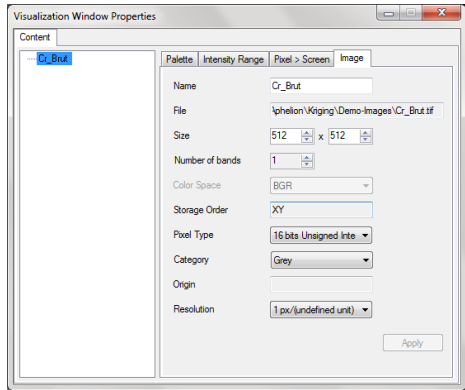
Name is the name of the image in the Aphelion interface, without its file type extension.


File is the Window's path to the image file, ending with image's *Name* plus file type extension. The value of this parameter is empty if the image is not loaded from a file nor saved in a storage volume.


Size comprises two or three values, respectively for 2D or 3D images. The values are in pixel units, with the first value as the width (X axis), the second value as the height (Y axis), and the third value as the depth (Z axis). Increasing any of these values results in adding black pixels to the non-origin end of the corresponding axis. Decreasing any of these values results in discarding image pixels at the non-origin end of the corresponding axis. Remember that the origin is the left (X), upper (Y), near (Z) corner of the image.

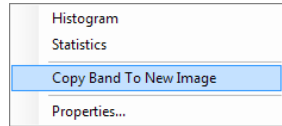
Number of bands is the number of image bands. This parameter value is determined by the image category chosen (1 band for Binary, Grey, Label, Complex, and Frequency; 2 bands for Edge; and 3 bands for Color). It is automatically set when the *Category* parameter is altered and the Apply button is then clicked.

Color Space is the color representation of the image. By default, a color image is represented in the BGR (Blue, Green, and Red) color space. The *Color Space*



parameter can be changed by selecting another color space in the pull-down list as shown beside. Refer to *6.4.6 Color Space Definitions* to get a detailed definition of each color space. The visual appearance of a color image is the same whatever the *Color Space* value, but the appearance of each individual band components will vary by *Color Space* (use the  buttons in the Visualization Window banner to display a single band of the image).

Tip: Right clicking in a single band of a color image displays a contextual menu. Selecting **Copy Band to New Image** extracts the current band into a new image. To restore the visual appearance of the color image, browse through the color bands using the  button.



Storage Order provides information on how the image is stored in memory. B stands for the band order of the color space, and XY means that the image is stored line by line. For example, if color space is RGB, the order of the bands in memory are red band followed by green band followed by blue band.

Pixel Type defines the data type of the pixels.

Category defines the image class. By default, a monochrome image has an 8 bit or 16 bit unsigned type, and a Grey category.

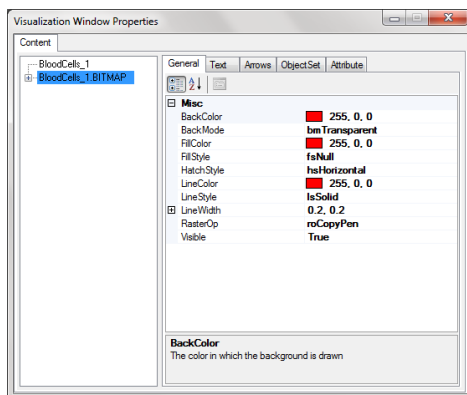
Origin is the coordinates of the pixel at the upper left corner of the image. By convention, the image origin point (x,y) for images is defined to be (0, 0) or (0,0,0) for 2D and 3D images, respectively. These origin points correspond to the left, upper corner of a 2D image. For a 3D image, the origin is the left, upper, near corner.

Resolution defines the image pixel size in real units. If the image's resolution was determined at the time of image capture and recorded in the image header, it will automatically appear in this parameter. If no resolution is displayed for this parameter, one can be selected from the *Resolution* drop-down list. If the None entry is selected, measurements will be calculated based on pixel counts.

After specifying values for the parameters, click on the Apply button to change the image properties and the display their effects on the image in the Visualization Window.

Contextual Tabs to Graphics and ObjectSets

When a Graphics or an ObjectSet attribute is selected, the right panel contains stacked panels whose tabs are labeled General, Centers, Texts, Arrows, Points, ObjectSets, Attribute, and Ellipses. Each of these panels provides a list of parameters that affect some aspect of the display of the selected Graphics or the ObjectSet in the list displayed in the left panel. The initial values are the default values set in the Tools→Options→Advanced window. Clicking on any parameter will allow the user to make changes to its value(s). Some are changed by selecting a different value from a dropdown menu or a color palette, and others by typing in new numeric values. A parameter listed with a plus sign to the left will expand when clicked to reveal its sub-parameters. Click an item with a minus sign to the left will cause it to close and hide its sub-parameters.



Tip: Press the Delete key to reset a parameter to its default value.

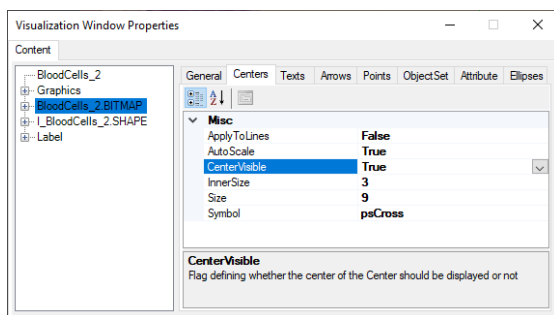
The General panel lists parameters that affect display of the Graphics or ObjectSet highlighted in the left panel. These include colors and other visual attributes.

Note: The ObjectSets are named by the ObjectSet name followed by a point and the name of the spatial attribute. The standard spatial attribute names are: BITMAP and SHAPE. However, custom spatial attribute names can be defined by user.

The Centers panel lists parameters that specify the appearance of centers drawn in the image overlay and if the display of the centers is enable.

The Text panel lists parameters that determine the font used when text is displayed and the attributes applied to the font. Setting AutoScale to True will cause the font size to change on screen in proportion to the zoom factor.

The Arrows panel lists parameters that specify the appearance of lines drawn in the image overlay, including the existence of graphics at the start and/or end of a line (e.g., arrowhead, circle, and square).



Tip: Use the Arrows panel to place graphics at the extremities of a line (e.g., add arrowheads that point to areas or objects of interest).

The Points panel lists parameters that specify the appearance of points drawn in the image overlay (e.g., dot, cross, cross hairs).

The ObjectSet Tab provides information on the ObjectSet, including its name, its file path, and the number of objects contained in the Objectset.

The Attribute Tab provides information on the ObjectSet including the spatial attribute type and the resolution. Note the resolution can be altered by clicking the arrow at the right of the resolution value and selecting one of the defined resolutions from the drop down list that pops up.

The Ellipses panel lists the parameter that specifies the style used to draw an ellipse arc.

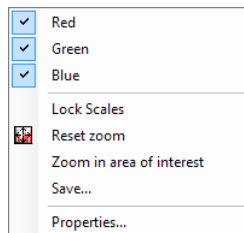
2.9.8. Chart Window

A chart computed in Aphelion is displayed in window E. The set of charts that are computed in Aphelion includes:

- Intensity profile along a line;
- Histogram of pixel intensities within an area of interest;
- Histogram of an attribute;
- Scatter plot between two attributes.

A contextual menu is available in the Chart window (see adjacent). The menu's entries are tools to enable the user to explore the information provided in the chart. These tools include the ability to:

- Display any combination of the image's color bands;
- Lock the vertical and horizontal scales of the chart to prevent their changing when the data are updated;
- Zoom in to see finer detail in the data;
- Reset the chart to its original state;
- Save the chart as an XML file including the chart data and settings for future use in another program (e.g., C#);
- Access and alter the chart's display properties.



Message passing is available between a Profile chart and a corresponding profile line shape drawn on the image. Click on the profile graph in the Chart window to mark a reference point on the graph, denoted by a small +. A short, perpendicular line will appear on the drawn line shape at the location corresponding to the + in the Chart window.

A section of the profile graph can also be referenced by placing reference marks (+) at the two extremities of the section along the graph. Place the mouse pointer at one extremity, hold down the left mouse button and then drag and drop the mouse pointer on the other extremity. The + mark will appear at the section extremity points and the chart area between those points will be shaded. At the same time two short perpendicular lines will intersect the drawn line shape at points that correspond with the section extremity points on the graph.

Message passing is also available between Histogram chart and the measurement grid, and the ObjectSet overlaid on the image displayed in the Visualization window. Define a section on the histogram by dragging the mouse along the horizontal axis of the histogram. The corresponding objects belonging to that section are highlighted in blue in the grid.

2.9.9. Image Gallery Window

The Image Gallery window contains a thumbnail representation of each image currently loaded (i.e., opened) in the Aphelion environment. This window enables the user to quickly find an image and display it in the Visualization window by double-clicking its thumbnail. If a 3D image has been loaded in the Aphelion environment, then a 3D frame is displayed around the image's thumbnail. To display the 3D image in the Visualization window, select the Show entry in the thumbnail's contextual menu, and then the desired rendering method.

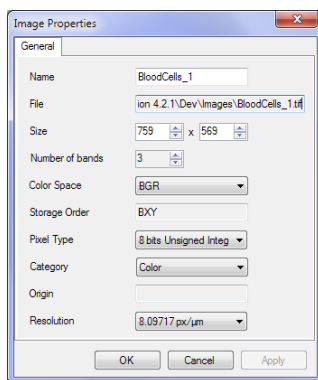
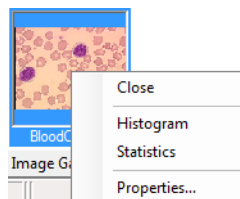
The contextual menu associated with the image thumbnail includes the following entries:

Close: Closes the image. The image is removed from the visualization window, and if it was created during the work session, then a window pops up prompting the user to save the image.

Histogram: Computes the histogram of the whole image and displays it in the Chart window located in window E.

Statistics: Computes the minimum, maximum, mean, standard deviation, skewness and curtosis of the image and displays these values in the Output window located in window B. If the image is a color image, then these values are displayed for each color band.

Properties: Displays the properties of the image in a window, as shown beside.



Note: Refer to the description of a similar window in the *Image Tab* section.

Tip: To change the image color space, pull down the *Color Space* list, and select a new *Color Space*. Then click on the **Apply** button to apply the change.

2.9.10. ObjectSet Gallery Window

The ObjectSet Gallery window contains a common thumbnail representation (🖼️) for each ObjectSet or set of Interactive shapes loaded (i.e., opened) in the Aphelion GUI. This window enables the user to quickly find an ObjectSet and display it in the Visualization

window by double-clicking its thumbnail. There are three methods to generate an ObjectSet:

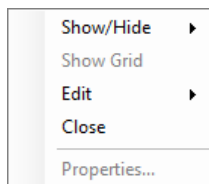
- An ObjectSet created in the **Object Extraction** Task. Its name is the name of the image from which it was extracted;
- An ObjectSet created in the **Object Editing** Task. If there is not an Active ObjectSet when this task is used, the first object drawn will cause an ObjectSet to be created and it will be given the name of the Active Image. Otherwise, the drawn objects become members of the Active ObjectSet;
- An ObjectSet created in the **Developer** Task using its available functions. The ObjectSet's name is the name given by the user in the Output ObjectSet dialog.

Note: The Interactive shapes that a user draws while in the **Measurements** Task are not objects and do not form an ObjectSet. However, many Aphelion operations treat a set of Interactive shapes like an ObjectSet. Where there are differences in treatment, the differences will be noted.

A set of Interactive shapes takes the name of the source image for which they were created. The string “I_” is added at the beginning of the image name (e.g. “I_MyImage”).

Right-clicking on an *ObjectSet* thumbnail opens a menu as shown below.

Close: Removes the ObjectSet from the ObjectSet Gallery, although the ObjectSet remains in Aphelion's memory until the user exits from Aphelion.



Show/Hide: Displays the ObjectSet in the Visualization window on top of the Active Image. Double-clicking on the ObjectSet thumbnail also has this effect. The Show/Hide entry has a submenu that enables the user to select the spatial attribute (e.g., *Bitmap*) to be displayed.

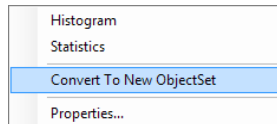
Show Grid (in **Developer** Task only): Displays in window B the grid(s) associated with the ObjectSet. The displayed grids are stacked with the Image Gallery and the ObjectSet Gallery and have identifying tabs.

Help: Only one grid of each type (Object Measurements, Object Global Measurements, Interactive Measurements, and Interactive Global Measurements), when computed, is displayed, even if more than one grid of each type has been computed, except in the **Developer** Task. The *Show Grid* entry in the contextual menu of an ObjectSet, available in the **Developer** Task only, allows displaying the grid of your choice, and all displayed grids are stacked.

Edit: Lets the user annotate the ObjectSet. It automatically switches to the **Object Editing** Task and enables all drawing tools as defined in *2.10.4 Object Editing Task*.

Properties: Displays the properties of an ObjectSet.

Tip: An ObjectSet can be quickly generated from a binary image. Right-clicking on the binary image displays a contextual menu. Select the entry **Convert to a New ObjectSet** to generate an ObjectSet derived from the binary image.



2.9.11. Status Bar

Image: BloodCells_2 | (imported resolution) - 1 px = 0.1235 micron | (308, 289) = 255, 212, 178

The Status bar, located at the bottom of the user interface, displays the following information, from left to right:

- Name of the Active Image or Active ObjectSet, depending whatever the Visualization window or a Grid window is selected;
- Resolution of the Active Image or Active ObjectSet whose name is displayed on the left;

- Mouse pointer coordinates (e.g., H=308, V=289) and pixel intensity values (e.g., R=255, G=212, B=178) at the displayed coordinates in the Active Image.

The pixel coordinates are always relative to the image under the mouse pointer, with the upper left-most pixel at 0,0 for a rectangular image. For color or multi-band images, each intensity value corresponds to a specific band (Red Green, Blue for color images and amplitude, phase, dx, dy for frequency images).

2.10. Tasks

2.10.1. Administrator Settings Tasks

The **Camera settings** and **Calibration settings** Tasks are the tools with which an Administrator specifies the value of acquisition control parameters that affect all users of Aphelion. Specifically, these parameters assure proper set up of image acquisition devices.

Upon successful entry of the Administrator password, a new version of the **Task Bar** appears that contains two new task icons corresponding to these settings tasks. These two settings tasks are described in detail below.

Important note: A user who has Administrator rights for Aphelion must also have Windows operating system rights to read/write the file **AphelionDev.config** for Dev or **AphelionLab.config** for Lab, located as follows:

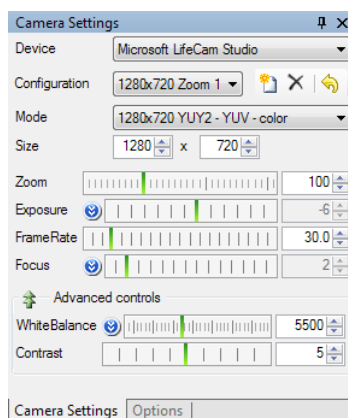
	Aphelion Lab	Aphelion Dev
7, 8, & 10	<p>“C:\ProgramData\ADCIS\...</p> <p>...Aphelion Lab\4.x.y\AphelionLab.config”</p>	<p>...Aphelion Dev\4.x.y\AphelionDev.config”</p>

Camera Settings Task

The **Camera settings** Task provides interfaces used by an Administrator to specify parameters that configure image capture hardware (e.g., camera) to be used for the target project. Selection of the **Camera settings** Task opens a stack of two _jicontrol interface windows in window D and one display interface in window E.

Camera Settings (Tab) Interface


This interface is used to specify the active camera for the project and set its initial control parameter values. The *Device* parameter is used to identify the camera to be used for the project. If more than one camera is connected to the computer, then the user can select the desired camera from the *Device* drop-down list by clicking on its list display arrow. If no compatible camera¹ is connected to the computer, then the *Device* list will be empty.



Note: The *Device* parameter can only be defined in the **Camera Settings** task, which is only available in Administrator mode. Camera settings, which were previously selected by the Administrator, cannot be changed in the **Image Acquisition** Task.

The *Configuration* drop-down list is used to define a configuration file that contains all parameters defined in the window. It is used to associate a configuration with a device and a resolution. Click on the

¹ Refer to the sections *2.4.6 Camera interface installation* and *6.6 Hardware interfaces* for camera compatibility.

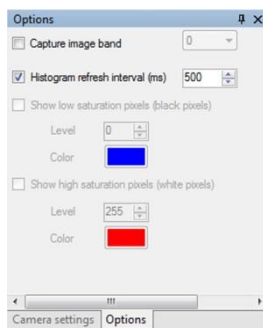
New icon to define a new configuration file. Every modification is automatically saved in the current configuration. The  button allows to undo the last modification.

The *Mode* parameter specifies the image type (color or monochrome), the number of bits per pixel (8 or 16), the number of pixels per row and per column, and the acquisition rate (number of frames (i.e., images) per second captured by a video camera). If the camera has multiple modes, the user may select the appropriate mode for the project from the *Mode* drop-down list.

The remaining parameter values displayed are those presets for the selected *Device* and *Mode*. These can be adjusted by the user for the current project. The values defined using the Camera settings interface will become the default values for the **Image Acquisition Task**.

Options (Tab) Interface


The Options window (see right) opens when selecting the Options tab. It provides tools to control the quality of the image acquisition. The first checkbox provides the option to capture a specific color band (e.g., specify 0 for Red, 1 for Green, 2 for Blue). The second checkbox enables specification of the refresh interval of the histogram displayed in window E. The last two checkboxes, which are only available for monochrome images, are used to specify a graphics overlay in which low saturation pixels and high saturation pixels are displayed in colors selectable by the user.. The counter boxes can be used to modify the two pixel intensity saturation points, which are set to 0 and 255 by default.



Calibration Settings Task

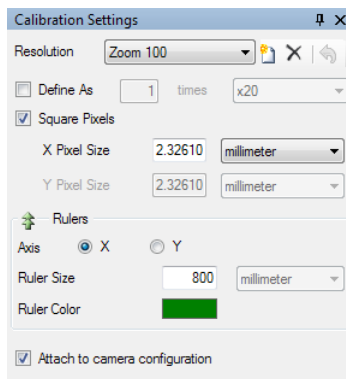
The **Calibration Settings** Task enables an Administrator to specify calibration parameters that are used to convert measurements from pixel units to real world units (e.g., microns). After these parameters are set, the measurement conversion happens automatically during the image analysis process.

The end result of the **Calibration settings** process is the computation of the acquisition system's resolution (i.e., camera, microscope, lens, and other optical components). This is done by determining the ratio between a known, real world distance and the number of pixels corresponding to that distance in a captured image.



To define a resolution, first the user must capture an image of an object of known dimensions (e.g., micrometer scale). Do this using the **Camera settings** Task and the **Snap** button on the task's **Contextual toolbar** (right edge of Workspace area). The “snapped” image will appear in the Visualization window. Return to the **Calibration settings** Task and click on the **New** button () located between the **Resolution** drop-down button and the **Delete** button. In the box that pops up, enter a name for the calibration setting (e.g., to identify the acquisition system configuration) and then save the name.

Tip: The Live image can be used to define a resolution. Select the Live mode and then select the **Calibration settings** Task and process as described for a still image, except you can move the gauge under the camera to align it with the displayed ruler.

When an image acquisition system is symmetric in the X (horizontal) and Y (vertical) directions, the system is said to have *square* pixels. In this case, calibration needs only be done for the X direction. If the



system is asymmetrical, then calibration must be performed for both directions. If the system is symmetrical, then checkmark the *Square Pixels* box; if it is asymmetrical, leave the box blank.

Next, a horizontal line is displayed as an overlay in the Visualization window. This line can be positioned and resized to precisely coincide with a known, horizontal dimension of the reference object. Be sure that the *Axis* radio button for *X* is selected and that the *Ruler Size* drop-down box is displaying the correct dimensional unit. Next, enter the real-world size of the reference object's horizontal dimension in the *Ruler size* box. The pixel size is now automatically computed and displayed in the *X Pixel Size* box. If you did not check the *Square Pixel* box, you will now have to calibrate in the *Y* direction by clicking on the *Axis* radio button for *Y* and then repeat the calibration procedure using the vertical line that appears on the screen. When the calibration steps have been completed, validate the calibration information (resolution) by clicking on the  button. In case you wish to redefine the current calibration, then click on the  button. A validated calibration is saved either when exiting Aphelion and saving the configuration settings, or when invoking the menu **Tools→Save Administrator Settings**, or when clicking on the **Yes** button when exiting the **Calibration Settings** task.

Click on the *Attach to camera configuration* option to associate the current calibration settings with the current *Device* configuration selected in the **Camera Settings** task. This option is only enabled when the calibration settings are defined for live images.

Important note: A saved resolution is specific to a) the camera and other optical equipment with which an image was captured, b) the distance between the captured object or scene and the camera, and c) the Mode of the camera when that image was captured. This resolution will not be valid if any of these factors change and cause a change in pixel size. If there is any doubt that the pixel size has not changed, the calibration should be performed again.

The Aphelion concept of a *camera configuration* requires the user to define an extended configuration that includes parameters such as the

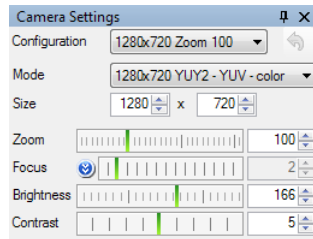
lens used to capture the image, the distance between the camera and the object, and other parameters that are not dependent on the camera. The user must select a camera configuration depending on all these parameters to define calibration settings. A camera configuration must be defined for each setting of the acquisition system.

2.10.2. Image Acquisition Task



The **Image Acquisition** Task provides user tools for acquiring images with a camera connected to the computer.

Through the Camera settings control interface, the user can alter camera settings. The settings available to the user depend on the camera selected and the settings authorized to users by the Administrator. The graphic above shows an example. For additional camera settings information, see the **Camera settings** Task in section 2.10.1 *Administrator Settings Task*.



The **Image Acquisition** Task also provides three display interfaces: the Visualization window that displays the Live or captured image, the Image Gallery that displays all open images, and a Histogram window. The Histogram window displays the histogram for the image currently being received by the camera. As the user changes camera settings, those changes can be seen as changes in the histogram.

Tip: Image Acquisition can only be performed when the current image displayed in the **Visualization** window is the Active Image (A is displayed on left of the window banner). Tool icons in the contextual toolbar are active in this case.

An image histogram plots the number of pixels (Y axis) that have a given intensity value (X axis). The intensity value ranges from 0 to 255 for a camera using 8-bit mode. Thus, increasing the brightness

setting shifts the histogram plots from the left (pixels with lower intensity values) to the right (pixels with higher intensity values). While decreasing the brightness setting has the opposite effect on the histogram.

The *Gain* setting determines how much the signal delivered by the camera sensor is amplified. The signal/noise ratio is lower for a correctly exposed image with a high gain than for a correctly exposed image with a low gain. Increasing the gain stretches the histogram of intensities to the right, until saturation of the signal occurs.

The *Shutter* setting determines the length of time the camera holds the shutter open, which affects the image exposure. The higher the value, the brighter is the image. The value has to be less than the time between two image captures (i.e., the inverse of the number of captured images per second or capture rate).

A shading correction can be applied to the live image to enhance its exposure. To define an image as the Dark Current (DC) image, or the Flat Field (FF) image, click on the corresponding icon in the vertical toolbar. Once an image has been defined as the FF or DC image, a specific icon is displayed in the image banner. To apply a live shading correction on the received image, click on the corresponding icon.



Tip: To improve image quality, if the image is underexposed: 1) increase illumination of the scene, if possible, 2) increase the image exposure by increasing the shutter setting value, and 3) alter the gain value as needed. Taking these steps in this order helps to limit deterioration of image quality (i.e., limit the reduction of signal/noise ratio). If the image is overexposed: 1) decrease the gain value to have a suitable exposure, and if the image is still overexposed, 2) decrease the illumination of the scene, if possible, and 3) decrease the shutter setting value until the image is correctly exposed.

Important note: There are two ways to apply resolution profiles to images:

Resolution Tool Button – When a resolution is selected using this tool, that resolution is applied only to the Active Image. This button is on the **Main Toolbar**.

Default Resolution – After the *Default Resolution* is set (**Tools→Default Resolution**), it will be automatically applied only to images as they are snapped.

REMEMBER – The resolution must be changed each time the acquisition system is altered (e.g., a lens changed).


2.10.3. Object Extraction Task

The **Object Extraction** Task provides a pre-defined sequence of image processing functions that can effectively extract objects from a wide range of image domains. The user controls this processing sequence by specifying parameter values for the functions and observing a real-time preview of their object extraction results.

This task provides the user with specialized interfaces in windows D and E. Window D contains a set of three, sequential panels labeled as Object Extraction. It is with this window that the user specifies parameters for the object extraction processes. Window E is labeled Preview and it provides a real-time preview of object extractions resulting from the parameters chosen by the user.

The Preview window only displays that area of the Visualization window framed by a cyan rectangle. After clicking on this rectangle, the user can reposition it over a representative area of the image. The size and proportions of the rectangle can be adjusted, but only within the constraints of the Preview window's size and proportions. Since the Aphelion GUI gives its users great flexibility in configuring the size and proportions of its windows, it is possible to increase the size of the Preview window and then increase the size of the cyan rectangle accordingly. Note, however, that increasing the size of the Preview window may adversely affect its real-time character.

Objects are extracted in the form of Bitmaps. Parameters the user specified in the Object Extraction panels determine how the image's pixels will be aggregated to form those Bitmaps (i.e., objects). Red outlines of the objects are displayed in the Preview window as a graphics overlay on the previewed portion of the image. When a parameter or the preview frame is changed by the user, the effects are shown immediately in the Preview window as changes in the object outlines.

When the user is satisfied with the parameters chosen, clicking on  causes the object extraction processes to be applied to the entire image and the outlines for all extracted objects to appear as a graphics overlay in the Visualization window. The user can iteratively vary parameters, check the Preview window, and then see the results applied to the full image.

Object Extraction Parameter Settings (window D)

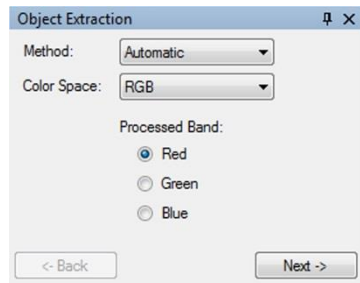
Two methods of object extraction are provided: Automatic and User-assisted. Both methods use a three panel sequence to specify parameter settings prior to applying the method to an image. The panels 1 and 2 are different for the two methods, but panel 3 is the same for both methods.

Note: When the Object Extraction task is selected, if the active Method is not the method you want, use the **Back** button to return to panel 1 and change the method type there using the Method dropdown menu.

Automatic Method

Panel 1 - If the active Method is not *Automatic*, select *Automatic* from the Method dropdown menu.

If the Active Image is a gray-scale or binary image, Panel 1 will have no parameter settings. Click on **Next**.



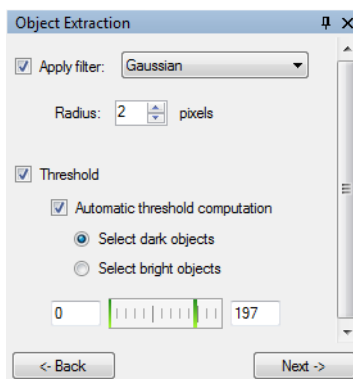
If the Active Image is a color image, the user specifies the Color Space in which the object extraction is to be performed by selecting from the Color Space dropdown menu. Next, select the band to be processed by clicking one of the radio buttons listed under Processed Band. Usually, best results are achieved by selecting the band in which the target objects have the most contrast with their backgrounds in the image. This contrast can be seen in the Preview window. Then click on the **Next** button to open the second panel of the **Object Extraction** Task.

Panel 2 - This panel provides parameter settings for two functions:

- *Smoothing Filter* to compensate for excessive image noise
- *Threshold Segmentation* to identify objects in the image based on pixel brightness.

If the user selects the *Apply filter* checkbox, a Gaussian filter is performed. This filter calculates a weighted average of the pixel values within a neighborhood whose size is determined by the *Radius* counter value in the dialog box. The intensity of the center pixel in the neighborhood is assigned that weighted average value. The higher the radius value, the greater the smoothing effect on the image, and the blurrier the resulting image will appear. The smoothing effect reduces the impact of noise in the image, but it also alters the position of object boundaries.

If the user selects the *Threshold* checkbox, a threshold segmentation will be performed that will identify objects based on their brightness or darkness. The user can choose either automatic or manual setting of the lower and upper thresholds for pixel brightness. If the user selects the *Automatic threshold computation* checkbox, the user must next choose either *Select dark objects* or *Select bright objects* by clicking on the associated radio button.



Aphelion will then calculate threshold settings based on intensity values of the pixels displayed in the Preview window. Only pixels whose intensity values fall between these thresholds will be assigned to objects.

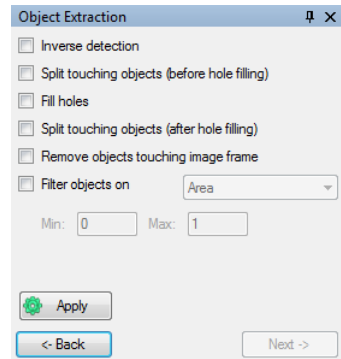
However, if the user manually changes either of the threshold values, the *Automatic threshold computation* checkbox is cleared, and the *Dark* and *Bright* objects options are disabled. Threshold values can be manually changed by editing the number in the threshold boxes or by dragging the vertical green lines displayed on the dial, left line for the lower threshold and right line for the upper.

Note that whenever the filtering or threshold parameters are changed, the results are immediately displayed in the Preview window.

Note: When Automatic threshold computation is selected, the min and max threshold values are computed based on the contents of the Preview window. Thus, as the area displayed in the Preview window is changed, the min and max values will change accordingly. When the **Apply** button is pressed in Panel 3 (see following section) the min and max values for the last Preview window are used for the entire image.

Panel 3 - Object Extraction's third panel is identical for both *Automatic* and *User-assisted* methods. It provides further opportunity for refining the objects extraction process. When the extracted objects are viewed in either the Preview or Visualization window, one might see that some objects are touching or have holes in them. Also, some objects may only be partially displayed because they intersect with

the image frame. These conditions might limit the quality of the object extraction results. For example, touching objects might be extracted as a single object. Partially displayed objects will distort extraction statistics. Panel 3 provides a sequence of functions that



complement the Panel 2 functions and can significantly enhance the object extraction results.

Checkboxes are provided for selecting processes for filling holes in objects, splitting touching objects, removing objects that are touching the image's frame, and filtering objects (i.e., removing them) based on one of its attribute values. Note the selected processes are applied sequentially from top to bottom.

Inverse detection – The result of the detection after applying the operations available in Panel 2 is inverted. In other words, the Not of the detection is computed and used as the input of the subsequent process. Note that this inverting process is not observable in the Object Extraction Task.

Fill holes – A hole is an arbitrary set of contiguous pixels located totally in the interior of an object that are not in the object's Bitmap. Generally, holes are either part of the object or are an image artifact that obscure or alter that part of the object in the image. The user must decide if the holes should be treated as part of the objects that contain them. Selecting the *Fill holes* process adds into the object's Bitmap the pixels that compose the hole(s) in the object. While checking the *Fill holes* box will cause all holes to be filled, this process also affects the results from the *Splitting touching objects* process (described next).



Figure 2.10-1: Left object includes one hole. Right object has no hole because the white area inside the object is not totally surrounded by the object

Split touching objects – When objects are touching or overlapping in an image, the *Filter and Threshold* processing will likely cause them to be segmented as a single object. To get the best results, such objects need to be split into separate objects. The two *Split touching objects*

processes will define a boundary line between touching/overlapping objects transforming the single object into its elementary components.



Figure 2.10-2: Left object is divided into two objects by the white boundary while the right object remains a single object when the Split touching objects processing is applied

Results from the two alternatives for splitting touching objects can differ significantly based on the source image and if and when the *Fill Holes* option is performed. The combinations of functions possible with the first three checkboxes are:

Split touching objects (before hole filling) – First the touching objects are split, then all holes are filled provided that the *Fill holes* box is checked. If the *Fill holes* box is not checked, then only the *Splitting touching objects* operation is performed.

Split touching objects (after hole filling) – First, provided that the *Fill holes* box is checked, all holes are filled and then the *Split touching objects* operation is performed.

The following table describes the possible behaviors of the checkboxes related to hole-filling:

Table 2.10-1: Results of the segmentation according to the processing options

SPLIT TOUCHING OBJECTS CHECKED?	FILL HOLES CHECKED?	RESULTS
Yes (before hole filling)	Yes	Split then fill
	No	Split only
Yes (after hole filling)	Yes	Fill, then split
	No	Split only
No	Yes	Fill only
	No	None

Remove objects touching image frame – An object is said to be touching the image frame if any pixel in the object's Bitmap is on the boundary of the image. This process simply deletes that object's Bitmap.

Filter objects on – Filtering an object is the process of deleting that object based on a geometric property of the object. After the check-marked processes described above have completed, the *Filter objects on* process is executed, provided that it has also been check marked. The *Filter objects on* process is applied based on the criterion selected from its drop-down menu and the *Min* and *Max* measurement values specified. The definition of these measurements can be found in paragraph 4.2. *Object Measurements*.

For example, to remove small objects whose area is less than 500 pixels, select *AREA* as the measurement, and enter 500 in the *Min* box and the maximal object size in the *Max* box. The maximal object size is usually the size of the image, 1 million pixels for a 1024x1024 image. If the image is calibrated (has a resolution) then the Min/Max values should be entered in real-world units rather in pixels.

Tip: The order of the *Split touching objects...* and the *Fill Holes* processes can have a significant impact on the result of the object extraction. If objects are spread over the image, and if there are holes inside some of these objects due to the segmentation or the presence of other objects with different pixel intensities, then first perform a *Fill Holes* operation and next perform the *Split touching objects (after hole filling)* operation.

If objects appear to be clusters of smaller objects with holes inside those clusters due to gaps between touching objects, then first perform a *Split touching objects (before hole filling)* operation and next a *Fill Holes* operation. In the latter case, filling the holes first causes the splitting operation to make unusual (but explainable) errors.

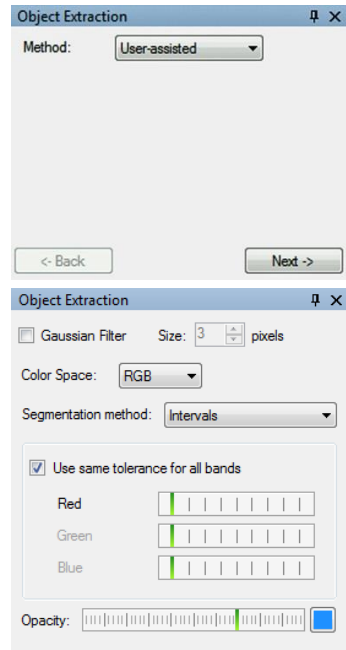
User-assisted Method

The User-assisted Method for **Object Extraction** provides the user with four segmentation methods, one of which is included with the Aphelion Dev product and the other three are available in the optional Dev extension called Color Segmentation. The included segmentation method is called Color Interval and it is described in the following paragraphs.

The segmentation methods included in the optional Color Segmentation extension are described in section 6.4 *Color Segmentation Extension* of this user guide. The three methods are called Color Distance, Region Growing, and Morphological Partition. While Color Interval is a generally useful technique for segmentation of color images, the three additional methods significantly enhance Dev's object extraction capabilities for a wide range of image domains. Refer to the Quick Help information displayed in Window E of the user interface to learn more about the segmentation methods that are available and the settings of associated parameters.

Panel 1 - If the Method selected is not *User-assisted*, choose *User-assisted* from the Method dropdown menu. There are no other parameter settings for this panel. Click the **Next** button.

Panel 2 - Four different segmentation methods are available to the user from the Segmentation method dropdown menu. The contents of this panel will change depending on the segmentation method chosen. Three parameters are common to all four methods and they are described next.



Gaussian Filter - This is a smoothing filter that is used to compensate for excessive image noise. If the user selects the *Gaussian Filter* checkbox, a Gaussian filter is performed. This filter replaces the color intensities of each pixel with the weighted average of the color intensities of the pixels in a circular neighborhood whose radius is the number of pixels specified in the Size parameter and whose center is the modified pixel. The larger the radius, the greater the smoothing effect on the image, and the blurrier the resulting image will appear. The smoothing effect reduces the impact of noise in the image during the segmentation process. But, it also alters the position of object boundaries.

Color Space – If the Active Image is a color image, the user specifies the color space in which the object extraction is to be performed. The color space is selected from the Color Space dropdown list which provides these options: RGB, HSI, Lab, YUV, LCH, YIQ, and XYZ.

Clear Selected Regions – Delete regions that are currently defined after performing a manual segmentation.

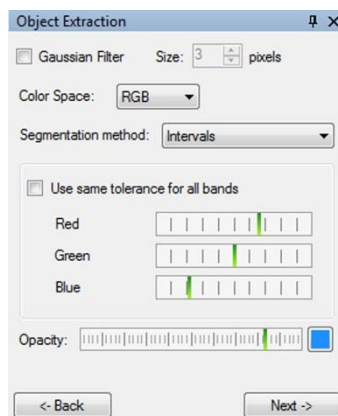
Opacity – Each object found in an image is represented by a region of color overlaid on the source image. The Opacity slider control is used to specify the degree to which the source image can be seen through the graphics overlay. Clicking on the color button seen at the right side of the slider enables the user to select from a palette of colors for the overlay.



Segmentation method – This parameter is a dropdown list containing four segmentation methods. The first method, Color Interval, is always available in Aphelion Dev. The three other methods are only available in the optional, Color Segmentation Extension. Depending on which method is selected by the user, the list of parameters displayed changes. The term reference point is used in the segmentation method descriptions. A reference point is a pixel neighborhood the user selects by clicking in the interior of a region of interest in the Active Image. The size of the neighborhood can range from a single pixel to

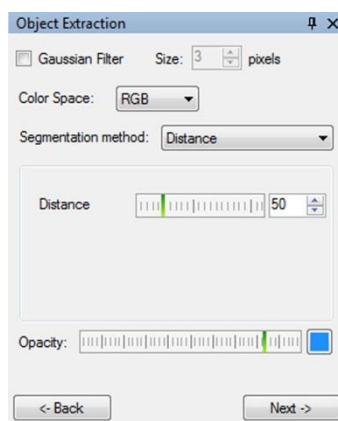
multiple pixels, depending on the settings found at **Tools→Options→Advanced→Behavior→ObjectExtraction**.

Method: Interval – This method is based on the processing of the three color bands independently. The color value is defined by clicking on a reference point inside an object to be detected. A threshold is then performed using the color band values of the reference point, plus and minus the respective band tolerance values defined by settings of the three color band sliders. A checkbox is provided that causes the lower two sliders to be locked to the setting of the top slider. The Opacity controls are explained separately below



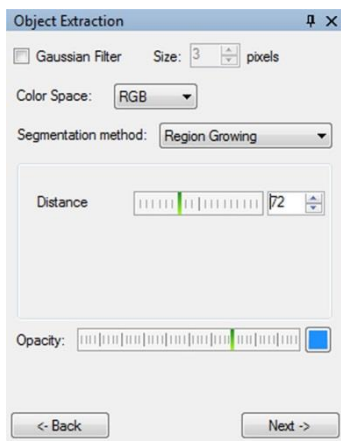
Note: It is often the case that the interesting objects in an image have more than one significant color interval. After selecting the first reference point and setting the interval sliders, additional color intervals can be added to the segmentation. This is done by control-clicking on additional reference points as needed. Thus, each added color interval forms a union of intervals with the first color interval.

Method: Distance – This method defines an object as being a set of connected pixels such that each pixel is less than or equal to a specified color distance from a reference point. The user specifies the distance value by adjusting the Distance slider. Next the user clicks in the interior of an object to specify a reference point in the object. Based on the color of the



reference point and the Distance setting, all pixels in the image that are within the specified color distance of the reference point will be marked as part of an object. The Distance slider can then be adjusted to include more or fewer pixels as being part of objects. If the object interiors have more than one color of significance, additional reference points can be specified to increase the number of pixels that meet the color distance requirement to a reference point. This is done by holding down the control (Ctrl) key while clicking to specify another reference point.

Method: Region Growing – This method of segmentation is based on manually specifying object seeds inside objects of interest using a mouse left-click or specifying non-object areas using a shift-left-click. Each seed point is an initial region in the image of usually a few pixels. The color of an initial region is the average of the pixels included in that initial region. Such seeded or initial regions are grown larger through the user's changing the color Distance parameter or placing additional object and non-object seeds on the image. The region growing algorithm processes each seeded region in sequence, adding to the region those pixels adjacent to the region's boundary pixels and that are not part of another seeded region, and whose color is within the Distance value from region's average color. This sequential processing of seeded regions is repeated until no pixels remain that are qualified to be part of one of the seeded regions. The user continues the interactive process of placing seeds in object and non-object regions until all of the desired objects are properly extracted and no non-object regions are extracted.

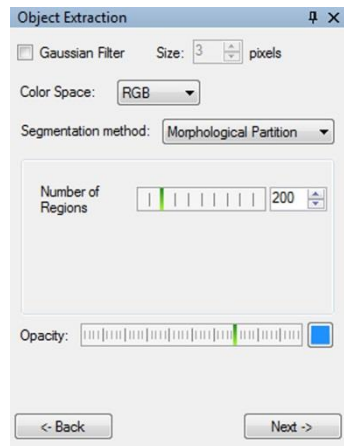


Method: Morphological Partition – This segmentation method is based on a morphological watershed operation that partitions an image into N regions such that each regional boundary line corresponds to an image edge (i.e., a gradient sign change in a three by three neighborhood). The *Number of Regions* parameter defines the maximum number of regions to be partitioned by the operation.

When the mouse pointer is moved into a region, the corresponding area in the object overlay turns green to preview the object. It remains green until the mouse pointer is moved out of the region.

The user must manually select all of those regions that correspond to objects of interest in the image. This is done by left-clicking or control-left-clicking in a green object preview. When the mouse pointer is moved from the green object preview after its corresponding object has been selected, its color changes to the color indicated by the Opacity color box.

If an object selection was done with a left-click, all previously selected objects become unselected. If an object selection is done with a control-left-click, all previously selected objects remain selected. To unselect an individual object, control-left-click that object. To unselect all selected objects, left-click in any object or region, which leaves that region's object selected. Then control-left-click that object to unselect it.




Note: Refer to section 6.4 *Color Segmentation Extension* for more information about the four segmentation methods and the color space definitions.

Panel 3 - This panel is identical to the Panel 3 described in section 2.10.3 *Object Extraction Task - Automatic Method*.


Note: By default, objects generated in the **Object Extraction** Task are defined in 8-connectivity. In other words, for the same object, neighbored pixels are either connected side by side or a corner. Object connectivity can be modified by editing the *ObjectExtract→ConnectivityGraph* parameter in the Advanced tab of the **Tools→Options** menu.

2.10.4. Object Editing Task

The **Object Editing** Task enables the user to improve on the **Object Extraction** Task results by manually altering those results. It can also be used on ObjectSets generated in the **Developer** Task or to create a new ObjectSet starting from an empty one. The **Object Editing** Task's **Contextual toolbar** provides editing tools that enable the user to split touching objects, connect (i.e., merge) unconnected objects, modify object boundaries, delete objects, and create new objects. When this task is selected, the objects outlined in the graphics overlay are automatically filled-in. An icon () on the **Object Editing** Task's **Contextual toolbar** toggles the objects between filled and not filled states.

Tip: Zooming in the image will aid in drawing more accurate objects.

Object Editing Contextual Toolbar – Following is a description of the **Object Editing** contextual toolbar.

-  **Select:** Used to select an object. Point at an object then left click. The selection is indicated by an outline of the object's bounding rectangle. To select multiple objects, hold the **Ctrl** or **Shift key** down while left clicking the objects. Alternatively, hold the left mouse button down and draw a rectangle encompassing or touching objects to be selected. Left clicking anywhere other than on a selected object without holding down the **Ctrl** or **Shift key** will cause all previously selected objects to

become unselected.



Draw: Used to modify objects or draw new objects (add points, lines, curves, or polygons depending on the geometry tool selected). By default, *Freehand Polygon* is selected.



Erase: Used to modify or delete objects (remove points, lines, curves, or polygons depending on the geometry tool selected). By default, *Freehand Polygon* is selected.

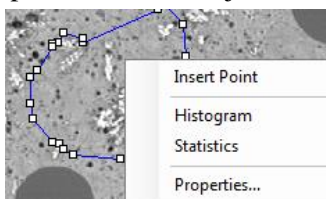


Bucket: Fills the drawn object.

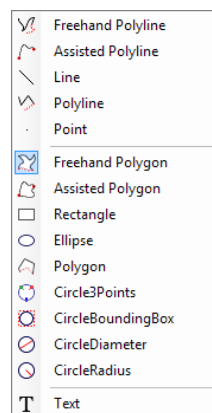
The following geometric tools are used in conjunction with the **Draw** and **Erase** tools to edit a Bitmap. Those tools need to be selected first. Click on the **shape** icon first to pull down a list of available drawing tools.



Free-hand Polyline: Draws or erases a curved line. Click on the drawn object with the Select tool to display control points on the object boundary. Right-



clicking then opens a contextual menu to let the user insert /remove points.



Assisted Polyline: Helps the user drawing or erasing a curved line. The drawing is automatically adjusted to the sharpest (most significant) edge and it then follows that edge. Left click to drop a point when the curved line is diverging too much from the edge. Double click at the end of the drawing to complete the drawing.

Note: After clicking on the first point of the shape, Aphelion Dev computes the optimal path. An hour glass icon is displayed during the computation.



Line: To draw or erase straight lines. Click on the icon just below to specify the line thickness.



Polyline: To draw or erase a polyline. Left click to define a vertex between two straight lines. Double click at the end of the drawing to complete the drawing



Point: To draw or erase objects made of one or more pixels. Click on the icon just below to specify the point size defined in pixels.



Free-hand Polygon: To draw or erase a closed curve defining an arbitrary shape. Click on the drawn object with the Select tool to display control points on the object boundary. Right-clicking then opens a contextual menu to let the user insert/remove points.



Assisted Polygon: To help the user drawing a curve defining an arbitrary shape. The drawing is automatically adjusted to the sharpest edge and it then follows that edge. Left click to drop a point when the curve is diverging too much from the edge. Double click at the end of the drawing to complete the drawing.



Rectangle: To draw shapes of type *rectangle*. The rectangle is defined by two, diagonally opposite corners. Move the mouse pointer to the location of the first corner. Press and hold down the left mouse button down to mark that corner. While holding the left button down, move the mouse pointer to the location for the second corner. A preview of the rectangle is shown as the mouse pointer is moved from the first to the second corner. Releasing the button marks the second corner and displays the final rectangle.



Ellipse: To draw shapes of type ellipse. An ellipse is uniquely defined by its bounding rectangle and, therefore, by any pair of

the bounding rectangle's diagonally opposite corners. Move the mouse pointer to the location of the rectangle's first corner. Press and hold down the left mouse button to mark that corner. While holding the left button down, move the mouse pointer to the location for the second corner. A preview of the ellipse and its bounding rectangle are shown as the mouse pointer is moved away from the first corner. Releasing the left button defines the second corner and displays the final ellipse.



Polygon: To draw shapes of type polygon. A polygon is a closed shape comprised of three or more straight line segments (i.e., sides) such that each endpoint of a line segment intersects exactly one other line segment endpoint. Move the mouse pointer to the location of the first endpoint and click the left mouse button to define the first endpoint. Move the mouse pointer to the location of the second endpoint and click the left mouse button to define the first line segment (i.e., side). Repeat this line segment drawing process as needed to complete the polygon. A preview of the polygon begins as the second line segment is drawn. A double click of the left mouse button completes the polygon drawing. (Note that if you allow any side in a polygon drawing to intersect any other side more than twice, you will have drawn multiple, connected polygons, although they will still be treated as a single shape.).



Circle by 3 points: To draw shapes of type circle using three points on its circumference. This method is based on the geometric property that a circle is uniquely defined by any three points on its circumference. Each time the left button of the mouse is clicked, a point is defined. A preview of the circle is shown as the mouse pointer is moved after the second point is defined. When the third point is defined by a click, the final circle is displayed.



Circle by Bounding Box: To draw shapes of type circle based on the bounding box of the circle. A circle is uniquely defined as the largest circle completely contained in the drawn square.

Move the mouse pointer to the location of the square's upper left corner. Click and hold down the left mouse button to mark that corner. While holding down the left button, drag the mouse pointer away from the upper left corner. The square and circle are previewed as the mouse is moved. When the circle is the desired size, release the left button to display the final circle.



Circle by Diameter: To draw shapes of type *circle* based on the circle's diameter. A circle is uniquely defined by the end points of any of its diameter lines. Move the mouse pointer to the location of the first end point. Click and hold down the left mouse button to mark that end point. While holding the left button down, move the mouse pointer to the second end point. The diameter and circle are previewed as the mouse pointer is moved. Release the left mouse button to mark the second end point and display the final circle.



Circle by Radius: To draw shapes of type *circle* based on its radius. A circle is uniquely defined by the end points of any of its radius lines. Move the mouse pointer to the location of the circle's center point. Click and hold the left mouse button down to mark the radius' first end point (i.e., circle's center). While holding down the left button, move the mouse pointer to the second radius end point (at the circle's circumference). The radius and circle are previewed as the mouse pointer is moved. Release the left mouse button to mark the radius' second end point and display the final circle.



Text: To add text on an image. Select the Text entry in the Shape dropdown list and then click in the image. The Enter Text window opens. Enter the desired text in the empty box at the top of the Enter Text window. Alignment of the text can be changed using the Alignment dropdown menu. The text is then moved into the image depending on the options selected and the location of the mouse cursor. The Rotation Angle counter can be varied $\pm 180^\circ$. If the Use default value box is checked, the font of the entered text will be Arial and the size and attributes

of the font will be those last selected by a user. To change the font type, size, and attributes, clear the Use default value checkbox and click the Font button to access a font selection dropdown list. Check or clear the Auto Scale box to define if the text follows a zoom action or not. If auto Scale is set to False, the size of the text is not changed when zooming in the image. Click the Apply button to view the effects of the changed settings. After the Enter Text dialog box has been closed, the displayed text can be moved by first selecting the text (i.e., click the Select button on the main toolbar and then click the text) and then drag the text to the desired location. The Edit Text dialog box can be reopened by selecting text and then right clicking to access the contextual menu. From that menu, choose the Edit Text entry.

Note: By default, any shape drawn in the **Object Editing** Task is defined in 4-connectivity. For instance, a single line is composed of a set of pixels that are 4-connected, i.e. two pixels that are connected through a corner are not connected. Connectivity defined for drawn objects can be modified by editing the *Editing→Connectivity* parameter in the Advanced tab of the **Tools→Options** menu.

The following tools remove objects if they are either selected or not selected.



Delete selection: All selected objects are deleted and all unselected objects are kept. This tool is active if at least one object is selected.



Invert Selection: Inverts the current selection of objects. All selected objects are deleted and all unselected objects become selected. The tool is active if at least one object is selected.

The following tools change the display of the Bitmap.




Color: Changes the color of the drawn object. Select a color

and click the OK button.



Opacity: Changes the transparency of the drawn object. Move the slider to alter the transparency value.

At the end of the editing process, the corresponding ObjectSet is automatically generated to reflect edits that have been made in the image. Once the **Object Editing** Task is completed, the existing measurements grid should be manually updated by returning to the **Measurements** Task and re-clicking the appropriate object measurement tools. It is also a good idea to save this edited ObjectSet for future analysis and to avoid having to repeat the manual object editing steps.

Note: The Object Measurements grid is automatically updated when objects are edited: all the measurements are deleted. The Object Measurements must be  recomputed.

However, the Object Global Measurements must be recomputed whenever the ObjectSet is modified in any way.

2.10.5. Measurements Task

The **Measurements** Task provides a set of tools that enables calculation of attribute measurement values for either the objects resulting from the **Object Extraction** Task and/or the **Object Editing** Task or the interactive shapes drawn in this task. These tools include drawing tools used to create special-purpose objects that we refer to as "shape objects" or just "shapes." Shapes have several versatile forms that enable a user to specify ad hoc measurements that may not be possible with the standard measurements that were pre-selected by an Administrator user. Like objects, shape objects also have attributes.

The attribute measurements for objects and shapes are computed and then displayed in numeric arrays called grids. Four different grids are provided that display: Object Measurements, Object Global Measurements, Interactive Shape Measurements, and Interactive Shape Global Measurements. Object attribute values can also be displayed as histograms and scatter plots in the task's Chart window.

In addition to computing and displaying object measurements, the **Measurements** Task can also output the measurements grids in both MS Excel and Comma Separated Values (CSV) formats.

Performance of the **Measurements** Task's capabilities is provided through its **Contextual toolbar**, located at the right edge of the Workspace. The tools provided there are grouped by related functions as follows: **Compute Tools**, **Data Display Tools**, **Data Export Tools**, and **Interactive Drawing Tools**.

Please review section 2.8 *Terminology* for detailed descriptions of objects, attributes, ObjectSets, Active ObjectSet, and grids.

Contextual Toolbar – Compute Tools

Each of the four **Compute Tools** computes and displays the measurements for one of the four grid types. The measurements computed are those previously selected in the **Tools** menu by an Administrator. The computations are performed on the objects created with the **Object Extraction**, **Object Editing**, and **Developer** Tasks, and the shapes drawn interactively with the **Measurements** Task's **Interactive Drawing Tools** described below.



Object Measurements: Computes and displays individual attribute measurement values for each object in the Active ObjectSet that was generated by the **Object Extraction**, **Object Editing**, or **Developer** Tasks and display them in the Object Measurements grid in window B.



Object Global Measurements: Computes and displays attribute measurement values aggregated for all objects in the Active ObjectSet, plus one measurement value for the ratio of the aggregate object areas to the source image area (i.e., *Fraction-OfSurfaceArea*). An aggregate measurement treats all objects in an ObjectSet as a single object. Measurements are displayed in the Object Global Measurements grid in window B.



Interactive Shape Measurements: Computes and displays measurements for each shape manually drawn in the graphics

overlay of the Visualization window using the **Interactive Drawing Tools** described below. Measurements are displayed in the Interactive Shape Measurements grid in window B.



Interactive Shape Global Measurements: Computes and displays interactive shape attribute measurements values aggregated for the shapes manually drawn in the graphics, plus one measurement value for the ratio of the aggregate interactive shape areas to the source image area (i.e., *FractionOfSurfaceArea*). An aggregate interactive shape measurement treats all shapes listed in the selected grid as if they were a single shape entity. Measurements are displayed in the Interactive Shape Global Measurements grid in window B.

If you have computed measurements for an ObjectSet (or an interactive shapes set), and then attempt to compute measurements for another ObjectSet (or interactive shapes set), you will be given the option to save the current measurements under a different file name before the prior measurements are overwritten by the new values.

The ObjectSet aggregate measurements made by **Object Global Measurements** are a predefined set of commonly useful attribute measurements such as image name, surface area fraction, region coordinates, and various statistical measurements based on quantity and intensity of pixels. A more detailed description of those global measurements is provided in section *4.1 Global Measurements*. The first time global measurements are computed, the resulting measurement values are entered in the corresponding global measurements grid in a single row. Each subsequent time that global measurements are computed, irrespective of what ObjectSet is used for those measurements, a new row is added to the global measurements grid. Save the current grid using the **File** menu.

Any row of a global measurements grid can be removed from that grid by left-clicking the row's Keys cell, followed by right-clicking to access the rows drop-down menu, then selecting **Delete**. Select **Delete All Objects** to remove all rows from the grid.

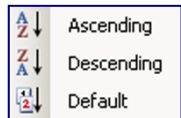
Each object in the graphics overlay is logically linked to its entry in a measurements grid. Clicking on an object in the graphics overlay causes both the object and its row in a grid to become highlighted. Conversely, clicking on a cell in the Keys column of a grid will highlight both that row and its associated object in the graphics overlay.

Note: After at least one object has been edited using the drawing or erasing tools, the prior measurements grid computations are no longer valid and those measurements should be recomputed to update their values, as should be the corresponding global measurements, if used. The same procedure should be followed when interactive shapes are edited.

Contextual Toolbar – Data Display Tools



Sort: Sorts objects (rows) in a grid based on an attribute's measurement (column). Before using this button, a column in a grid must be selected by clicking on a measurement name at the top of that column. The default use of this button is to perform the sort represented by the button's icon. Clicking on this button's drop-down menu symbol (▼) reveals a list of sorting alternatives. The icon displayed on this button will reflect the last sort alternative chosen. Following below is a brief description for each sorting alternative.



Note: Scalars or scalar values are single numbers. The area of a rectangle is a scalar number. Vectors or vector values are a set of numbers, separated by a punctuation mark, whose default setting is a semicolon. To specify a different separator mark, use:

Tools→Advanced→Appearance→GeneralAppearance→ListSeparator

A pixel location is an example of a vector value since it is written as a pair of numbers x,y.



Descending sort: Sorts objects based on their values for the selected attribute (column) from lowest to highest value. Only available for measurement values that are scalar.



Ascending sort: Sorts objects based on their values for the selected attribute (column) from highest to lowest value. Only available for measurement values that are scalar.



Default sort: Sorts objects based on their index number in the Keys column (left-most column) from lowest to highest value.



Hide: Hides a grid's selected attribute column(s). Note that measurements values in a hidden column are still contained in the associated ObjectSet. They are just not displayed in the grid. Recomputing the ObjectSet's measurements will not redisplay a hidden column. To redisplay a hidden column, save the ObjectSet as an .aso file and then reopen that .aso file. All of the hidden columns will be displayed again.



Delete: Deletes the grid's selected attribute column(s). Measurements in a deleted column are deleted from the active ObjectSet. If the ObjectSet's measurements are recomputed, the deleted column will be restored to the grid. You can also restore a deleted column to the grid by reopening its .aso file, provided that it was saved prior to the deletion operation and was not saved with the same file name after the deletion.



Histogram: Computes the histogram of a selected attribute (i.e., column) and display it in the Chart window. This button is disabled if more than one column is selected. Values in the selected column must be scalar (i.e., not vectors).



Scatter plot: Computes the scatter plot of two attributes (i.e., columns) that are selected. The scatter plot is displayed in the Chart window. Exactly two columns must be selected to enable this button. Press the keyboard Ctrl key and click the left mouse button on the measurement name at the top of the column to select the second column. Values in the two selected columns

must be scalar (i.e., not vectors).

Contextual Toolbar – Data Export Tools

The two data export tools provide exporting of a measurement grid to either an Excel-compatible spreadsheet file or a CSV (comma separated values) file. First, select a grid by clicking on its tab. After clicking on one of the export buttons, the user is given the opportunity to specify a name and save location for the exported file. The entire grid is exported.

The user can also specify that the file be opened after it is saved. If the open option is exercised, the file will be opened by the default application for the file format chosen. If a CSV file is opened by a spreadsheet program, all of the column data for a row will appear in the first column of the spreadsheet as a set of appended text strings with all other columns empty, if the selected separator is not the right one. However, Microsoft Excel and OpenOffice Calc provide an import function (*Data→Import External Data→Import Data...*) that will allow proper parsing of a CSV file so the column headings and values appear in proper row, column format. Note, if Microsoft Excel is not installed on the PC, then the .xls file is only saved on disk.



Export as Excel file (.xls): Exports a grid's measurements to an Excel spreadsheet file format (.xls).



Export to CSV: Exports a grid's measurements to a CSV (comma separated values) file format. Note that semicolons are used to separate the values.

Help: The selection of measurements (columns) and objects (rows) in a measurement grid is done respectively by clicking on the name of the measurement (first row of the grid) or on an object's index Key (first column of the grid). The selection of multiple columns or rows is achieved by simultaneously holding down the keyboard's **Ctrl** key and clicking the left mouse button for each column or row to be selected (or unselected if already selected). To select a group of adjacent

columns or rows, first click on one of the group's two outer columns or rows, then hold down the **Shift** key while clicking on the group's other outer column or row.

Contextual Toolbar – Interactive Drawing Tools

The interactive drawing tools enable the user to quickly draw geometric shapes in the graphics overlay. Attribute measurements of these shapes can then be quickly computed and displayed in the Interactive Shape Measurements and Interactive Shape Global Measurements grids.

The drawing tools provided in this task are different from the drawing tools available in the **Object Editing** Task, described earlier. While the **Object Editing** drawing tools are used to create new or modify existing objects (i.e., Bitmaps), the interactive drawing tools have no effect on objects. Rather, the interactive drawing tools are used to create geometric shapes (e.g., Lines, Angles, Circles, and Polygons) whose attributes can also be measured (e.g., length, angle, radius, area). While both the interactive shapes and extracted objects are displayed in the graphics overlay, their respective sets of attribute data are displayed in separate grids and saved as separate .aso files.

Note: Interactive shapes can overlay one another and can intersect with objects, whereas objects are always distinct and separate from one another.

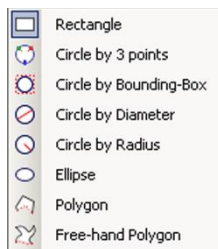
Detailed descriptions of each interactive drawing tool follow below.




Selection: To select objects in the graphics overlay.





Closed shape: To draw geometric shapes that have closed borders. The default use of this button is to draw the shape type displayed on the button's icon, which will be the last shape chosen. Clicking the button's drop-down menu symbol (▼) displays a list of closed shape alternatives




(see right). Following is a description of each closed shape tool.

- 
Rectangle: To draw shapes of type *rectangle*. The rectangle is defined by two, diagonally opposite corners. Move the mouse pointer to the location of the first corner. Press and hold down the left mouse button down to mark that corner. While holding the left button down, move the mouse pointer to the location for the second corner. A preview of the rectangle is shown as the mouse pointer is moved from the first to the second corner. Releasing the button marks the second corner and displays the final rectangle.

- 
Circle by 3 points: To draw shapes of type *circle* using three points on its circumference. This method is based on the geometric property that a circle is uniquely defined by any three points on its circumference. Each time the left button of the mouse is clicked, a point is defined. A preview of the circle is shown as the mouse pointer is moved after the second point is defined. When the third point is defined by a click, the final circle is displayed.

- 
Circle by Bounding Box: To draw shapes of type *circle* based on the bounding box of the circle. A circle is uniquely defined by the smallest square that can completely contain the circle. Move the mouse pointer to the location of the square's upper left corner. Click and hold down the left mouse button to mark that corner. While holding down the left button, drag the mouse pointer away from the upper left corner. The square and circle are previewed as the mouse is moved. When the circle is the desired size, release the left button to display the final circle.

- 
Circle by Diameter: To draw shapes of type *circle* based on the circle's diameter. A circle is uniquely defined by the end points of any of its diameter lines. Move the mouse pointer to the location of the first end point. Click and hold down the left mouse button to mark that end point. While holding the left button down, move the mouse pointer to the second end point.

The diameter and circle are previewed as the mouse pointer is moved. Release the left mouse button to mark the second end point and display the final circle.



Circle by Radius: To draw shapes of type *circle* based on its radius. A circle is uniquely defined by the end points of any of its radius lines. Move the mouse pointer to the location of the circle's center point. Click and hold the left mouse button down to mark the radius' first end point (i.e., circle's center). While holding down the left button, move the mouse pointer to the second radius end point (at the circle's circumference). The radius and circle are previewed as the mouse pointer is moved. Release the left mouse button to mark the radius' second end point and display the final circle.



Ellipse: To draw shapes of type *ellipse*. An ellipse is uniquely defined by its bounding rectangle and, therefore, by any pair of the bounding rectangle's diagonally opposite corners. Move the mouse pointer to the location of the rectangle's first corner. Press and hold down the left mouse button to mark that corner. While holding the left button down, move the mouse pointer to the location for the second corner. A preview of the ellipse and its bounding rectangle are shown as the mouse pointer is moved away from the first corner. Releasing the left button defines the second corner and displays the final ellipse.



Polygon: To draw shapes of type *polygon*. A polygon is a closed shape comprised of three or more straight line segments (i.e., sides) such that each endpoint of a line segment intersects exactly one other line segment endpoint. Move the mouse pointer to the location of the first endpoint and click the left mouse button to define the first endpoint. Move the mouse pointer to the location of the second endpoint and click the left mouse button to define the first line segment (i.e., side). Repeat this line segment drawing process as needed to complete the polygon. A preview of the polygon begins as the second line segment is drawn. A double-click of the left mouse button

completes the polygon drawing. (Note that if you allow any side in a polygon drawing to intersect any other side more than twice, you will have drawn multiple, connected polygons, although they will still be treated as a single shape.)



Free-hand Polygon: To draw shapes of type *polygon*. Move the mouse pointer to a location on the perimeter of the polygon. Press and hold down the left mouse button to define the first endpoint of the polygon. While holding down the mouse button, move the mouse pointer to draw the perimeter of the polygon. Releasing the left mouse button will define the last endpoint and cause a straight line to be drawn connecting the last and first endpoints. While the drawn polygon may appear to have curved sides, each curve is comprised of many small, straight line segments, connected end-to-end.



Open shape: To draw open shapes, including straight lines and lines of arbitrary geometry. The default use of this button is to draw the line type displayed on the button's icon, which will be the last type chosen. Clicking the button's drop-down menu symbol (▼) displays a list of open shape alternatives (see adjacent). Following is a description of each open shape tool.



Line: To draw shapes of type *line*. A line is defined uniquely by its two end points. Move the mouse pointer to the location of the first endpoint. Press and hold down the left mouse button to mark that end point. While holding down the left mouse button, move the mouse pointer to the location for the second endpoint. A preview of the line is shown as the mouse pointer is moved from the first to the second endpoint. Releasing the button marks the second endpoint and displays the final line.



Polyline: To draw shapes of type *polyline*. A polyline is a set of straight line segments connected end-to-end without connecting the first and last endpoints. The first click of the mouse marks the

start of the first line segment. Thereafter, as the mouse is moved, each click of the mouse marks the end of the current segment and the start of a new segment. A double-click marks the end of the last segment and displays the final polyline.



Free-hand Polyline: To draw shapes of type *free-hand polyline*. Move the mouse pointer to the location of the starting endpoint. Press and hold down the left mouse button to define the first endpoint and continue to hold down the mouse button while moving the pointer to draw the line. When the line is complete, release the mouse button to define the final endpoint of the line. The line is actually a sequence of small, straight line segments connected end to end.

T Text (Developer Task only): To add text on an image. Select the **Text** entry in the Shape dropdown list and then click in the image. The Enter Text window opens. Enter the desired text in the empty box at the top of the Enter Text window. Alignment of the text can be changed using the Alignment dropdown menu. The text is then moved into the image depending on the options selected and the location of the mouse cursor. The Rotation Angle counter can be varied $\pm 180^\circ$. If the Use default value box is checked, the font of the entered text will be Arial and the size and attributes of the font will be those last selected by a user. To change the font type, size, and attributes, clear the Use default value checkbox and click the Font button to access a font selection dropdown list. Check or clear the Auto Scale box to define if the text follows a zoom action or not. If auto Scale is set to False, the size of the text is not changed when zooming in the image. Click the Apply button to view the effects of the changed settings. After the Enter Text dialog box has been closed, the displayed text can be moved by first selecting the text (i.e., click the Select button on the main toolbar and then click the text) and then drag the text to the desired location. The Edit Text dialog box can be reopened by selecting text and then right clicking to access the contextual menu. From that menu, choose

the Edit Text entry.



Angle: To draw shapes of type *angle*. An angle is defined by a polyline composed of two straight line segments whose connecting point is the angle's vertex. Move the mouse pointer to the start of the first line segment. Left click to define the first endpoint. Move the pointer to the vertex point and left click. Then move the pointer to the end of the second line segment and left click to define the final endpoint. The straight line segments are previewed as they are drawn.



Caliper: To compute the distance between two points in the image. Draw a straight line connecting the two points by moving the mouse pointer to the first point and press and hold down the left mouse button to define this endpoint. While holding down the mouse button, move the pointer to the second point and release the mouse button to define the second endpoint. The line is previewed as it is drawn.



Delete selection: Deletes the selected objects or shapes. Using the **Selection** tool and select all objects you want to delete. Then click the **Delete selection** button. The selected objects are deleted and the unselected objects remain.



Keep selection: Keeps the selected objects or shapes and deletes all other objects or shapes. Using the **Selection** tool and select all objects you want to keep. Then click the **Keep selection** button. The selected objects remain while the unselected objects are deleted.

Important Note: When the **Selection** tool is the active tool, the object or shape selected by a left-mouse click is the one located under the mouse pointer. The Active ObjectSet is the ObjectSet or the ShapeSet whose the selected object or shape is belonging. For the multi-selection, note you cannot select both shapes and objects belonging from different ObjectSets and ShapeSet. If you select a shape while

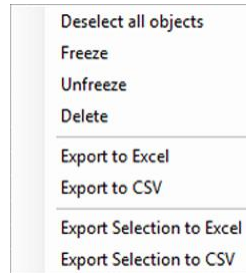
objects were previously selected then the shape is selected and all the previously selected objects become unselected.

Contextual Menus of a Measurements Grid

Measurements grids provide various contextual pop-up menus. The entries in these menus are options for displaying or exporting grid data. There are specific menus for row, column, and cell operations and these are activated by right-mouse clicking, respectively a row index in the *Keys* column, a column heading, or an individual grid cell.

Row Contextual Menu

Access this menu by right-mouse clicking on any cell in the *Keys* column (first column). If no rows are selected when this menu is activated, only Freeze, Unfreeze, Export to Excel, and Export to CSV are enabled. If one or more rows are selected when this menu is activated, all entries in the menu are enabled.



Deselect all objects: Unselects all rows (i.e., objects).

Freeze: Scrolling is enabled only for the rows below the row whose *Keys* index was right clicked. All other rows are frozen (i.e., always in view) until an **Unfreeze** is executed or another row **Freeze** operation is applied to a different row. A row **Freeze** operation will not change an existing column **Freeze** setting.

Unfreeze: Scrolling is re-enabled for all rows.

Delete: Deletes all selected rows.

Export to Excel: Exports the entire grid to Excel.

Export to CSV: Exports the entire grid to a CSV file.

Export Selection to Excel: Exports selected rows to Excel.

Export Selection to CSV: Exports selected rows to a CSV file.

Column Contextual Menu

Access this menu by right-mouse clicking on any column heading (first row). Some menu entries are disabled depending on which column(s) are selected. If a single column is selected that has scalar values, all entries are enabled except for Scatter Plot. If two columns are selected that have scalar values, all entries are enabled except for the first four. If more than two columns are selected or if a selected column includes vector values, the first five entries are not enabled. If no columns are selected, then only Freeze, Unfreeze, Export to Excel, and Export to CSV are enabled.

Following is a brief description of each of the operations listed in the contextual menu for columns (attribute measurements).

Expand/Collapse: If a measurement is a vector with multiple entries, the Expand option displays each individual entry of the vector in a single column, with an index ranging from 0 to the dimension of the vector, and the Collapse option restores the original display in one single column.

Ascending sort: Sorts the rows such that measurement values in a selected column are increasing from top to bottom. This operation is only available if exactly one column with scalar values is selected.

Descending sort: Sorts the rows such that measurement values in a selected column are decreasing from top to bottom. This operation is only available if exactly one column with scalar values is selected.

Default sort: Sorts the rows such that Keys index values (leftmost column) are increasing from top to bottom. This operation is only available if exactly one column with scalar values is selected.

Histogram: Computes and displays the histogram of the measurement values in the

Expand
Collapse
Ascending sort
Descending sort
Default sort
Histogram
Scatter Plot
Hide
Delete
Deselect all attributes
Show hidden attributes
Freeze
Unfreeze
Export to Excel
Export to CSV
Export Selection to Excel
Export Selection to CSV

selected column. This operation is only available if exactly one column with scalar values is selected.

Scatter Plot: Computes and displays the scatter plot of the measurement values in the two selected columns. This operation is only available if exactly two columns with scalar values are selected.

Hide: Hides all selected columns.

Delete: Deletes all selected columns.

Deselect all attributes: Unselects all columns (i.e., attributes).

Freeze: Scrolling is enabled only for the columns to the right of the column whose heading cell was right clicked. All other columns are frozen (i.e., always in view) until an **Unfreeze** is executed or another column **Freeze** operation is applied to a different column. A column **Freeze** operation will not change an existing row *Freeze* setting.

Unfreeze: Scrolling is re-enabled for all columns.

Export to Excel: Exports the entire grid to Excel.

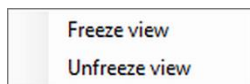
Export to CSV: Exports the entire grid to a CSV file.

Export Selection to Excel: Exports selected columns to Excel.

Export Selection to CSV: Exports selected columns to a CSV file.

Cell Contextual Menu

Access this menu by right clicking any data cell in a grid. There are only two operations in this menu and they are always available.



The cell that is right clicked becomes the reference cell that determines which rows and columns can be scrolled and which are fixed. Following are descriptions for the two menu entries.

Freeze view: Scrolling is enabled for those rows below the reference cell and those columns to the right of the reference cell. All other rows and columns are frozen (i.e., always in view). If any **Freeze** operation is in effect when the **Freeze view** operation is selected, the existing *Freeze* settings are replaced by the new *Freeze view* settings.

Unfreeze view: Scrolling is re-enabled for all rows and columns.

2.10.6. Report Generation Task



The **Report Generation** Task provides an easy way to create a project report that can contain images, ObjectSets, Measurements grids, and histograms. It also includes tools to copy Aphelion images and ObjectSets to the Windows clipboard for easy insertion into other documents. This task provides a contextual toolbar, the Visualization window, and the Measurement grids. The **Contextual Toolbar** operations are described below.

The report process uses an Excel macro, written in VBA (Visual Basic for Applications), that imports selected project data from Aphelion into an Excel Workbook that contains multiple worksheets of project imagery and data. The macro can be found in the Excel file located at:

FOR	PATH
Dev	<Aphelion Dev Installation Path>\Aphelion 4.x.y\Dev\bin\<x64> or <win32>\release\report_template.xls
Lab	<Aphelion Lab Installation Path>\Aphelion 4.x.y\Dev\bin\<x64> or <win32>\release\report_template.xls

This macro can be edited by an Administrator to adapt it to the project's specific needs. It is a good idea to back up the file before modifying the macro. Note that knowledge of programming Excel macros in Visual Basic is required.



Report Generator: Generates a project report. Clicking this button causes the Excel macro in *report_template.xls* to execute. This operation is enabled only if there is an Active Image, an Active ObjectSet, and at least one measurements grid computed. Refer to appendix B for a detailed description of the Excel macro, including information on edits that can be made to the report format and layout.

Note: Macro execution must be enabled in Excel. To do this, open Excel and click on **Tools**→**Macro**→**Security**. The medium security level will allow the Aphelion macro to execute.



Copy whole image to clipboard: Exports the whole Active Image to the Windows clipboard.



Copy whole image with ObjectSet to clipboard: Exports the whole Active Image and its Active ObjectSet displayed in the graphics overlay to the clipboard.



Copy displayed part of image to clipboard: Exports the visible portion of the Active Image to the clipboard. Zoom and pan the image as needed before using this operation.



Copy the displayed part of image with ObjectSet to clipboard: Exports the visible portion of the Active Image and the visible portion of its ObjectSet displayed in the graphics overlay to the clipboard. Zoom and pan the image as needed before using this operation.

After exporting the Active Image with or without its Active ObjectSet to the Windows clipboard, the standard Windows tools can be used to paste the clipboard's contents into a document created with Microsoft Word, Excel, PowerPoint, or other compatible applications.



2.10.7. Developer Task (Dev version only)

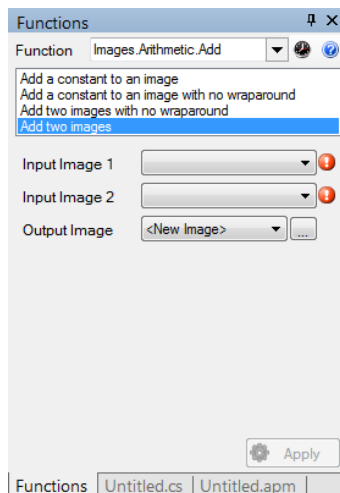


The **Developer** Task provides a wide range of functions that can be applied to images and ObjectSets. It also provides four scripting languages that enable easy development of image processing applications in the Aphelion environment. Once the **Developer** Task is selected, window D (see *Figure 2.9-1*) is initialized with four, stacked windows. Each of these windows and its contextual toolbar are accessible by clicking on the window's tab.


Note: To add a user function to the pull-down list, open the Aphelion User Guide (Help→Aphelion Help menu), go to the section *APPENDIX G - C# Programming Language (DEV VERSION ONLY)* and refer to *G. 2 Adding a custom function to the Aphelion GUI in C#*.

Functions Panel

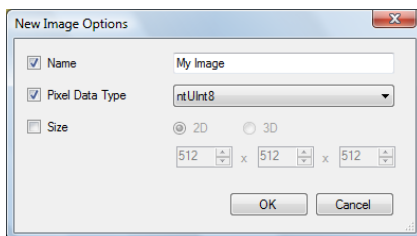
The selection and set up of an image processing or image analysis function is performed in window D after clicking its Functions tab. First, choose the function to be performed by selecting it from the **Process** menu or the Function drop-down list located in window D. When a function is selected using the **Process** menu, then that function will automatically appear as the displayed entry in *Function* name box. Click on the **Recently used function** icon  to quickly select a function that has been previously used. To learn more about the selected function, click on the Help icon .



When a selected function has overloads (i.e., it has functional variations based on the type and number of its parameters), any of its overloads is selectable by clicking on one of the entry name located under the *Function* name box. When a function has no overloads, the list contains only one entry. The first overload displayed for a function is the most common one (e.g., for *Image*→*Arithmetic*→*Add*, the first overload is the sum of two input images that generates an output image without controlling the sign or the overflow).


The Functions panel has one or more *Image* selection boxes, each with a drop-down list button. The drop-down lists include all currently open images. However, a drop-down list for *Output Image* boxes includes the entry *<New Image>*. If *<New Image>* is chosen, the adjacent button  becomes active. Click on this button to specify the new image's *Name*, *Pixel Data Type*, and *Size* (see below).


To enter an image name, click on the *Name* checkbox and enter a name for the *Output Image*. The name entered cannot be the name of an open image (i.e., available via a tab in the Visualization windows).



To have the output image converted to a data type different from the input image(s), pull-down the *Pixel Data Type* menu to choose the desired data type (e.g., 8-bit unsigned, 16-bit signed, float 64). If necessary, choose between the 2D and 3D image alternative and then set the correct pixel counts for the image dimensions. There is usually no need to alter the image size.

Note: The 3rd dimension is only available if the optional 3D Image Processing extension is installed and licensed.

The  icon is displayed when a parameter value is invalid or the selected function cannot be applied to it. Hovering the cursor over the icon will display a warning message as a tooltip.

The  icon identifies a parameter that has sub-parameters for which a graphical tool is provided to specify their values (e.g., defining a convolution kernel). Clicking on the icon displays the parameter's graphical tool (e.g., see *APPENDIX F - Kernel and Structuring Element Editor (Dev version only)*). After the sub-parameter values have been set, click the **OK** button to save them and close the graphical tool. Alternatively, click the **Cancel** button to close the graphical tool without saving the sub-parameter values.

After all of the selected function's parameters are specified, click the













button to execute the function.











Macro Programming Windows




Window D's four stacked windows includes, along with the Functions panel, three windows that host programming environments for macro scripting languages, one window each for Visual C#, BasicScript (a Visual Basic compatible language) and Python. A Visual C# macro file has a .cs extension, a BasicScript macro file has a .apm (for **A**phelion **m**acro) extension, and a Python macro file has a .py extension. These extensions can be seen in the file names on their respective window tabs.

An Aphelion Dev work session can be recorded in a macro file using the C# or BasicScript languages. All functions invoked and ran in window D are recorded in the macro, none of the interactive actions such as drawing in images, zooming, etc. are recorded. Since a recorded macro file can be edited, debugged, and played using the contextual toolbar, it provides a convenient way for developing image-based applications. One can construct a macro using the record capability or by typing code directly. While Python code can be written and executed in the Aphelion Dev environment, this language did not include a recording capability at the time this document was written.

The **Macro Programming Contextual Toolbar** includes the following functions:

	Runs the macro
	Pauses the execution
	Stops the execution
	Step through the code
	Step over the code
	Goes to the end of the code
	Enables/Disables break point
	Adds watch point to enable the display of the variable value during the macro running
	Stack icon. Displays the stack of all the entry points
	Starts recording

	Stops recording
	Cancels recording
	Finds a text (string) in the macro
	Undoes the last edition
	Redoes the last cancelled edition
	Increases indentation
	Decreases indentation
	Comments selected lines
	Uncomments selected lines
	Shows/hides carriage return

To record a macro, select the C# or BasicScript Macro tab in window D (if the window is empty, the tab name will be *Untitled.cs* or *Untitled.apm*). Then click on the **Start Recording** icon () on the **Contextual Toolbar**. To stop the recording, click on the **Stop Recording** icon () . To abort a recording, click on the **Abort Recording** icon () .

Important note: Recording and debugging a macro is only available in C# and BasicScript.

Tip: A macro will be easier to view if its window is undocked and then expanded to display full lines of code. To undock the Macro window, double-click on the associated tab or window banner (in this case, all the stacked windows are undocked). To redock the window, double-click on its banner. Use the icons in the contextual toolbar to execute the code. For further details about window management, refer to section *2.9.1 Workspace and windows* of this document.

Contextual menus are provided for each Macro Programming interface in window D. Each menu provides operations specific to one of the languages. The menus are activated by right-mouse clicking in the selected Macro window.

BasicScript (*.apm) Contextual Menu

New	Creates a new macro
Load...	Opens an existing macro
Reload	Reload the macro previously loaded
Save	Saves a macro
Save As...	Saves macro in a user-specified file
Find... Ctrl+F	Finds a string of characters
Replace... Ctrl+H	Replaces a string of characters
New dialog...	Creates a new dialog structure
Edit dialog...	Edits an existing dialog structure
Run	Runs the current macro

The dialog editor available in BasicScript can be invoked from the menu above after clicking on the *New dialog* menu entry. It helps the user create dialogs in a macro. To get help on a specific BasicScript function, press the F1 key.

Note: All macros developed with Aphelion version 3.2 can be executed in Aphelion Dev version 4.x after minor edits and modifications. See *APPENDIX E - Differences in programming syntax between Aphelion 3.2 and Aphelion 4.x (Dev version only)* for the list of BasicScript functions that were available in version 3.2, but are not available in version 4.x. Please also refer to *7.1. Aphelion Macros*.

Python (*.py) Contextual Menu

New	Creates a new macro
Load...	Opens an existing macro
Save	Saves a macro
Save As...	Saves a macro in a user-specified file
Find...	Finds a string of characters
Replace...	Replaces a string of characters
Show line numbers	Shows line numbers
Run	Executes selected lines of code
Execute selection	Executes the selected lines
Execute current line	Executes the current line

Visual C# (*.cs) Contextual Menu

New	Creates a new macro
Load...	Opens an existing macro
Save	Saves a macro
Save As...	Saves a macro in a user-specified file
Find...	Finds a string of characters
Replace...	Replaces a string of characters
Show line numbers	Displays the line numbers
Compile	Compiles the current macro
Run	Runs the current macro

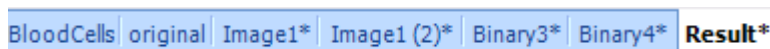
During macro execution, images are not automatically displayed in the Visualization window, except in BasicScript; a specific function has

to be called in the macro code to perform that task. The display function alternatives are:

LANGUAGE	IMAGE DISPLAY FUNCTION
BasicScript:	AphImgView
Python:	AphImages.Add
Visual C#:	app.Images.Add

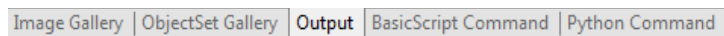
Note: To run a macro in an undocked window, the window D banner must be highlighted to activate the Macro Programming Contextual Toolbar.

When executing a macro that generates successive images, the images will be displayed as stacked images in window A, each with a tab containing its image's name. In the figure below, the set of tabs named BloodCells, original, Image1*, Image1 (2)*, Binary3*, Binary4*, and Result* were created by running a macro.



The presence of an asterisk appended to an image name means the image has not been saved since it was last modified or is a new image.

Immediate and Output Windows



When the **Developer** Task is selected, window B contains several stacked windows that display thumbnail and measurement grids for images and ObjectSets, as well as various data output windows. The **Developer** tabs for window B typically include the names Image Gallery, ObjectSet Gallery, Output, BasicScript Command, Python Command, and various measurement grid names. Images and ObjectSets generated by functions and macros appear in their respective Galleries.

The Output window displays measurements and other information generated by functions and macros. For example, if a Python macro executes a **print** function, the output of that **print** function is displayed in the Output window. Similarly, for a BasicScript macro, the output of the **AphInfoWrite** function is displayed in the Output window.

The two remaining windows, BasicScript Command and Python Command, can be used to execute individual commands. When a macro command is typed or copied into one of these windows, it is immediately executed after the **Enter** key is pressed. For example, typing a print function in the Python Command window, followed by pressing the **Enter** key, causes the print results to be immediately displayed in the Output window. Similarly, typing an **AphInfoWrite** function in the BasicScript Command window, followed by pressing the **Enter** key, causes the function's results to immediately display in the Output window.

The BasicScript Command window has two features that are not available in the Python Command window:

- The BasicScript Command window enables the user to execute individual BasicScript command lines. A command can be typed into the command line dialog box (located at the bottom of the BasicScript Command window) or a command line can be copied or cut from the BasicScript Macro window and pasted into the command line dialog box. The upper section of the BasicScript Command window is the command line history list which displays an ordered list of the previously executed commands. When the **Enter** key is pressed, the command in the dialog box is (1) immediately executed, (2) inserted as the last line of the history list, and (3) cleared from the dialog box. When the dialog box has been cleared, the user can easily copy a command line from the history list by using the up and down arrow keys
- The dialog box has an auto-complete feature that speeds up typing of a function's name. When the first character of the function name is typed, a list appears containing all functions names

beginning with the typed character. As one types additional characters, the list is accordingly reduced to qualifying names. If the user highlights a name on the list, that name is automatically copied into the dialog box. At this point, the user enters the appropriate function parameters into the dialog box and depresses the **Enter** key.

3. TUTORIAL

This chapter should be read by new Aphelion users and by users of Aphelion version 3.2 who wish to get started quickly with Aphelion version 4. Reading through the tutorial material will quickly acquaint you with the Aphelion product's all new graphical user interface and many of its powerful new features. Performing the steps listed in the tutorial sections will provide a good general overview of Aphelion 4.x methods and capabilities, helping assure you will quickly become productive with Aphelion 4.x. A file containing Frequently Asked Questions on Aphelion is also available in the Help folder of the DVD.

3.1. *Multimedia demonstrations*

If you are new to Aphelion, you will find it helpful to play the Task specific Video Tutorials are available either in the Quick Help window, from the Online Video Tutorials entry of the Help menu, or on the Aphelion DVD in the Multimedia Demos folder. The demos show typical usage of the Aphelion software, from basic settings to report generation. The demos can be found in the *Multimedia Demos* folder as .avi files compatible with Windows Media Player software.

3.2. *Walk-through of an image processing and image analysis application*


If you are a new user and want to try out some of the basic tasks in Aphelion, such as opening an image and running a function, you can follow the tutorial below.

Note: We recommend that you read this section before using Aphelion on a regular basis, and refer to the online Aphelion Imaging Software Suite User Guide as needed.

1. Select a task

Each task has a specific work environment and purpose. The **Task Bar**, located by default along the left edge of the Aphelion graphical user interface, is used to select the task to be performed. The user controls an Aphelion project by successively selecting the tasks, as needed, from **Image Acquisition** to **Developer**. For simple projects, the linear sequence of the tasks **Image Acquisition** through **Report Generation** may be sufficient. For more complex projects, the **Developer** Task (only available in the Dev version) provides an extensive set of additional image and ObjectSet functions, as well as macro programming environments.

2. Open or acquire an image to process






There are two ways to select an image: 1) open an image stored on media or 2) capture an image with an attached imager (e.g., camera). For this walk-through, we'll choose an example image from the hard drive. On the **Main toolbar**, click the  button. Navigate to the folder:

<Aphelion Installation Path>\Aphelion 4.x.y\Dev\Images


Note: If Aphelion is not installed in this default path, navigate to the Aphelion installation folder called *Images*.

From the Open dialog box, double-click *BloodCells_1.tif*. The image opens in the Visualization window.

3. Adjust the display parameters for the image



The following buttons    1:1   in the **Main Toolbar** are used to change the zooming factor and the image area to be displayed in the Visualization window. Experiment with these operations to learn how they work. Refer back to the zoom buttons discussion in section 2.9.4 *Main Toolbar*.

4. Extract blobs in an image

Select the **Object Extraction** Task by clicking the  button on the

Task Bar. In window D, the Object Extraction window, click the **Back** button until you are at the first panel (**Back** button becomes grayed-out). In the first panel, select the *Green* channel, then click **Next**. In the second panel, unselect *Apply Filter* and then select *Threshold*, *Automatic threshold computation*, and *Select dark objects*.

As you made changes to these parameters, their effects could be seen immediately in the Preview window. Remember that you can also change what image area is previewed by modifying the cyan rectangle in the Visualization window. Click **Next**.

At the third panel, first click  to see the object extraction results in the Visualization window. Visually inspect the image in the Visualization window. Be sure you see the entire image by clicking on the  icon or zooming out so the image frame is visible. Determine if any objects have holes and if any objects are touching (clustered).


- If no objects are touching and none have holes, clear the first three checkboxes.
- If no objects are touching and some have holes, select only the *Fill holes* option.
- If some objects are touching, but none have holes, then select the *Split touching objects (before hole filling)* option.
- If some objects are touching and some have holes, then select the *Fill holes* and the *Split touching objects (after hole filling)* options.

For the *BloodCells_1.tif* image, select the options for *Fill holes* and *Split touching objects (after hole filling)*.


When an object is touching the image frame, an object processing function will assume where the frame touches the object is actually part of the object's boundary. Such partial objects will bias computation of individual measurements. In such cases, the

Remove objects touching image frame option should be selected. Be aware that there can be cases where all objects are touching the image frame. In such cases, the function would eliminate all of the objects. Thus, the use of this function requires thoughtful consideration of the image contents and the analysis goals. For our example, this option is appropriate and should be selected.






The last checkbox is *Filter objects on*. For this tutorial, we will not use this function.



Finally click  to apply all of the selected extraction processes to the entire image. All of the extracted objects are now outlined in the Visualization window. Sometimes it will be necessary to experiment with the object extraction parameters to achieve an acceptable extraction.



5. Edit the result of the Object Extraction Task

After completion of the Object Extraction Task, it may be useful to edit its results. To begin editing, select the Object Editing Task by clicking on the  button. Note that the object outlines are now filled in, forming a red mask over the underlying image pixels. Those pixels that are not part of an object are still visible. To become familiar with the drawing tools (found on the task contextual toolbar on the right edge of the Workspace), do the following:




- Find an object with a hole and fill in the hole.
- Join two neighboring objects to make a single object.
- Split a large object into two separate objects.
- Smooth out the edges of an object.



Try some of your own ideas using , , , , .

You need to select a drawing tool, **Draw** () or **Erase** (), before selecting the shape you will draw.


Remember, the **Undo**  button only cancels the last editing action, and the **Redo**  button cancels only the last undo action (see the topic *Object Editing Contextual Toolbar* in section 2.10.4 *Object Editing Task*).


6. Compute measurements

Select the **Measurements** Task by clicking on the  task button. Select the *Object Measurements* operation by clicking the  button on the **Contextual toolbar**: Individual measurements for each object will be computed and displayed in the Object Measurements grid. Next, select the *Object Global Measurements* operation by clicking the  button on the **Contextual toolbar**. The Object Global Measurements grid will become active and the global measurements will be computed and displayed in this grid. Examine these two grids to become familiar with their contents.

Tip: If the image includes objects touching its frame and both global and individual measurements are computed, then perform as follows: 1) Select the **Object Extraction** Task; 2) Uncheck the Remove objects touching image frame option and click the  button; 3) Select the **Measurements** Task; 4) Compute the Object Global Measurements; 5) Select the **Object Extraction** Task; 6) Select the *Remove objects touching image frame* option and click the  button; 7) Select the **Measurements** Task; 8) Compute the Object Measurements.



Next, you will use the four shape tools (closed shape, open shape, caliper, and angle), found on the **Contextual toolbar**, to draw shapes in the graphics overlay that provide measurements that can help achieve your analysis goals. Those interactive shapes will be displayed in green in the graphics overlay.

Draw at least one of each shape type, and then select the *Interactive Shape Measurements* operation by clicking the  button on the **Contextual Toolbar**. Individual measurements for each shape will

be computed and displayed in the Interactive Shape Measurements grid. Next, select the *Interactive Shape Global Measurements* operation by clicking the  button on the **Contextual Toolbar**. The Interactive Shape Global Measurements grid will become active and these global measurements will be computed and displayed in this grid. Examine these two grids to understand how using the interactive shapes tools can provide useful, supplemental information.

Note: While interactive shapes are drawn in the graphics overlay, they are special purpose objects that are not fully compatible with objects created with the **Object Extraction, Object Editing, and Developer Tasks**. These shape objects cannot be combined in any way with the other object types. The only ObjectSet functions that can be applied to shape objects are the *ObjectSet→Utility* functions.

7. Generate the analysis report

First, be sure the computer you are using has Microsoft Excel installed. Next, be sure you have both an image and either an ObjectSet or set of interactive shapes open and at least one grid computed. Select the **Report Generation Task** by clicking the  button on the **Task Bar**. Next, execute the *Generate Report* operation by clicking the  button on the **Contextual toolbar**. If the macro security warning message appears, select the *Enable Macros* button in that message. The report is then quickly generated as an Excel compatible file. During the generation process, you will have the opportunity to specify up to nine object attributes to export and what attribute should be used in a histogram chart.

The **Contextual toolbar** provides four additional buttons that enable you to copy image, ObjectSet, and interactive shape data to the Windows clipboard. View the pop-up tooltip for these buttons by hovering the mouse pointer over each of the buttons. The copied data can be pasted into the report just generated or into a

separate document (e.g., Word). Experiment with these tools to customize your report.

Remember, you can customize the Excel macro and the Excel template used by the **Report Generator**.




8. Save images and ObjectSets

Before closing a window containing images, ObjectSets, or interactive shapes that have not been saved since being created or modified, Aphelion Lab and Dev ask if the files should be saved. Select the save options you prefer. Remember, you may save an image, ObjectSet, and interactive shapes at any time using the Save operations provided by the **Files** menu.


3.3. *Interactive Analysis Tools (Dev version only)*

3.3.1. Intensity Profile



1. Draw a line and display its intensity profile

Select the **Developer** Task. Enable the **Profile** tool by clicking on the **Profile** button () on the **Main toolbar**. Next, click the drop-down menu button on the **Shape** tool () to select a shape drawing tool. Since an intensity profile is always taken along a straight line, select *VerticalLine* (). Create a vertical line profile by clicking on a point in the image through which you want the vertical profile to be taken. A vertical line is drawn and the intensity profile along that line is then displayed in the Chart window (window E).

2. Select and move the line

Make sure the **Select** tool () is active (button outlined in blue). If it is not, click on it now. Select the line drawn in the previous step and move it. Note that the profile chart is updated in real-time to show the intensity profile along the moving line.



3. Delete the selected line

Using the **Select** tool (), click on the line to select it. Next, click **Delete Selection** button (). The line is deleted and the profile chart is cleared.


- Note that multiple lines can be drawn. However, the intensity profile will reflect the last line drawn or selected. More than one line can be selected by holding down the **Shift** or **Control (Ctrl)** key and clicking on the lines you want selected. All selected lines can be moved or deleted simultaneously.

3.3.2. Histogram

1. Draw a shape and display its histogram




While in the **Developer** Task, enable the **Histogram** tool by clicking on the  button on the **Main toolbar**. Next, click the drop-down menu button on the **Shape** tool to select a shape drawing tool. While any closed shape can be used, choose the **Rectangle** () tool and draw a rectangle over the desired image area. Release the left mouse button to complete drawing of the rectangle. The intensity histogram is displayed immediately in the Chart window.

2. Select, move, and resize the rectangle

Make sure the **Select** tool () is active (button outlined in blue). If it is not, click on it now. Any shape in the Visualization window can now be selected and moved. Select the rectangle drawn in the previous step to cause its handles to appear. With the mouse pointer positioned on any one of the handles, hold down the left mouse button and move the mouse to resize the rectangle. Release the mouse button to complete the resizing. To move the rectangle, select it and move the mouse pointer to the rectangle's interior. Hold down the left mouse button while you drag the rectangle, releasing the mouse button when the rectangle is at the desired location. Note that the histogram is updated in real-time as the rectangle is resized or moved. Note also that the user can

turn on or off any colors in the histogram by clicking that color's label under the histogram or turn on all three colors by clicking anywhere in the Chart window except on the color labels and in the chart's graphing area.


3. Delete the selected rectangle

Using the **Select** tool () , click on the rectangle to select it. Next, click **Delete Selection** button () . The line is deleted and the histogram chart is cleared. Multiple shapes can be selected by holding down the **Shift** or **Control (Ctrl)** keys while clicking on the shapes. Once selected, multiple shapes can be moved as a group or can be deleted by a single click the  button.

3.4. Using Developer functions (Dev version only)

3.4.1. Select and run a function

1. Access the Developer Task


Click on the **Developer Task** () on the **Task Bar**. Note that the **Developer Task** can also be accessed by selecting a function from the **Process** menu on the **Menu Bar**.

2. Select the function to run

A function can be selected using either the **Process** menu on the **Menu Bar** or the *Function* drop-down list located near the top of the Functions panel in window D. For example, using the **Process** menu select *Images→Utility→ExtractBand*. Using the *Function* drop-down list, select *Image.Utility.ExtractBand* entry. Try both methods; sometimes one will be more convenient to use than the other. You can also type a part of the function's name into the *Function* text box to retrieve the function faster.

3. View the online Help for the selected function


The *ExtractBand* is selected if its name appears in the Function box


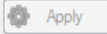

at the top of window D. Click on the Help icon  near the *Function* drop-down list to display the Help topic for the selected function *ExtractBand*.

4. Specify the function parameters, including the input and output images

If you haven't already done so, open the *BloodCells_1.tif* image found at `<Dev Installation Path>\Aphelion 4.x.y\Dev\Images\`. Then, click the **Input image** box in the Functions panel and select *BloodCells_1* from the drop-down list. Then click the **Output image** box and select `<New image>`. In this case, Aphelion Dev will automatically define the data type and the size of the output image depending on the function executed. Finally, change the band value from 0 to 1 (for an RGB color image: 0 = Red, 1 = Green, 2 = Blue).

5. Run the function

Click  to run the function. Observe that the extracted green band appears as a new image in the Image Gallery in window B with the name Image n (where n is an index value for multiple uses of the name Image).

Note: The  button will be disabled () if any parameter is not correctly specified. The  icon is displayed at the right of a parameter that is not properly specified. Hover the mouse pointer over the icon and a tooltip will pop-up explaining the problem.

3.5. Using macros

1. Load a macro

Aphelion Dev supports programming of macros in three different languages: C#, BasicScript and Python. Click on the window D tab *Untitled.cs*. Load the C# macro *Ceramic.cs* by right-clicking in the C# Macro window and selecting **Load...** from the contextual


menu. Windows File Explorer will open. Navigate to:



*<Dev Installation Path>\Aphelion 4.x.y\Dev\
Examples\Macros\CSharp\Processing*


and select the *Ceramic.cs* file. The file opens in the Macro window and the file name appears in the window's banner.

Note: The Macro Programming panel can be undocked as a window by double-clicking its tab. This window becomes a floating window. It can be moved to any location on the Windows desktop and resized so the macro code can be more easily read and edited. To redock the panel, double-click on its banner.

2. Run the macro


Click  to run the *Ceramic.cs* macro that is open in the Macro window. You will see the macro processing as the intermediate images appear in the Visualization window. The final image shows the fiber ends outlined in red. You can also see that the macro excluded fibers touching the window's frame. Each of the intermediate images can be viewed in the Visualization window by clicking on its tab at the bottom of the window. The intermediate images are also viewable in the Image Gallery as thumbnails. Any image can become the Active Image in the Visualization window by just double-clicking on its thumbnail.




Run the macro again, but use the **Step Into** button () to see the macro executed line-by-line. In this case, the macro can be stopped before reaching its end by clicking the **Stop** button ().

Note: If the Macro Programming window is undocked or not active, double-click the **Run** button () instead of a single click to run the macro. (The first click selects window D.)


3. Record a new macro

Only C# and BasicScript macros can be recorded. The process below records a simple C# macro (the same applies for BasicScript macros). Begin by selecting the C# panel in window D


by clicking on its tab (labeled <macro_name>.cs). If macro code already exists in this panel, it must be removed first. To do this, right click in the panel's programming area (white) and select *New* from the drop-down menu. If the existing code has not been saved since it was last modified, a window opens asking if the macro should be saved. Once you have answered the save macro question, the macro disappears from the programming area. Next, click on the **Start Recording** button () on the Contextual toolbar. Now perform the following steps:

- a. Click on **Close All** from the **Windows** menu to close all the loaded images. This will ensure that the first <New Image> created will be called Image 1.
- b. Load (open) the *BloodCells_1.tif* image.
- c. Click on window D's Functions tab.
- d. Select the function: *Images*→*Utility*→*ExtractBand*.
- e. Set *Input Image* to: *BloodCells_1*.
- f. Set *Output Image* to: <New Image> to avoid overwriting of the original *BloodCells_1* image.
- g. Set *Band* to: 0 to extract the red channel that corresponds to band 0 of the original RGB image.
- h. Click  **Apply** (Note name of resulting image is *Image 1*.)
- i. Set *Output Image* to: <New Image>.
- j. Set *Band* to: 1 to extract the green channel.
- k. Click  **Apply** (Note name of resulting image is, *Image 2*.)
- l. Select the function: *Images*→*Arithmetic*→*Subtract*.
- m. Set *Input Image 1* to: *Image 1* (result of step g).
- n. Set *Input Image 2* to: *Image 2* (result of step j).
- o. Set *Output Image* to: <New Image>.
- p. Click  **Apply** . (Note name of resulting image is, *Image 3*.)
- q. Click on the C# tab to switch to the macro code.

r. Click on the **Stop Recording** button (.

Now, run the macro you just created by clicking on the **Run** button (.

Your macro extracted the red and green bands from the *BloodCells_1* image and labeled them *Image 1* and *Image 2*, respectively. Then it subtracted the second image (i.e., the green band) from the first image (i.e., the red band).

Note: Steps a. and b. in the above sequence, which included opening the image *BloodCells_1*, were not recorded in the macro. This is because these two steps used GUI operations rather than **Developer** functions that are callable from C# and BasicScript. To record the opening of an image in a macro, follow the instructions below: 1) Select function: *Images*→*IO*→*Read*; 2) Set image to <New Image>; 3) Set Filename to <Dev Installation Path>\Aphelion 4.x.y\Dev\Images\BloodCells_1.tif. 4) Click  **Apply** to load the image.

Note that the *BloodCells_1* image will be called *Image 1* in Aphelion and the red and green channels will be respectively called *Image 2* and *image 3*.

3.6. Basic knowledge in image processing & analysis

3.6.1. Processing Images

This section describes the basics of how to process and enhance images.

Filtering to remove gray-level noise

Gray-level noise is characterized by varying pixel values. This noise can be random or regular. Any filtering function will affect pixel values and will usually remove any type of noise in an image.

Linear or Convolution Filters

Linear filters, such as a convolution are the most basic of image processing tools. Depending on the kernel passed to *Images→Filtering→Convolve*, you can apply a low-pass filter or a high-pass filter to an image. For removing random gray-level noise, use one of the low-pass filters available in Aphelion **Developer** Task, such as *Images→Filtering→Box*, *Images→Filtering→Gaussian*, or select the *Convolve* function and choose its overload that provides a predefined kernel, then select the *Low Pass 5x5* predefined kernel from its Kernel drop-down menu.

Tip: To select a function overload, scroll through the list of available overloads that are displayed in the section below the function name.

To enhance object boundaries in an image, use a high-pass filter.

Non-linear Filters

Non-linear filters are filters whose output is not proportional to the input. For example, smoothing by averaging is linear, while median smoothing is not. An example of a non-linear filter in Aphelion is *Images→Filtering→Median*. This function replaces each pixel's value with the median value (i.e., middle value of rank-ordered values) of its neighboring pixels. As with the linear low-pass filters, a larger neighborhood results in a more uniform output image (large areas with quite similar pixel intensity values).

Frequency Filters

Frequency filters are useful when you have predictable gray-scale noise (e.g., non-random noise generated by the sensor, such as noise due to the alternating current). You can run *Images→Frequency→FFT* to view an image's power spectrum (also an image). If you see well-defined clusters that are not near the center of the power spectrum image, these may be caused by repetitive noise or by a repetitive pattern such as a grid. Such artifacts often can be removed with a frequency filtering function such as *Images→Frequency→Filter*.

After filtering the power spectrum image, removing high frequency pixels, use the *Images→Frequency→InverseFFT* function to recreate the original gray-scale image without the undesired pixels.

To view any of the four bands of a frequency image use the function *Images→Math→RealPart | ImaginaryPart | Magnitude | Phase*.

Filtering to remove spatial noise

Some noise is spatial rather than gray-level. This noise is characterized by roughness along the boundaries of objects, or holes within objects. Aphelion's morphological functions can be very effective at cleaning up this type of noise. For instance, the function *Images→Morphology→OpeningClosing→Open* can be applied to a binary, gray-scale, or color image in order to remove boundary roughness from bright objects. The function *Images→Morphology→OpeningClosing→Close* can be used to fill in holes in objects.

Other Image Processing functions

The above functions provide an introduction to just a few image processing groupings in Dev's function library. Following are additional examples of image processing function groups in Dev:

- *Arithmetic/Logic (Add, Multiply, And);*
- *EdgeDetection (SobelEdges);*
- *Geometry (Rotate, Scale);*
- *Utility (Copy, ExtractBand).*

3.6.2. Extracting and Analyzing Objects from Images

This section describes how to use Aphelion software to measure objects in images.

Global Measurements

Global measurements are either computed on the entire image or limited by a mask. The mask used is the aggregation of the object surfaces generated by the **Object Extraction** and **Object Editing** Tasks, or by specific functions in the **Developer** Task. For instance, the

measurement called `FractionOfSurface` computed in the **Measurements** Task is a global measurement. It is the surface area of the mask divided by the surface area of the entire image. Given a binary image (i.e., each pixel is either black, having a value of zero or is red, having a value of 1, meaning each pixel is in, respectively, the image background or its foreground), the area of the image is defined as the number of foreground pixels in the image multiplied by the pixel area in real-world units. Other global measurements are: intensity mean of all the image pixels (computed by *Images→Measurements→Moments*), intercepts, object count, etc.

A binary image can be generated with a simple threshold operation (e.g., *Images→Segmentation→Threshold*).

Note: A simple *Threshold* operation generates a binary image. The **Object Extraction** Task described above automatically generates an `ObjectSet`, bypassing the step of generating a binary image. But it is always possible to perform the conversion step by step, as described in the example below.

Then, one can compute the total area of the objects as the number of pixels in the foreground of the binary image. After the *Threshold* function just referenced, apply the function *Images→Measurements→Area* and select the binary image as the input image.

The volume of a gray-scale image is defined as the sum of the pixel intensity values for all pixels in the image. The function that performs this measurement is *Images→Measurements→Volume*.

Segmentation

One is often interested in individual objects in an image, rather than characteristics of the overall image. Aphelion allows you to identify individual objects using either the processes found in the **Object Extraction** and **Object Editing** Tasks, or the segmentation functions (i.e., *Images→Segmentation* group) found in the **Developer** Task.

Bitmap is the most common object *spatial attribute* value. A Bitmap is a set of connected pixels (i.e., each pixel is a neighbor of at least one

pixel in the same Bitmap). With the **Developer** Task, the most basic way to generate Bitmaps is to threshold the image using:

ObjectSets→Bitmaps→Generation→Threshold

This threshold function is manual in that one must specify the threshold interval (i.e., upper and lower limits). The resulting Bitmaps (i.e., ObjectSet) can then be displayed in the graphics overlay by double-clicking the left mouse button while the mouse pointer hovers over the ObjectSet thumbnail in the ObjectSet Gallery, or right clicking the thumbnail, followed by clicking *Show→Bitmap*.

There are also a number of automatic segmentation operators, such as *EntropyThreshold* in the same function group.

If the image is already segmented as a binary image, then it can be converted into a set of Bitmaps using the *ObjectSets→Bitmaps→Generation→Clusters* function.

An object type is defined by its spatial attribute. In addition to the most common spatial attribute, Bitmap, the **Developer** Task provides other spatial attributes. The following list gives example functions for extracting some of the other object types:

- Chains (*ObjectSets→Chains→Generation→EdgelsToChains*);
- Edgels (*ObjectSets→Edgels→Generation→EdgesToEdgel*);
- Lines (*ObjectSets→Lines→Generation→RegionLineFit*);
- Polygons (*ObjectSets→Polygons→Generation→ConvexHull*).

Object Measurements

Object measurements are functions that calculate the value of object attributes (e.g., length, area, and angle). The attributes possible depend on the object type (e.g., Line, Bitmap, and Chain). Typically, measurements are computed in order to quantify, filter, or classify objects found in an image. Aphelion contains powerful functions for computing and visualizing object measurements.

Note: The terms *Bitmap* and *Region* both name the same entity and may be used interchangeably in this text and in the Aphelion software.

Region was used exclusively in Aphelion versions prior to Aphelion 4.x.

ObjectSets

An ObjectSet is a group of objects derived from a specific source image and saved together in a special file format called AphelionSerialObjects (.aso). This file includes the spatial attribute(s) (i.e., the spatial representation) and the numeric attributes (measurements available as scalars or vectors) for each object. Numeric attributes are displayed in a grid in Aphelion. Each row corresponds to a specific object in the ObjectSet and each column contains the measurement values for a specific attribute of the objects in the ObjectSet. Deleting a row in the grid results automatically in the deletion of all data (including the spatial attribute) associated with the corresponding object. Using the **Object Editing** Task to add an object to an ObjectSet results in also adding a new row in the grid for the corresponding ObjectSet.

There are a number of ObjectSet utility functions, including these examples:

- *ObjectSets*→*Utility*→*Append|Copy|Merge|ToImage*;
- *ObjectSets*→*Filtering*→*Filter*.

You can load and save ObjectSets using the entries in the **File** menu.


Tip: Aphelion 3.2 used a different file format for saving ObjectSets (.tks). Aphelion 4.x ObjectSet access functions are backwards compatible with the Aphelion 3.2 file format. However, the .aso format supports new attribute types and very large images since image coordinates are now defined as 32 bit variables. For these and other reasons, the .aso format should be used instead of the old .tks format.

Example: Producing an Aphelion ObjectSet using the Developer Task

This example describes how to use the **Developer** Task to produce object measurements in a grid when starting from an image.


1. Open the image for which you want to compute an Object Measurements grid.
2. Use the **Process** menu to select the function:

Images→Utility→ExtractBand

- From the *Input Image* pull-down list, select the image you loaded in step 1 above.
- From the *Output Image* pull-down list, select *<New Image>*.
- In the *Band* box, choose the color band from which you wish to extract objects (For BGR images: 0 = Blue, 1 = Green, 2 = Red).
- Click  to execute the function.

3. Use the **Process** menu to select the following function:

ObjectSet→Bitmaps→Generation→Threshold

- From the *Input Image* pull-down list, select the color band image you created in step 2 above (e.g., Image 1).
- From the *Output ObjectSet* drop-down list, select *<New ObjectSet>*.
- Slide the Low and High threshold sliders until the desired objects are outlined in red in the graphics overlay. The preview of the threshold is only available if the image is gray-scale.
- Select *8 connected* from the Graph drop-down list (see *Connectivity* in the section 2.8 *Terminology* to learn more about 4- and 8-connected).
- Click  to execute the function.

4. A new ObjectSet is created and appears in the ObjectSet Gallery. Right-click on the ObjectSet thumbnail in the ObjectSet Gallery to open a drop-down menu. Choose either *Show/Hide→Bitmap* to display the ObjectSet in the graphics overlay of the Active Image or *Show Grid* to display a grid in window B that lists values for each object's area and its bounding rectangle coordinates (see section

2.9.10 ObjectSet Gallery Window).

Grids

Results from an object analysis (i.e., forming an ObjectSet and computing attribute measurements for that ObjectSet) are displayed in an Aphelion grid. A grid is displayed in window B after the **Measurements** Task computes the attribute values for an ObjectSet's objects. If measurements have not yet been computed for an ObjectSet, entering the **Developer** Task and clicking the *Show Grid* function (accessible by right clicking the ObjectSet thumbnail in the ObjectSet Gallery) displays the ObjectSet's default attributes for each object, namely, Area (i.e., pixel count) and the coordinates for its minimum bounding rectangle.

Tip: An ObjectSet can be converted into an image using the *ObjectSets→Utility→ToImage* function. This function assigns an object's scalar value of a user selected numeric attribute to all pixels of that object. As pixel values outside objects are not modified by the function, intensity values of pixels not contained in an object can be set to zero if the output image is set to zero before running the function.

Other Object Processing Functions

The above sections are just an introduction to the object function libraries in Aphelion. To view the highest grouping level of ObjectSet functions, go to the **Menu Bar** and click on **Process→ObjectSets**. Click through each entry in the menu to become more familiar with the functions available to extract, display, and compute measurements for objects. Also see section 5.2 *ObjectSets*.

4. LIST OF MEASUREMENTS

This chapter defines global and object measurements.

4.1. *Global Measurements*

Global measurements are measurements computed on an entire image. As such, these measurements are applied to all pixels in an image or to the aggregate of all pixels in an ObjectSet. The results are displayed in the Global measurements grid. This grid has only one row and it corresponds to an entire image or ObjectSet, and one column for each measurement calculated for that image or ObjectSet.

Note: Pixel intensity values are computed and displayed based on the number of intensity channels in the image: one value for gray-scale images and three values for color images (e.g., red, green, blue channels). For color images, channel results are specific to the channel. For example, Pixel Intensity Minimum will display as $[I_{\text{Red}}, I_{\text{Blue}}, I_{\text{Green}}]$, where I_{Red} is the lowest intensity value found in the red channel and is independent of the blue and green channels, and similarly for I_{Blue} and I_{Green} .

4.1.1. List of Global Measurements

Statistical Measurements (based on pixel intensities)

Kurtosis: An image's centered moment of order 4 of pixel intensities.

Maximum: An image's highest pixel intensity value.

Mean: An image's mean pixel intensity value.

Minimum: An image's lowest pixel intensity value.

Skewness: An image's centered moment of order 3 of pixel intensities.

Standard Deviation: An image's standard deviation of pixel intensities.

Area Measurement

FractionOfSurfaceArea: Aggregate area of the objects in an ObjectSet divided by the area of the image from which the ObjectSet was extracted. This measurement is sometimes referred to as Specific Area.

4.2. Object Measurements

Object measurements are measurements computed for each object in an ObjectSet, in contrast to global measurements which are computed for the whole image (i.e., all pixels). Object measurements that can be computed depend on the object type and on the list of measurements enabled by the Administrator (see section *2.10.1 Administrator Settings Tasks*).

4.2.1. Object types

Aphelion can generate the following object types:

Surface Object Types:

Bitmap: An object having irregular shape (e.g., a blob) generated by the **Object Extraction** or the **Developer** task.

Ellipse and Circle: Object with an elliptic shape.

Polygon: Object with a polygonal contour (i.e., comprised of closed, connected line segments). A polygon can have a regular shape (e.g., square, parallelogram) or be irregular.

Rectangle: Object with a rectangular shape that also qualifies as a polygon.

Line Object Types:

Chain: A set of two or more line segments (i.e., straight lines) connected end-to-end.

Line: A single line segment connecting two pixels as the extremities of the line segment.

Point: Line of length equal to one pixel.

4.2.2. List of Object Measurements

When computed, the following measurements are displayed either in the Interactive Measurements grid or Objects Measurements grid for all objects in the active ObjectSet. Please see Section 2.10.5 *Measurements Task* for an explanation of this feature.

Statistical and Texture Measurements

Statistical measurements can be applied to all object types.

HaralickContrast: Contrast of the object in four directions. The mean value of the contrast is also computed.

HaralickCorrelation: Correlation of the object in four directions. The mean value of the correlation is also computed.

HaralickEnergy: Energy of the object in four directions. The mean value of the energy is also computed.

HaralickEntropy: Entropy of the object in four directions. The mean value of the entropy is also computed.

HaralickIDMoment: Inverse difference moment of the object in four directions. The mean value of the inverse difference moment is also computed.

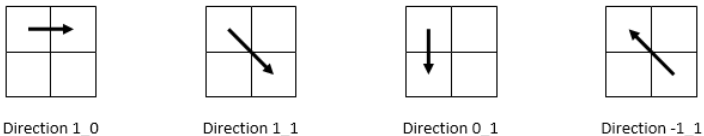


Figure 4.2-1: Coding of the directions for the Haralick's texture features.

$$\begin{aligned}
 \text{Energy} &= \sum_{i=0}^{\text{Max}} \sum_{j=0}^{\text{Max}} p^2(i, j) & \text{Inverse Difference Moment} &= \sum_{i=0}^{\text{Max}} \sum_{j=0}^{\text{Max}} \frac{p(i, j)}{(i-j)^2} \\
 \text{Entropy} &= - \sum_{i=0}^{\text{Max}} \sum_{j=0}^{\text{Max}} p(i, j) \times \text{Log}(p(i, j)) & \text{Correlation} &= \frac{\sum_{i=0}^{\text{Max}} \sum_{j=0}^{\text{Max}} (i-i) \times (j-j) \times p(i, j)}{\sigma_i \times \sigma_j} \\
 \text{Contrast} &= \sum_{i=0}^{\text{Max}} \sum_{j=0}^{\text{Max}} (i-j)^2 \times p(i, j)
 \end{aligned}$$

Figure 4.2-2: Haralick's texture features calculated from the co-occurrence matrix.

Kurtosis: An object's fourth standardized moment of pixel intensities.

Maximum: An object's highest pixel intensity value.

Mean: An object's mean pixel intensity value.

Median: An object's median pixel intensity value.

Minimum: An object's lowest pixel intensity value.

Skewness: An object's third standardized moment of pixel intensities.

StandardDeviation: An object's standard deviation of pixel intensities.

WeightedCentroid: The average of the intensity-weighted locations of all pixels in an object, expressed as an x,y coordinate pair. Thus, $x_{wc} = \text{sum of } p_i \text{ times } x_i \text{ divided by number of pixels}$, and similarly for y_{wc} . For some objects, the *WeightedCentroid* can lie outside the object.

Size and Shape Measurements

These measurements can be applied to any object type except Points:

Centroid: The average location of all the pixels in an object, expressed as an x,y coordinate pair (i.e., center of mass of the object). For some objects, the *Centroid* can lie outside the object.

Height: The difference between the uppermost Y coordinate of an object and its lowermost Y coordinate, plus the Y pixel size. This value is expressed in calibrated units.

LogOfHeightToWidth: $\text{Log}_{10}(\text{Height/Width})$.

MajorAxis: The angle in radians from the X axis of the major axis of inertia. This object attribute provides the main orientation of the object relative to the X axis. The range of the Major Axis values lies between $-\pi/2$ and $+\pi/2$.

NumberOfBlobs: The number of connected components in an object using 4-connectivity.

PixelCount: Number of pixels comprising an object.

Width: The difference between the rightmost X coordinate of an object and its leftmost X coordinate, plus the X pixel size. This value is expressed in calibrated units.

The following measurements apply only to line objects (i.e., objects of type Line and objects of type Chain):

Angle: Angle (in radians) between the two first lines. The second point of the chain is the vertex of the angle. The range of the Angle values lies between $-\pi$ and $+\pi$.

Important notes: a) In Aphelion, clockwise angle values are positive since the Y axis is pointing down. b) All angular measurements are expressed in radian units (e.g., $\pi/2$ radians) unless specified otherwise in the text (90 degrees).

Curvature: Mean of the inverse of the curvature radii for all the points on the chain, divided by the object's *PixelCount*. A curvature radius value equals the length of the line that connects a point on a chain to the X,Y axes origin (point 0,0). The *Curvature* attribute computes a value using all possible radii for a chain.

Length: Number of pixels comprising a line object in 4-connectivity expressed in calibrated units.

The following measurements apply only to objects of type Line (i.e., straight line comprised of a single line segment):

MaxAbscissa: Distance between the image origin (0,0) and the furthest extremity of a Line object type. See Max T in *Figure 4.2-3*. This distance is expressed in calibrated units.

MiddlePoint: Middle pixel of a Line object type, defined in pixels.

MinAbscissa: Distance between the image origin (0,0) and the closest extremity of a Line object type. See Min T in *Figure 4.2-3*. This distance is expressed in calibrated units.

Rho: Perpendicular distance between a Line object type and the image origin (0,0), expressed in calibrated units.

Theta: Angle formed with the X axis by a line drawn from the image origin (0,0) perpendicular to a Line object type (see *Figure 4.2-3*), expressed in radians. The range of the Theta values lies between $-\pi$ and $+\pi$.

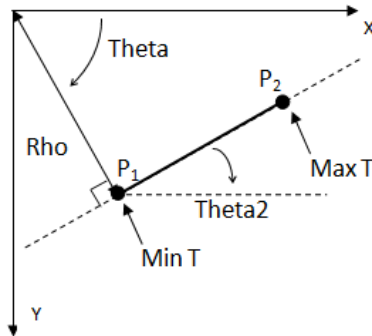


Figure 4.2-3: Attributes of type Line object (not type Chain).

Theta2: Angle between a Line object type and the X axis (see *Figure 4.2-3*), expressed in radians. The range of the Theta2 values lies between $-\pi$ and $+\pi$.

The following measurements can be applied to any 2D object (i.e. Bitmap, Rectangle, Ellipse, and Rectangle):

Area: The area of an object, expressed in calibrated units.

BRFillRatio: Ratio between the *Area* of an object and the *Area* of its bounding rectangle. The bounding rectangle has the same orientation as the X,Y coordinate system of the image.

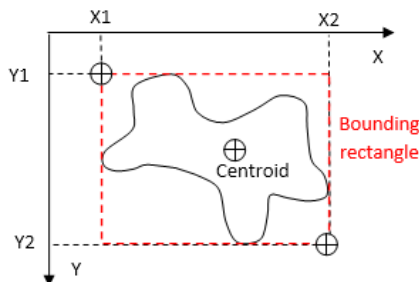


Figure 4.2-4: Bounding rectangle and centroid

Circularity: For a given object, this attribute is equal to $4\pi \cdot \text{Area} / \text{Perimeter}^2$. It is equal to 1 for a circle and close to zero for a thin and long object.

Compactness: An object attribute that is equal to $16 \cdot \text{Area} / \text{Perimeter}^2$. It is equal to 1 for a square object oriented along the X,Y axes and approaches zero for irregular or long and thin objects.

ConvexArea: Area of the *convex hull* of an object. *ConvexArea* is always greater than or equal to *Area*. This measure is expressed in calibrated units.

Convexity: This attribute is equal to the area of an object divided by the area of its convex hull (see following *Help*).

Help: A *convex hull* is the smallest shape that can completely contain an object such that for any straight line segment connecting two points on the convex hull's boundary, the entire line segment is contained inside the convex hull.

ConvexMinAngle: The minimum of the angles formed by the adjacent pairs of line segments that comprise the polygonal boundary of an object, given in radians.

ConvexPerimeter: Perimeter of the convex hull of an object using the *Perimeter* measure and expressed in calibrated units.

CroftonPerimeter: An estimated value of an object's perimeter based on a more complex analysis than 4-connectivity. This analysis results in a more accurate perimeter estimate for most cases. This measure is expressed in calibrated units.

Help: *CroftonPerimeter* gives a more accurate estimate of an object's Euclidean (i.e., true) perimeter and is less sensitive than *Perimeter* to the object's orientation.

Elongation: The absolute value of the difference between the inertias of the major and the minor axes, divided by the sum of these inertias. The minor axis is defined as the perpendicular axis to the major axis. This measure is zero for a circle and approaches 1 for a long and narrow ellipse.

EquivalentDiameter: Gives the diameter of the circle whose area is equal to the area of the object, expressed in calibrated units.

EquivalentDiameterP: Gives the diameter of a circle whose perimeter equals the perimeter of the object, expressed in calibrated units.

Help: The Feret diameter is an important concept in image analysis. It is a line segment that is formed by the orthogonal projections of an object's boundary pixels onto a line of specified angle. *Figure 4.2-5* provides a graphical depiction of a Feret diameter.

Feret.Diameters: The set of projection lengths (i.e., Feret diameters) derived from an object, where the angle of each projection is $n \cdot \pi/N$, with n ranging from 0 to $N-1$ (N is the Direction count). The Feret diameters are expressed in calibrated units.

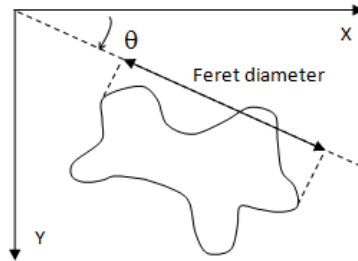


Figure 4.2-5: Feret Diameter for angle

Feret.Elongation1: This attribute is the ratio computed as the Feret diameter that is perpendicular with the *Feret.Max* diameter divided by the *Feret.Max* diameter.

Feret.Elongation2: This attribute is the ratio computed as the *Feret.Min* diameter divided by the Feret diameter that is perpendicular with the *Feret.Min* diameter.

Feret.Max: Maximum Feret Diameter in an object's set of Feret diameters.

Feret.Max.Theta: The angle of the Maximum Feret diameter (*Feret.Max*) for an object, expressed in radians. The range of the *Feret.Max.Theta* values lies between $-\pi/2$ and $+\pi/2$.

Feret.Mean: Mean of the Feret diameters of an object.

Feret.Min: Minimum Feret diameter in an object's set of Feret diameters.

Feret.Min.Theta: The angle of the Minimum Feret diameter (*Feret.Min*) for an object, expressed in radians. The range of the *Feret.Min.Theta* values lies between $-\pi/2$ and $+\pi/2$.

Feret.MinMaxRatio: Ratio between the minimum and the maximum Feret diameters for an object. This ratio is equal to 1 for a circle, is less than 1 for an elongated object, and equals zero for a straight line.

Feret.PentlandSphericity: Equal to $4 \cdot \text{Area} / (\pi \cdot \text{Feret.Max}^2)$ for an object. This attribute is similar to the *Circularity* attribute with the *Feret.Max* replacing the *CroftonPerimeter*.

FractionOfSurfaceArea: The number of pixels in an object (*PixelCount*) divided by the number of pixels in the image region from which the ObjectSet was extracted.

HolesArea: Area of the holes in an object. A hole is one or more connected background pixels fully contained within an object.

HolesTotalArea: Total area of all the holes in all objects. A hole is one or more connected background pixels fully contained within an object.

Volume (3D only): the calibrated volume of an object.

SurfaceArea (3D only): The number of occurrences of a voxel in the object that is 6-way adjacent to a voxel not in the object. Each boundary is counted once, so a single voxel has a surface area of six (when using a (1,1,1) calibration).

CroftonSurfaceArea (3D only): The normalized count of the number of occurrences of edges in the 13 directions of the cubic grid, obtained by applying the Crofton formula.

Sphericity (3D only): For a given object, this attribute is equal to $36 * \text{PI} * (\text{Volume}^2) / (\text{CroftonSurfaceArea}^3)$.

LeastSquaresPlaneNormalVector (3D only): The vector (x, y, z, rho, theta, phi) normal to the plane minimizing the sum of the squared distances of the pixels to the plane (x, y, z) is the centroid.

LeastSquaresPlaneVector2 (3D only): The second eigen vector in increasing eigen value order (LeastSquaresPlaneNormalVector is the first vector).

LeastSquaresPlaneVector3 (3D only): The third eigen vector in increasing eigen value order (LeastSquaresPlaneNormalVector is the first vector).

LeastSquaresPlaneError (3D only): The sum of the squared distances of the pixels to the least squares plane.

Intercepts: Number of transitions from the background to the object in the 0°, 45°, 90° and 135° directions.

Key: The Key of an object is the index number of this object in its ObjectSet. Clicking on a Key in a measurements grid causes the associated object to be highlighted in the Visualization Window. Conversely, clicking on an object in the Visualization Window causes the measurement grid row associated with that object's Key to be highlighted.

Help: MBR stands for *Minimum Bounding Rectangle*. It is the smallest rectangle whose area wholly contains an object (i.e., minimizing the following formula):

$$\text{Feret.Diameters}(\theta) \times \text{Feret.Diameters}(\theta + \pi/2).$$

The MBR is usually not parallel to the X,Y image axes.

MBR.Area: Area of the MBR, expressed in calibrated units.

MBR.Center: Coordinates of the center of the MBR.

MBR.FillRatio: Ratio between the area of an object (*Area*) and the area of its MBR (*MBR.Area*).

Tip: *MBR.FillRatio* is an object shape attribute independent of the object's orientation. It is not the case of the attribute *BRFillRatio*. So it is better to use the attribute *MBR.FillRatio* instead of *BRFillRatio* to discriminate objects based on their shape.

MBR.Height: Length of the smallest side of the Minimum Bounding Rectangle (see *Figure 4.2-6*) of an object, expressed in calibrated units.

MBR.HeightWidthRatio: Ratio between MBR.Height and MBR.Width.

MBR.Perimeter: *Perimeter* of the MBR, expressed in calibrated units.

MBR.Polygon: List of an MBR's corner points as x,y coordinates.

MBR.Theta: Angle of the largest side of the MBR (labeled as MBR.Width in *Figure 4.2-6*). This angle is expressed in radians. The range of the MBR.Theta values lies between $-\pi/2$ and $+\pi/2$.

MBR.Width: Length of the largest side of the Minimum Bounding Rectangle (see *Figure 4.2-6*) of an object, expressed in calibrated units.

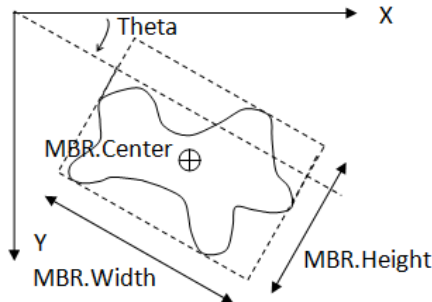


Figure 4.2-6: Minimum bounding rectangle measurements

NumberOfHoles: Number of holes in an object. A hole is one or more connected background pixels fully contained within an object.

Perimeter: An estimated value of an object's perimeter based on the number of 4-connectivity adjacent pixels along the object's boundary. This measure is expressed in calibrated units.

PerimeterRatio: Ratio between the perimeter of an object and the perimeter of its bounding rectangle, where the latter is oriented along the X,Y axes. The perimeter measure used for this ratio is *Perimeter* as described above.

PerimeterVariation: The sum of the direction changes between boundary pixels, where a 45-degree change equals 1, a 90-degree change 2, and a 135-degree change 3.

Projection.Count: A vector whose scalar elements are the number of pixels in each stripe of a set of contiguous stripes partitioning an object and having a given width and direction (angle measured from x axis). (*Figure 4.2-7*).

Projection.Mean: A vector whose scalar elements are the mean pixel value for each stripe of a set of contiguous stripes partitioning an object and having a given width and direction (angle measured from x axis). (*Figure 4.2-7*).

Projection.Width: A vector whose scalar elements are the lengths of each stripe of a set of contiguous stripes partitioning an object and having a given width and direction (angle measured from x axis). (*Figure 4.2-7*).

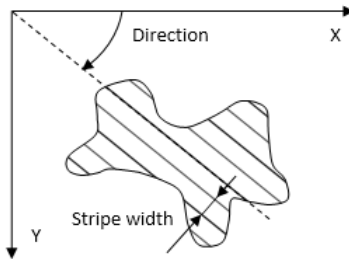


Figure 4.2-7: Direction and stripe width used to compute the Projection attributes Count, Mean, Width.

SymmetryMeanDifference: Mean of the absolute values of the length difference between the centroid and two opposite boundary points of an object (see *Figure 4.2-8*). This shape attribute is given in calibrated units. With N equal to the number of boundary points divided by two, the measurement's formula is:

Note: *SymmetryMeanDifference* is not computed when the centroid is outside the object, as one of the extremities may be undefined.

$$\frac{1}{N} \sum_{i=0}^{N-1} |\rho(i) - \rho'(i)|$$

With $\rho(i) = \|\overrightarrow{CX}\|$ and

$$\rho'(i) = \|\overrightarrow{CX'}\|$$

and $\text{Angle}(\overrightarrow{CX}, \overrightarrow{CX'}) = \pi$

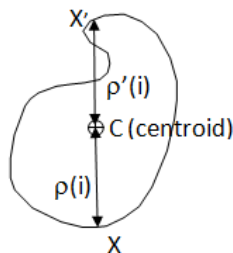


Figure 4.2-8: Symmetry mean difference

Volume: Sum of pixel intensity values in an object.

The following measurements can only be applied to objects of type Polygon:

PolygonArea: Area of a polygon, expressed in calibrated units.

5. LIST OF FUNCTIONS (Dev and SDK only)

The set of Aphelion functions² for images and ObjectSets are described below.

5.1. *Images*

5.1.1. *Arithmetic*

Abs: Computes the absolute value of pixel values of an image

Add: Adds two images together

Blend: Performs an alpha blending combination of two images

Divide: Divides two images together

Invert: Inverts the pixel values of an image

LinearScale: Maps image values using a linear ramp function

Maximum: Returns the pixel-by-pixel maximum of two images

Minimum: Returns the pixel-by-pixel minimum of two images

Multiply: Multiplies two images together

Subtract: Subtracts two images

5.1.2. *Color*

Conversion

SetColorSpace: Changes the color space of the image to the selected one and computes the three bands of the image in this space. See

² Note some functions are only available in the optional extensions of Aphelion Dev. Contact your Aphelion representative or the Aphelion support team to get further information about one of these functions.

6.4.6 Color Space Definitions for information about the space color transforms

Enhancement

StainCorrection: Transforms a color image based on the V algorithm. This transform is well suited to normalize the color rendering of a stained image

Utility

ExcessRGB: Computes a set of excess color images from RGB images

ExpandRGB: Converts a one band image with a look up table into an color image (RGB image)

Intensity: Computes the intensity image **JoinColor:** Joins 3 monochrome images to generate a color image in the defined color space

SplitColor: Splits the 3-band color image into 3 monochrome images

5.1.3. Edge Detection

AverageColorDistanceGradient: Performs a color edge detection using the default color distance defined for the specified color space

CannyDericheEdges: Performs a Canny-Deriche edge detection on the input image

EdgesThin: Performs edge thinning by suppression of non-maximal magnitude edge values in a local neighborhood

MorphoGradient: Performs morphological edge detection by subtracting the eroded image from the dilated image

PrewittEdges: Produces edges at every pixel where the gradient magnitude is at least as great as the *magnitudeThreshold*

RidgeValleyEdges: Detects ridge & valley edges for a given input image

RobertsEdges: Applies two 2x2 kernels over the input image: along the NW-SE diagonal & along the SW-NE diagonal

SobelEdges: Produces edges at every pixel where the gradient magnitude is at least as great as the *magnitudeThreshold*

ZeroCrossing: Computes an edge image based on the zero-crossings of the non-directional second derivative of the image intensity values

5.1.4. Enhancement

EqualizeHistogram: Equalizes the histogram of an image. A global or adaptative contrast enhancement can be applied to the image

ShadingCorrection: Performs the shading correction of the input image based on a flat field and dark current images

5.1.5. Filtering

Convolve: Convolves an image using a user-defined M*N kernel

BoxFilter: Performs box filtering on an image using an arbitrary window size

Gaussian: Convolves an image using a kernel generated with a Gaussian shape

LowStop: Performs a fast low-stop filter by subtracting the results of a fast low-pass filter from the original image

Median: Performs median filtering using a user-defined M*N window

Mode: Performs mode filtering on an image

Nagao: Performs the edge-enhancement image smoothing algorithm proposed by Nagao & Matsuyama

RankValue: Provides a median-like filter where an element can be selected from the sorted list of pixel values

Weymouth: Performs image enhancement proposed by Weymouth and Overton

5.1.6. Frequency

ButterworthFilter: Performs a bandpass or bandcut filter to a frequency image. The filter response is defined by a Butterworth function

ExponentialFilter: Performs a bandpass or bandcut filter to a frequency image. The filter response is defined by an exponential function

FFT: Performs fast Fourier transform on an input image

InverseFFT: Performs fast inverse Fourier transform on an input image

GaussianFilter: Performs a bandpass or bandcut filter to a frequency image. The filter response is defined by a Gaussian function

RectangularFilter: Performs a bandpass or bandcut filter to a frequency image. The filter response is defined by an exponential function

TrapezoidalFilter: Performs a bandpass or bandcut filter to a frequency image. The filter response is defined by the identity inside the mask and zero outside the mask

5.1.7. Geometry

AffineMap: Performs an affine transform of the input image

Rotate: Performs an affine rotation of the input image about its midpoint

Scale: Performs an affine scaling of the input image

Shear: Performs an affine shear transform of the input image

Translate: Performs an affine translation of the input image

Warp: Performs the warping of an image using a set of user-specified control points

5.1.8. Logic

And: Performs logical AND of two images

BitAnd: Performs a pixel-by-pixel bitwise AND of an image

BitDifference: Finds the bit difference of 2 images

BitNot: Takes the bitwise complement of the pixel values in an image

BitOr: Performs a bitwise OR of an image

Difference: Performs logical difference

Not: Performs logical NOT of an image

Or: Performs logical OR of two images

Xor: Performs logical exclusive OR of two images

5.1.9. Matching

AutoCorrelate: Performs the cross-correlation of an image by itself

Cooccurrence: Computes a cooccurrence matrix of an input image for a specified offset

Correlate: Computes correlation of a template pattern with an input image

CrossCorrelate: Performs a cross-correlation between 2 images

HoughCirclesAccumulator: Computes the Hough accumulator image for all circles whose radius belongs to the defined range and for all possible center locations

HoughLinesAccumulator: Computes the Hough accumulator image for lines whose length is at least equal to *Minimum Line Length* and in *Direction Count* directions ranging from 0 to $\pi/2$

OpticalFlow: Computes the optical flow between a source image and a target image

Register: Registers two images and generate a new image that corresponds to the first image aligned to the second one

5.1.10. Math

ACos: Performs an arc cosine operation of each individual pixel value of the input image

ASin: Performs an arc sine operation of each individual pixel value of the input image

ATan: Performs an arc tangent operation of each individual pixel value of the input image

ComplexFacet: Copies the selected band of a frequency image (real, imaginary, magnitude, or phase part) into a gray-scale image

Conjugate: Computes the complex conjugate of an image

Cos: Performs a cosine operation of each individual pixel value of the input image

Exp: Performs the Exponential function on every pixel

Exp10: Performs the Base-10 Exponential function on every pixel

ImaginaryPart: Copies the imaginary part of a frequency image into a gray-scale image

Inverse: Computes the inverse of each individual pixel value of the input image

Log: Performs the Logarithm function on every pixel

Log10: Performs the Base-10 Logarithm function on every pixel

Magnitude: Copies the magnitude part (band) of a frequency image into a gray-scale image

MatrixMultiply: Multiplies a three-band image by a 3x3 user-specified matrix on a pixel basis

Phase: Copies the phase part (band) of a frequency image into a gray-scale image

RealPart: Copies the real part of a complex image into a gray-scale image

Sin: Performs a sine operation of each individual pixel value of the input image

Sqr: Computes the Square of every pixel

Sqrt: Computes the Square root of every pixel

Tan: Performs a tangent operation of each individual pixel value of the input image

5.1.11. Measurements

Area: Computes the area of a binary image

BoundingBox: Computes the coordinates of the upper-left and lower-right corners of the bounding box surrounding all pixels whose value is not null

Compare: Compares each pixel in an image with the corresponding pixel in a second image, returning the quantity of such pixel pairs that have equal intensity

Correlation: Computes the correlation index between 2 images

Distance: Computes the distance between 2 points in an image

Euler: Computes the Euler number (connectivity number) of a binary image

Histogram: Computes the intensity histogram of all pixels in the image

Intercepts: Computes the intercepts of a binary image

LocalMoments: Computes the local moments of a gray level image

Moments: Computes the first & second order moments

MultiBandHistogram: Computes a two-dimensional histogram on 2 user-defined bands of a color image

ObjectCount: Returns the number of 4-connected objects/bitmaps in the input image

Profile: Get the values of all the pixels under a profile line

Range: Computes the minimum and maximum values of the image pixels for a given band

Variance: Computes the image variance

Volume: Computes the sum of all pixel intensities in an image

5.1.12. Morphology

Basic

ConstrainedThicken: Performs a constrained thickening which specified pixels cannot thicken

ConstrainedThin: Performs a constrained thinning which specified pixels cannot thin

Dilate: Performs morphological dilation of the input image

Erode: Performs morphological erosion of the input image

HitOrMiss: Performs a hit-or-miss transform on an input image

Thicken: Performs a thickening by a user-defined neighborhood configuration on a binary image

Thin: Performs thinning by a neighborhood configuration on a binary image

Distance

Distance: Computes for every non-zero pixel of an image the distance to the nearest zero pixel. The computed distance is a true Euclidean distance for the first overload, or a graph distance depending on the selected graph for the second overload

Enhancement

Contrast: Performs a morphological contrast on the input image

Features

LocalMaxima: Computes the binary image containing the local maximum pixels of a gray-scale image

LocalMinima: Computes the binary image containing the local minimum pixels of a gray-scale image

RegionalMaxima: Computes the binary image containing the regional maximum pixels or the h-maxima pixels of a gray-scale image depending on the specified overload

RegionalMinima: Computes the binary image containing the regional minimum pixels or the h-minima pixels of a gray-scale image depending on the specified overload

UltimateErodedSet: Computes the ultimate eroded sets, using the Euclidean or graph distance depending on the specified overload

Filtering

AlternateSequential: Performs an alternate sequential filter (ASF) on the input image

AutoMedian: Performs an automedian filter on the input image

Geodesy

BorderKill: Removes all connected components connected to the image borders

BorderKillAndHoleFill: Performs both a BorderKill and HoleFill

Dilate: Performs a geodesic dilation using a specified structuring element

Distance: Computes for every non-zero pixels the distance of the shortest path, inside the given mask, to the nearest pixel whose value is zero. The computed distance is a Euclidean distance when the first overload is selected or a graph distance depending on the specified graph

HoleFill: Puts all zero point sets surrounded by non-zero points to non-zero points

Reconstruct: Performs a reconstruction of an input image inside a reference image (mask)

WeightedDistance: Computes the geodesic distance to the background inside the specified mask image, using the specified graph, and using an image defining the weights of spread

Opening/Closing

AddReconsClose: Adds a constant to the input image and reconstructs the resulting image outside the input image

AreaClose: Performs a closing based on the surface area of structures present

AreaOpen: Performs an opening based on the surface area of structures present

Close: Performs morphological closing of the input image

DilateReconsClose: Dilates the input image & reconstructs the resulting image

ErodeReconsOpen: Erodes the input image & reconstructs the resulting image

InfimumClose: Performs the intersection of closings by segments in all directions

Open: Performs morphological opening of the input image

SubtractReconsOpen: Subtracts a constant to the input image and reconstructs the resulting image inside the input image

SupremumOpen: Performs the combination of openings by segments in all directions

Segmentation

BlackTophat: Performs a Top Hat over the black structures (clusters of low intensity pixels) of the input image using the supplied structuring element

CatchmentBasins: Computes the catchment basins of the input image

SeededCatchmentBasins: Reconstructs the catchment basins of the input image from seeds

SeededWatershed: Reconstructs the catchment basins with the 1-pixel width boundaries (watershed) of the input image from seeds

SplitConvex: Uses the watershed operator to split connected blobs into convex blobs

Watershed: Computes the catchment basins with the 1-pixel width boundaries (watershed) of the input image

WhiteTophat: Performs a Top Hat over the white structures (clusters of high intensity pixels) of the input image using the supplied structuring element

Skeleton

ConnectedSkeleton: Computes a connected skeleton of a binary image

MinimalSkeleton: Computes the minimal skeleton of a binary image

OpenSkeleton: Computes the opening skeleton of a binary image

ThickenSkeleton: Computes a skeleton by thickening the input binary or gray-scale image

ThinSkeleton: Computes a skeleton by thinning the input binary or gray-scale image

5.1.13. Segmentation

AdaptivePercentileThreshold: Automatically computes the couple of thresholds such as the number of pixels between the two thresholds-total number of pixel ratio of the input image is equal to the defined percentile. The first overload returns the couple of computed thresholds while the second overload produces the output binary image computed by the Threshold function using the computed thresholds

Clusters: Produces a region-label image from a binary image based on a specified graph

EntropyThreshold: Automatically computes the threshold using the entropy of the gray-scale histogram of the input image. The first overload returns the threshold interval defined by the computed threshold and the maximum value of the input image, and the second overload produces the output binary image computed by the Threshold function using the threshold interval

GraphSegmentation: Performs an efficient graph-based segmentation on an input color image

HierarchicalPartition: Constructs a hierarchical partition of an image based on a watershed

HysteresisThreshold: Reconstructs the binary image produced by the Threshold function using the user-defined hysteresis thresholds from the binary image produced by the Threshold function using the user-defined seed thresholds

MaximumContrastThreshold: Automatically computes of the thresholds using the maximization of the contrast of the input image and produces a N-level image, where N is equal to the user-defined threshold count plus one

OtsuThreshold: Automatically computes the threshold using the Otsu's method (minimization of the intra-class variance). The first overload returns the threshold interval defined by the computed threshold and the maximum value of the input image, and the second

overload produces the output binary image computed by the Threshold function using the threshold interval. A parameter lets select either dark or bright objects in the image.

RegionGrow: Performs region growing on a gray-scale input image and produces a region-label image

SeededColorRegionGrow: Performs a region growing on an input color image from a set of foreground and background seeds using the color distance

SeededRegionGrow: Performs a region growing algorithm on a gray-scale image from a region-label seed image and produces a region-label image

Threshold: Produces a binary image such as output pixel values are equal to 1 between the lower and upper bound, else equal to zero

5.1.14. Texture

LawsTexture: Computes the 9 Laws texture images for a given input image. The 9 single-band images are copied into a multi-band image

5.1.15. Utility

Clear: Sets all pixels in an image to 0

Clip: Clips the pixel values of an image to a specified range

Copy: Copies the input image to a destination image

CopyBand: Inserts a single band image (gray-scale image) into a multi-band image as its Nth band

CopySlice: Inserts a 2D image as a defined slice of a 3D image

ExtractBand: Extracts the Nth band of a multi-band image to produce a single band image (gray-scale image)

ExtractSlice: Extracts a defined slice from a 3D image and converts it into a 2D image

Fill: Fills each pixel value of an image with a constant value

MapThroughLUT: Creates an output image by applying a LookUpTable to the values of the input image

Mask: Masks an image using another image as the mask

Paste: Pastes (copies) an image on top of another image at a specified location

SetClass: Sets the class of the image

SetType: Sets the datatype of the image pixel values

SubCopy: Copies the portion of the input image inside the region of interest into an output image resized to the dimensions of the area being copied from the input image. One of the function overloads supports multiple ROIs

5.1.16. IO (Input/Output)

Export: Exports a 3D image to a series of image files

Import: Reads an arbitrary binary file into Aphelion image format

Read: Reads an image into an Aphelion Image

Write: Writes an Aphelion Image to a file in a specified image file format

5.2. ObjectSets

5.2.1. Arithmetics

Add: Performs the addition of two scalar attributes of an ObjectSet

Divide: Performs the division of two scalar attributes of an ObjectSet

Maximum: Performs the Sup operation of two scalar attributes of an ObjectSet

Minimum: Performs the Inf operation of two scalar attributes of an ObjectSet

Multiply: Performs the multiplication of two scalar attributes of an ObjectSet

Subtract: Performs the subtraction of two scalar attributes of an ObjectSet

5.2.2. Bitmaps

Generation

AdaptativePercentileThreshold: Produces a set of bitmaps from the output of the *Images.Segmentation.AdaptativePercentileThreshold* function

Clusters: Generates a set of connected components on the input image and converts these components into bitmap objects

EntropyThreshold: Produces a set of bitmaps from the output of the *Images.Segmentation.EntropyThreshold* function

HysteresisThreshold: Produces a set of bitmaps from the output of the *Images.Segmentation.HysteresisThreshold* function

Labels: Converts each label of a labeled image into a bitmap object

MaximumContrastThreshold: Produces a set of bitmaps from the output of the *Images.Segmentation.MaximumContrastThreshold* function

OtsuThreshold: Produces a set of bitmaps from the output of the *Images.Segmentation.OtsuThreshold* function

RegionGrow: Produces a set of regions from the output of the *Images.Segmentation.RegionGrow* function

SeededRegionGrow: Produces a set of regions from the output of the *Images.Segmentation.SeededRegionGrow* function

Threshold: Produces a set of bitmaps from the output of the *Images.Segmentation.Threshold* function

ZeroCrossing: Produces a set of bitmaps from the output of the *Images.Segmentation.ZeroCrossing* function

Logic

And: Performs the logical and of two bitmap attributes of an ObjectSet

Difference: Performs the logical difference of two bitmap attributes of an ObjectSet

Or: Performs the logical or of two bitmap attributes of an ObjectSet

Overlap: Computes the set of bitmaps which overlaps for each bitmap in an ObjectSet

XOr: Performs the logical exclusive or of two bitmap attributes of an ObjectSet

Morphology

Close: Performs a morphological closing of each bitmap in an ObjectSet

Dilate: Performs a morphological dilation of each bitmap in an ObjectSet

Erode: Performs a morphological erosion of each bitmap in an ObjectSet

HoleFill: Fills holes in bitmaps, creating a new bitmap attribute containing the filled bitmaps

Open: Performs a morphological opening of each bitmap in an ObjectSet

5.2.3. Chains

Generation

BitmapsToChains: Generates for each Bitmap shape of an ObjectSet a Chain shape corresponding to the contour of the Bitmap

EdgelsToChains: Groups edgels into chains in an iterative process

5.2.4. Circles

BitmapsToCircles: Generates for each Bitmap shape of an ObjectSet a Circle shape surrounding the Bitmap

HoughCircles: Extracts circles from an image based on a Hough transform

5.2.5. Classification

Attach: Attaches the image inside the bounding rectangle of any object to the ObjectSet

Classify: Classifies the objects of an ObjectSet by applying a classifier generated by ClassifierBuilder

5.2.6. Display

Draw: Draws one spatial attribute of an ObjectSet in the overlay of an image

Erase: Removes one spatial attribute overlay for one ObjectSet from image display

Expand: Expands or collapses an attribute in the grid displaying an ObjectSet

ShowGrid: Opens the grid containing the ObjectSet

ToText: Converts the values of an attribute to text objects stored in a text attribute and placed at a X,Y location

5.2.7. Edgels

Generation

EdgesToEdgels: Converts edge data from an image format to edgel Objects

Grouping

EdgelNeighbors: Computes the set of near-by for each edgel in an ObjectSet

5.2.8. Filtering

Filter: Removes Objects from an ObjectSet falling outside (or inside, depending on the selected overloading) the specified range for a numeric attribute

5.2.9. Geometry

AffineMap: Performs an affine transform of the input ObjectSet. The affine transform is defined by a 3x3 matrix. The result is defined as another spatial attribute of the input ObjectSet or in another ObjectSet depending on the selected overload

Rotate: Performs an affine rotation of the input ObjectSet about its midpoint. The result is defined as another spatial attribute of the input ObjectSet or in another ObjectSet depending on the chosen overload

Scale: Performs an affine scaling of the input ObjectSet. The result is defined as another spatial attribute of the input ObjectSet or in another ObjectSet depending on the specified overload

Translate: Performs an affine translation of the input ObjectSet. The result is defined as another spatial attribute of the input ObjectSet or in another ObjectSet depending on the specified overload

5.2.10. Input/Output (IO)

Export: Exports an ObjectSet to a text file. Note spatial attributes are not exported

EportToSTL: Exports a given spatial attribute of an ObjectSet into a STL file

Read: Reads an ObjectSet from a file and loads it

Write: Writes an ObjectSet in a file

5.2.11. Lines

Generation

BitmapLineFit: Fits a straight line for each region object of the input ObjectSet. The result is defined as another spatial attribute of the

input ObjectSet or in another ObjectSet depending on the specified overload

ChainLineFit: Fits a straight line for each chain object of the input ObjectSet. The result is defined as another spatial attribute of the input ObjectSet or in another ObjectSet depending on the specified overload

HoughLines: Generates lines from an image by invoking HoughLinesAccumulator then filtering the extracted lines

5.2.12. Matching

Register: Registers two Descriptor ObjectSets and generates a transform matrix

5.2.13. Measurements

ChainMeasurements: Computes the attributes of each chain object in a given ObjectSet (curvature, length, and angle)

Descriptors: Computes local floating-point descriptors on an image key points

FeretShapeMeasurements: Computes the Feret attributes (minimum and maximum bounding box and all associated orientations) of each bitmap in an ObjectSet. The minimum bounding box (MBR) and its attributes are computed by this operator

Histogram: Computes a 1D histogram for a chosen measurement

LinesMeasurements: Compute measurements on the specified line spatial attribute of an ObjectSet or on the default spatial attribute of a specified ObjectSet

Moments: Computes the first order moments of a chosen measurement (mean, standard-deviation, skewness, and Kurtosis)

ProjectionShapeMeasurements: Computes projections for each shape contained in the specified ObjectSet or contained in the specified spatial attribute of an ObjectSet along the direction specified by an angle

StandardShapeMeasurements: Computes the shape attributes for each object in an ObjectSet

Statistics: Computes the statistics (minimum, maximum average intensity, etc.) of a selected attribute for each object in an ObjectSet

TextureMeasurements: Computes the texture attributes defined by Haralick (Energy, Entropy, Contrast, Inverse Difference Moment, Correlation) for each object in an ObjectSet

Note: The number of measurements computed by the functions above depends on the measurements selected in the Setting Task.

5.2.14. Points

Generation

DetectKeyPoints: Detects key points of an image using one of the predefined key point detectors

5.2.15. Polygons

Generation

ConvexHull: Computes the convex hull spatial attribute of each bitmap object in an ObjectSet

5.2.16. Rectangles

Generation

SelectiveSearch: Generates candidate regions of interest (ROI) as rectangles in an ObjectSet from an image

5.2.17. Skeletons

Filter: Keeps only branches of the specified 3D skeleton ObjectSet longer than a specified length

Skeleton: Computes a skeleton by thinning the specified binary image, extracts the branches of the skeleton, and computes their lengths and their neighbors

TreeSkeleton: Extracts the 3D Skeleton in the 3D space of a binary image

TreeSkeletonSetRoot: Sets a specified branch as the root of the tree skeleton

5.2.18. Utility

Append: Combines two ObjectSets by adding the second set to the first one

Copy: Duplicates an ObjectSet

Merge: Merges two ObjectSets into one

Set: Initializes a numerical attribute to a constant value

SplitVectorAttribute: Extracts a scalar attribute specified by its index from a vector attribute

ToImage: Performs a raster conversion of a spatial attribute and writes the result into the output image. The gray-scale value sets inside each object in the output image is either the value of a specified numerical attribute or a constant value, depending on the selected overload

6. OPTIONAL EXTENSIONS (Dev version only)

Aphelion Extensions are optional programs that extend the capabilities of the Dev product. These extensions include both standalone programs and programs that integrate seamlessly with Dev. Following are brief descriptions of fourteen optional extensions available when the Dev product was released. Check our website for the availability of these and new extensions added in the future (www.adcis.net).

6.1. *3D Image Processing Extension*

Aphelion Dev provides a rich array of functions for 2D images. But, Dev's capabilities are easily extended to include 3D images through use of Aphelion's optional 3D Image Processing extension. Most of the functions in Aphelion's libraries are available for the 3D space. With the extension, 3D data (X, Y, Z) can be processed and measurements can be computed. For example, functions such as filtering, labeling, and watershed are available in the extension and accessible through Dev's GUI. To work on a 3D image, just enter its name in the selected function's Input Image dialog box.

6.2. *3D Image Display Extension*

The 3D Image Display Extension (3DID) is an optional extension of the Aphelion Imaging Software Suite that is fully compatible with Aphelion Dev. It is used to display 3D images and ObjectSets (intensity values for X, Y, and Z coordinates) within the Aphelion Dev environment. Used in combination with the 3D Image Processing extension, 3DID provides the user with the following capabilities:

- Display of a 3D image as a set of slices, a volume, or an isosurface

- Control of scene illumination and viewer position
- Control of image rendering (e.g., intensity, zoom)
- Cross sections (i.e., slices) in X, Y and Z directions
- Control of the palette and object opacity
- Full control over object orientation using only the mouse
- Display of a 3D Aphelion ObjectSet as a solid, points, or wireframe structure with capability to focus on a single object in the ObjectSet

The 3DID extension can be used seamlessly within the Aphelion Dev environment, or in stand-alone applications as a .NET component.

An AVICreator sub-extension can record the motion of a 3D object, and generate an AVI file to be used in a presentation or a multimedia document.

Note: The 3DID extension is available in both 32-bit and 64-bit versions. Use of the 64-bit version is recommended to avoid the limitations inherent in 32-bit environments. This is especially important if very large 3D images will be processed and displayed. Then, the only practical limitation will be the amount of available RAM.

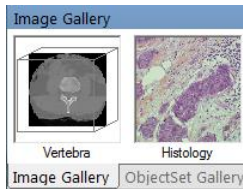
The 3D image display (3DID) capability is automatically available in the Aphelion Dev user interface if the 3DID extension is properly installed and licensed. The 3DID availability can be verified by selecting the Tools→Options→Extensions entry from the Main Menu bar in Aphelion Dev, and checking that the 3D Image Display is licensed and loaded.

Both 2D and 3D images and ObjectSets are correctly displayed in the Visualization window of Aphelion Dev in a way totally transparent and seamless to the user. To differentiate between 2D and 3D images concurrently open in the Visualization window, the name tab for a 3D

image has the image's Rendering Mode appended to its image name as shown in the adjacent graphic. In this example, the image name is "Vertebra" and the 3D Rendering Mode is "Isosurface."

Vertebra (Isosurface)

However, the thumbnail version of a 3D image appearing in the Image Gallery does not have its displayed name modified. Instead, a 3D frame is displayed around the 3D thumbnail as shown in the example below (3D image on left, 2D on right).



With the 3D image open as a thumbnail in the Image Gallery, choose one of the following three alternatives:

- Double-click the image's thumbnail;
- Right-click the image's thumbnail;
- Drag/drop the thumbnail into the Visualization window.

The method for specifying a Rendering Mode depends on which of the three opening alternatives described above was chosen.

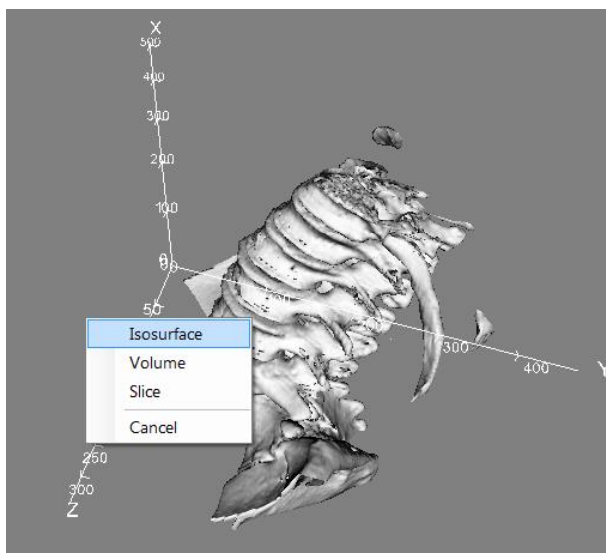
Double-click - If the thumbnail was double clicked by the user, then the image will be assigned the default Rendering Mode. To change the default Rendering Mode, on Dev's Main Menu toolbar select Tools→Options...→Advanced→Images→DefaultThreeDViewer. Note that this is an Administrator level parameter.

Right-click - When a 3D thumbnail is right-clicked, a pop-up menu appears with three entries. Left-click the Show entry to pop-up the Rendering Mode menu. Choose the Rendering Mode type you want

applied to the 3D image. Then, a new tabbed pane is added in the Visualization window and the 3D image is open in that window pane.

Drag/drop - When this alternative is selected, the user can drop the image on either:

- (a) The Visualization window pane, with the result that the image is added to the image(s) already open in that pane, or
- (b) The Visualization window tab bar (directly below the pane), in which case a new tabbed pane is added in the Visualization window and the image is open in that window pane. Irrespective of where the image is dropped, a Rendering Mode pop-up menu appears and the user must select from the list of three Rendering Modes.



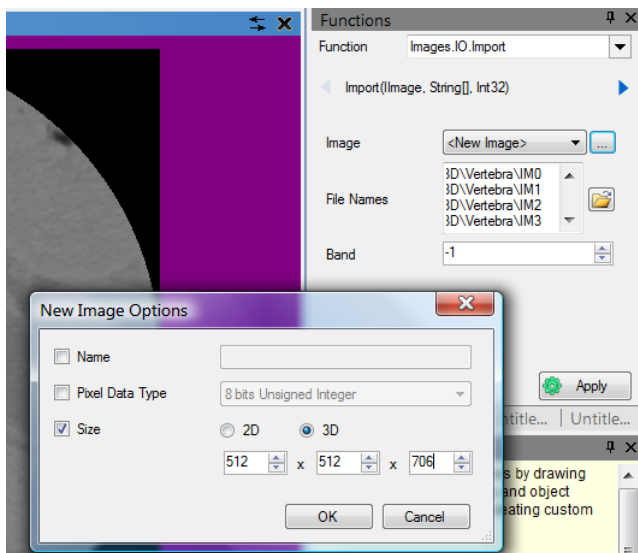
To add a 3D image or ObjectSet in the Dev environment, do the following:

- Open an image (resp. ObjectSet) file whose name has the form filename.vtk (resp. filename.aso or filename.tks)

- Perform one or more image/ObjectSet processing operators on an existing 3D image/ObjectSet that results in a new 3D image/ObjectSet
- Construct a 3D image from a set of 2D sections (see following paragraph)

The corresponding thumbnail representations then appear in the Image/ObjectSet galleries.

2D Sections Method - In the Aphelion Dev user interface, select the function `Images.IO.Import` from the Function drop-down list or click on the Process menu on the Main Menu toolbar and choose the menu entry `Images→IO→Import`. Next, choose the function overload (version) that enables the user to specify a list of 2D image files that will compose the resulting 3D image (see graphic below). Enter the parameters displayed in the Function panel, and also in the New Image Options pop-up window. Be sure that the resulting 3D image is properly specified in the New Image Options window.



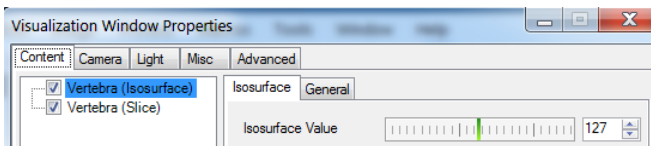
After all parameters are properly set, click on the Apply button to generate the 3D image. When the process finishes, the 3D image will be displayed as a thumbnail in the Image Gallery.

Note: 3D Image Display is based on the VTK product from Kitware, Inc. To learn more about VTK, visit the Kitware web site at www.kitware.com and select OPEN SOURCE→VTK.

6.2.1. Rendering Modes

Three different Rendering Modes are provided to enable the user to visualize 3D images and ObjectSets in different ways. They are named Isosurface, Slice, and Volume (only Isosurface is currently available for ObjectSets). A specific rendering mode, different from the default mode, can be selected when displaying the 3D image or ObjectSet.

The user can enhance the rendering by accessing controls provided in the Visualization Window Properties. These properties vary depending on the Rendering Mode selected and can be accessed by right-clicking on it in the Visualization window. The properties are then displayed in a pop-up window labeled Visualization Window Properties. These properties are divided into two sets of tabs, Main Tabs and Rendering Mode Tabs. There are five Main Tabs and they are aligned near the top of the window and are identical for each of the three rendering modes.

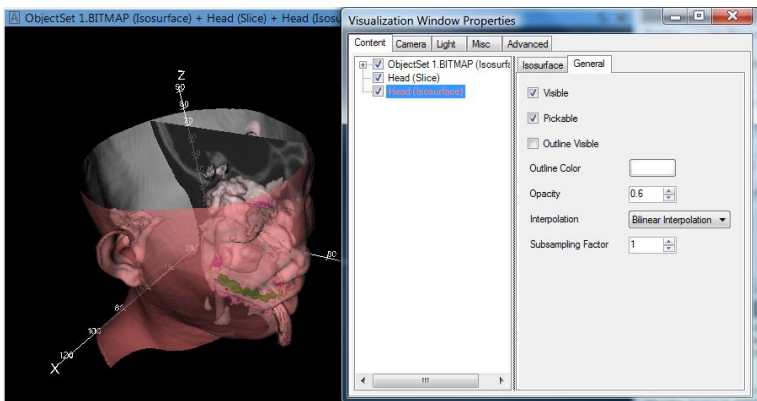


The Rendering Mode Tabs are only visible when the Main Tab named Content is selected. The quantity and functions of the Rendering Mode Tabs varies depending on the Rendering Mode specified for the 3D image. The Rendering Mode Tabs are described below, following the Main Tabs paragraphs.

6.2.2. Main Tabs

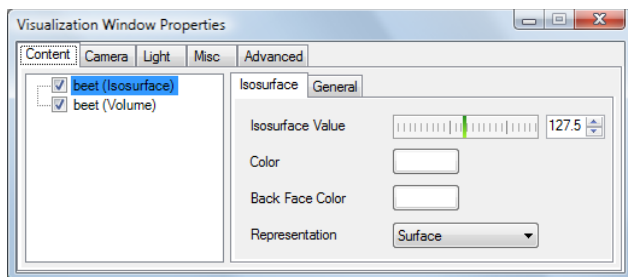
Content Tab

The Content tab displays a pane containing two panels. The left-side panel provides a list of open files that are concurrently displayed in the same Visualization window (i.e., all of the images are visible via the same Visualization window tab). This feature allows the user to concurrently display two or more related images or ObjectSets. In the figure below, the two different Rendering Modes for the same image are displayed concurrently with a3D ObjectSet.

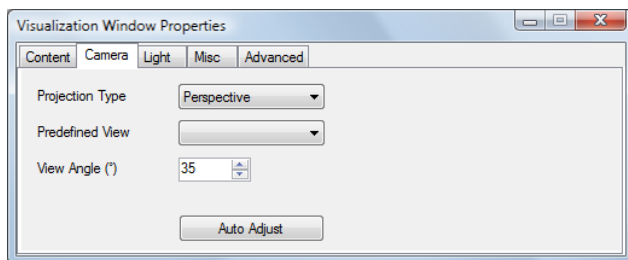


The open files list in the left-side panel provides a checkbox for each file listed. By toggling the checkboxes appropriately, the user can concurrently view any combination of the listed images.

The right-side panel contains the set of Rendering Mode Tabs. Each of these tabs provides tools for enhancing the 3D rendering to suit the user's needs. The number of such tabs varies from two to five depending on the Rendering Mode specified for the image. The example above lists two concurrently open and displayed files with the beet (Isosurface) file highlighted. Consequently, the tabs in the right-hand panel are configured for Isosurface rendering. The specific Rendering Mode tab sets and tools associated with those tabs are described following after the remaining Main Tabs.



Camera Tab



This panel provides four parameters that enable the user to specify the relative orientation of the three axes to a camera held by the user.

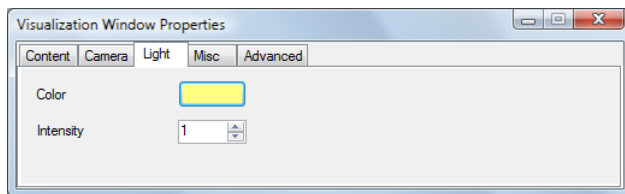
Projection Type - Two projection types are available, perspective and parallel.

Predefined View - Six view options are provided such that the selected axis (e.g., X) is perpendicular to the camera lens and while the other two (e.g., Y, Z) are parallel to the lens. The plus and minus signs mean the zero point of the perpendicular axis is nearer or further, respectively, from the camera.

View Angle (°) - The view angle, α , of the camera lens ranges between 0 and 180 degrees. This definition is similar to the definition used in digital photography.

Auto Adjust - Clicking on this button automatically adjusts the pan and zoom parameters so that the image fills the Visualization window. Note that the View Angle setting is not changed by this process.

Light Tab

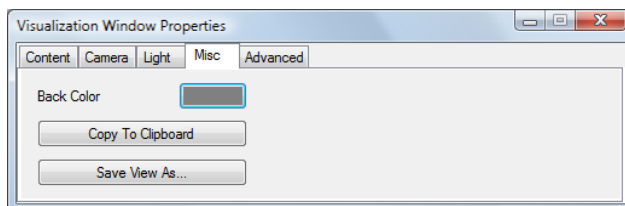


This panel provides two parameters that enable the user to define the light's color and intensity. Since the object is illuminated by the light, the resulting color of the object will appear as a combination of the light's color and intensity, plus the color specified for the object (see Content tab→Isosurface tab→Color button). If the object color is specified as white, the displayed color will be the color specified for the light. If the light color is set to white, the object color will appear as the color specified for the object. As the intensity of the light is increased, the object appearance increases in brightness, to the limit of becoming white.

Color - Clicking on the color rectangle displays a palette of colors from which the user selects the color emitted by the light source to illuminate the object in the image.

Intensity – Enables the user to specify the image intensity or visual brightness. The user can enter any number that lies in the range $0 \leq i \leq 1$ with decimal values.

Misc (Miscellaneous) Tab



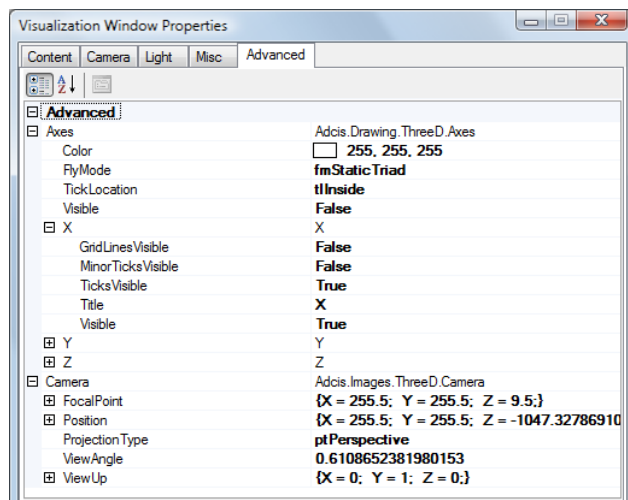
This panel provides three parameters that enable the user to specify the color of the background in the Visualization window and to save the contents of that window.

Background Color - Clicking on the color rectangle displays a palette of colors from which the user selects the background color for the displayed 3D image.

Copy To Clipboard - Clicking on the button copies the displayed contents of the Visualization window to the clipboard.

Save View As - Enables the user to save the displayed contents of the Visualization window as a 2D image in a format specified by the user.

Advanced Tab

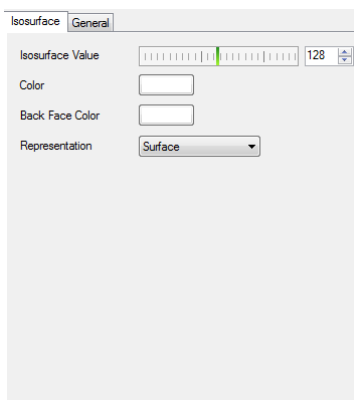
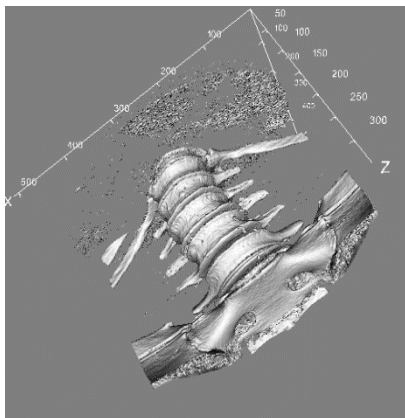


This panel provides a set of parameters that enable the user to fine tune advanced (infrequently changed) parameters of the 3D image currently displayed in the Visualization window.

6.2.3. Rendering Modes Tabs

The three Rendering Modes are named Slice, Isosurface, and Volume. The Rendering Mode Tabs specific to these three modes are only visible when the Main Tab labeled Content is selected.

Isosurface Mode Tabs



Isosurface mode enables the user to view the surface of an object in a 3D image, but not the object's interior surface(s). A surface in a 3D image is defined as a set of connected pixels. Isosurface rendering extends the surface through the intra-section areas by interpolating between neighboring pixels.

Isosurface Tab

Isosurface Value - A slider control to specify the pixel threshold value for inclusion as a surface pixel.

Color - Displays a color palette from which an object's surface color can be chosen.

Back Face Color - Displays a color palette from which a color can be chosen for the back surface of objects. If an error message pops up, then go to Tools→Options→Advanced→Appearance→Images and set the UseMemorySavingIsoSurface option to False. Note that this feature

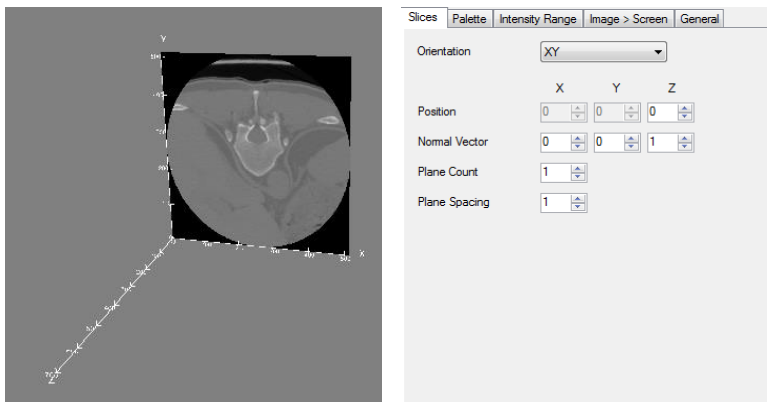
uses a lot of main memory on the video adapter and it is not recommended to set its value to False, unless needed for the project.

Representation - A drop-down menu that provides three options for visualizing the isosurface objects as:

- Sets of individual disconnected points,
- Wireframes inter-connecting the points, or
- Contiguous surfaces.

See Also *General Tab*.

Slice Mode Tabs



Slice mode enables the user to view individual 2D sections of the 3D image in a structured, relational manner. This is accomplished through the use of the Slice mode panel found in the Visualization window properties. The following figure shows a single, 3D image slice adjacent to the Slice mode panel.

Slices Tab - This tab provides the user with tools for visualizing one or more 3D image slices.

Orientation - To choose the plane (XY, XZ, YX) of the slice(s).

Position - To specify the index of the first slice.

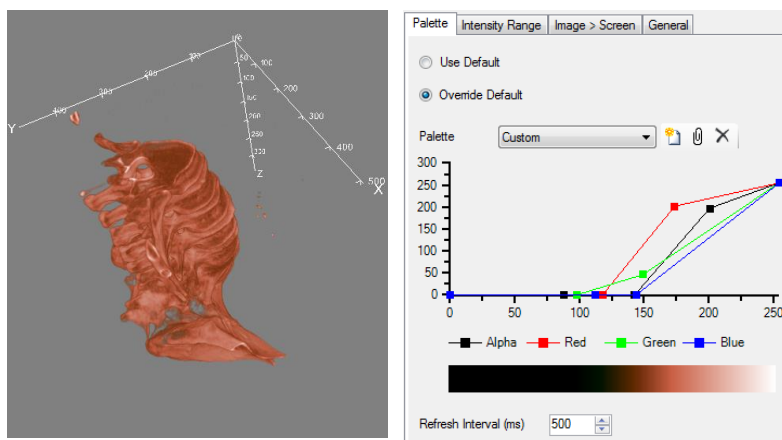
Normal Vector - To specify the 3D orientation of the normal vector to the slice (not yet implemented).

Plane Count - To specify the quantity of adjacent slices to be displayed beginning with the slice specified by the Position index.

Plane Spacing - To specify the quantity of pixels (i.e., distance) between any pair of adjacent sections.

See also *Palette Tab*, *Intensity Range Tab* and *General Tab*.

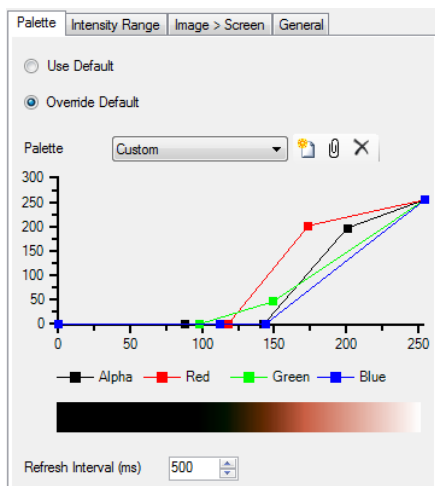
Volume Mode Tabs



The Volume Mode displays the 3D image using pixel intensities, resulting in a volume rendering based on transmitted light information. This Rendering Mode enables the user to look inside 3D volumes by controlling their opacity (complement of transparency) and adjusting the Alpha channel to locally modify the opacity value.

See also *Palette Tab*, *Intensity Range Tab* and *General Tab*.

Palette Tab



Tools are provided for adjusting the Alpha channel to enhance the opacity of a 3D object in order to better view its interior surfaces.

Use Default - When selected, the default specification of the Alpha channel, as reflected in the black curve displayed in the Palette panel, will be applied to the image currently displayed in the Visualization window. Selection of this option disables all other tools on this panel.

Override Default - When selected, all of the tools on this panel are enabled.

Palette - Provides a dropdown list from which the user can select a specific color palette to be used to represent the pixel intensities of the 3D object(s) displayed in the Visualization window.

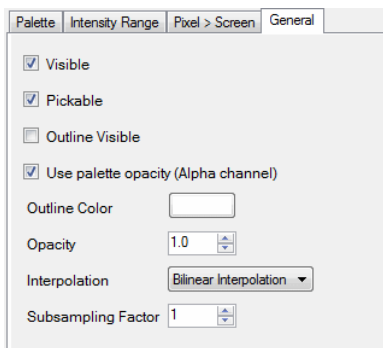
Color channel graph - The X axis corresponds to the actual pixel intensities for the R, G, B, and Alpha channels (8-bit pixels, intensity range 0 to 255) of the image. The Y axis shows the resulting pixel values for each X axis value, also 8-bit data. A color channel's connected line segments defines a graphical function that, for each pixel in the image, transforms the pixel's X value to the indicated Y value. The user can adjust the shape of these functions with the

mouse by moving the control points (i.e., small black squares) up and down. A control point can be added or removed by accessing its contextual dropdown menu. To remove a control point, right click on the control point to display its dropdown menu, then choose Remove→<Color Channel>. To add a control point, right click on the a channel's graph function at the point where you want the control point to appear, then chooses Add→<Color Channel>.

Refresh Interval (ms) - Adjusts the rate at which the rendered image is refreshed in the Visualization window. Can be used to help improve object rendering on PCs that have a low-end video card.

General Tab

This tab provides the user with a set of general parameters that are applicable to all Rendering Modes and can aid the user's visualization of the 3D image.



Visible - Enables display of the rendered 3D image

Pickable - Enables matching a 3D object in the Visualization window with its object index located in the Content tab's list of object index numbers. When Pickable is checkmarked, clicking on a 3D object in the Visualization window has two effects: 1) The object's bounding box blinks on twice; and 2) The corresponding entry in the list of object index numbers becomes highlighted.

Tip: By enabling matching of a displayed 3D object with its assigned index number, the Pickable capability also facilitates locating that object's measurements in the ObjectSet's grid (if any were computed) in Window B. If the grid has been sorted on index numbers, one can quickly find the measurements for the "picked" object.

Outline Visible - Displays a bounding box outline on the 3D image

Use palette opacity (Alpha channel) - To choose whether to use or not the Alpha channel of the palette. This option is checked by default in Volume Mode and unchecked in Slice Mode.

Outline Color - To choose the color of the bounding box

Opacity - To set the opacity value ($0.0 \leq \text{value} \leq 1.0$, up to 15 significant digits)

Interpolation - To choose the interpolation type from Nearest Neighbor, Bilinear, and Cubic

Subsampling Factor - To adjust the display refresh rate by scaling down the 3D image. Note that while the refresh rate will be faster, the decreased image resolution can result in loss of small details and distortion of object boundaries.

6.2.4. Displaying a 3D Aphelion ObjectSet

An Aphelion 3D ObjectSet can be displayed in the Visualization window. 3D ObjectSets are always displayed in the IsoSurface Rendering Mode. The process of displaying a 3D ObjectSet is very similar to displaying a 3D image. Important differences are described below.

To generate an Aphelion ObjectSet with Aphelion Dev, open a 3D image in the Visualization window, then apply a Dev operator such as Process→ObjectSets→Bitmaps→Generation→Threshold to the 3D image. Alternatively, open an existing 3D ObjectSet from the disk. Aphelion ObjectSets have a tks or aso extension.

Note: Only Aphelion aso ObjectSets are available in the 64 bit version of Aphelion.

Similar to 3D images, display of a 3D ObjectSet in the Visualization window requires that it first be opened in the ObjectSet Gallery. To do this, drag and drop it into the Visualization window or the ObjectSet Gallery. Next, drag the 3D ObjectSet from the ObjectSet Gallery and drop it in the Visualization window. Alternatively, just double-click the 3D ObjectSet's thumbnail in the ObjectSet Gallery.

As with 3D image thumbnails, right-clicking the thumbnail of a 3D ObjectSet opens a contextual menu. While the first entry has the same name in both cases, Show/Hide, its function is different. Clicking on the Show/Hide entry results in another drop-down menu whose entries are the spatial attributes available for that 3D ObjectSet. The default spatial attribute, BITMAP, is always available at the top of the menu, but all other spatial attributes computed for the ObjectSet also appear in the menu.

Other important differences between display of 3D images and 3D ObjectSets are found on the Content Tab of Visualization window properties for the displayed ObjectSet (see below). In the left-side panel is a list of the ObjectSets concurrently open for a single Visualization windows tab. The checkbox used for hiding or showing the 3D ObjectSet in the Visualization window is analogous to checkboxes for 3D images. However, to the left of the checkbox, is a smaller box containing a plus or minus sign. If a plus sign is displayed, clicking on it will cause display of a drop-down list of index numbers for the objects that compose the ObjectSet. Each object in the list has a checkbox to enable the hiding or showing of the object in the Visualization window.

Whereas property settings for 3D images are always global (relative to an image), property settings for 3D ObjectSets can be either global,

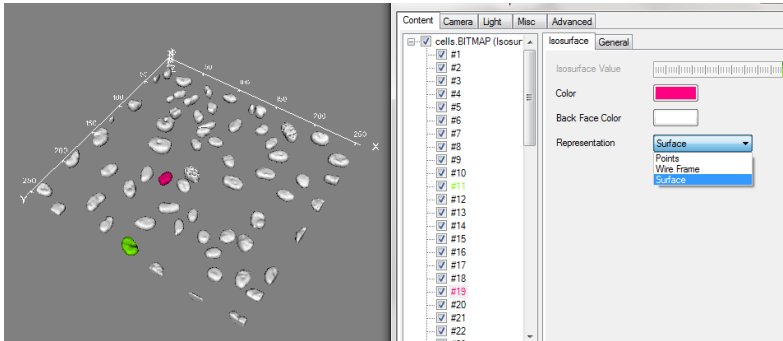
for the entire ObjectSet, or local, for individual objects. The property settings shown on the Isosurface and General tabs are always applied to the entity selected in the left-side panel of the Content Main Tab. If an ObjectSet is selected, then the property settings have a global effect for the entire ObjectSet. If an individual object is selected, the property settings only affect that object. Some parameter settings only apply globally and these disappear when an individual object is selected.

Setting or clearing the checkmark for an ObjectSet will set or clear the checkmarks accordingly for all of the objects in that ObjectSet, irrespective of the prior setting of the checkmark for any individual object. Note that when changing a property for an entire ObjectSet, if the new property value is the same as the former property value, no change is made to any of the objects in the ObjectSet. This condition applies to the following parameters:

- On the Isosurface tab Color, Back Face Color, Representation
- On the General tab - Visible, Pickable, Outline Visible, Outline Color, Opacity, and Interpolation, but not Subsampling Factor.

The **Apply Label Colors** button on the Isosurface tab assigns a color to each object on a random basis. This button is only visible when an ObjectSet is selected.

The user can identify what index number is assigned to an object by clicking the object in the Visualization window. This results in that object's index number being highlighted in the object index number list in the Content tab. Conversely, if one clicks an object number in the list, the corresponding object in the Visualization window will have its bounding box flash twice. Note that if you click on an object more than once in sequence, the bounding box flashes only for the first click.



The user can assign any RGB color to objects by using the Color function on the Isosurface panel. First, the user highlights the index number corresponding to the object to be color coded. Next, clicking on the Color rectangle will display a color palette from which the user picks the color to be assigned to the selected object. When a color is assigned to an object, the object's index number in the properties list is displayed in that same color. Note that colors having low contrast with the white background of the list may be hard to read or may appear to be missing.

Back Face Color - Displays a color palette from which a color can be chosen for the back surface of objects. If an error message pops up, then go to Tools→Options→Advanced→Appearance→Images and set the UseMemorySavingIsoSurface option to False. Note that this feature uses a lot of main memory on the video adapter and it is not recommended to set its value to False, unless needed for the project.

Representation - A drop-down menu that provides three options for visualizing the isosurface objects: as sets of individual disconnected points, as wireframes inter-connecting the points, or as contiguous surfaces.

6.2.5. Mouse Interaction

The rendered view of 3D images and 3D ObjectSets can be altered by mouse operations. These operations are somewhat different than those provided by Dev for 2D images and 2D ObjectSets.

Zoom - The mouse wheel is used to zoom into and out from an image or ObjectSet.

Pan - While simultaneously holding down the Shift key and the left mouse button, move the mouse in the direction of the part of the image or ObjectSet you want to see.

Rotate - While simultaneously holding down the **Control (Ctrl)** key and the left mouse button, move the mouse in any direction to rotate the image or ObjectSet around the center of the Visualization window. The direction of rotation will depend on the direction of the mouse movement.

Please refer to sections *6.2.3 Rendering Modes Tabs* and *6.2.4 Displaying a 3D Aphelion ObjectSet* for other mouse operations, such as selecting, coloring, identifying, and adjusting the opacity of 3D images, ObjectSets, and individual objects.

6.2.6. Synchronization between image windows

Aphelion Dev's Four Images mode is operational when working with 3D images and ObjectSets. This mode enables any combination of four 3D images and/or ObjectSets to be displayed in the Visualization window, subdivided in a 2x2 window array. Any combination of the four windows can be synchronized so that changes made in one will be replicated in the others. To implement the synchronization, while holding down the Control (Ctrl) key, left-click on the window banner of each window that you wish to synchronize. Moving an object in any of the synchronized windows will cause the other synchronized windows to be updated in the same way. To remove a window from synchronization, hold down the Control (Ctrl) key and left-click on that

window's banner. Note that windows displaying 2D data cannot synchronize with windows displaying 3D data.

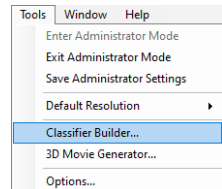
Note: synchronization between image windows is also available in single image display mode.








6.3. *Classification Extensions*

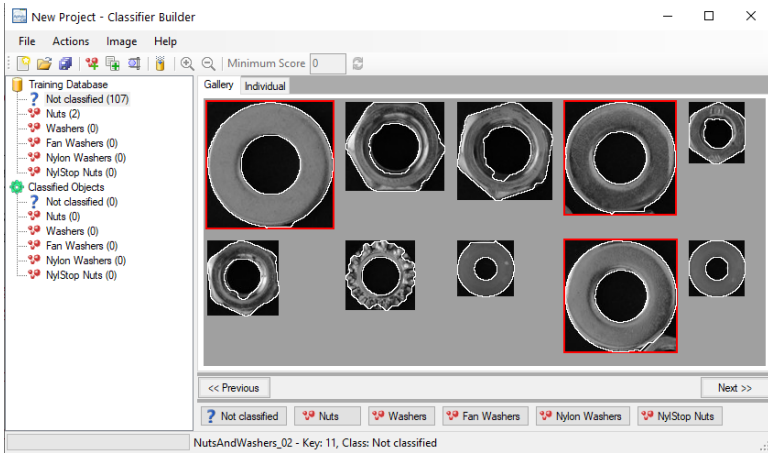
The Aphelion™ Imaging Software Suite includes four tools for developing classification applications for automatically identifying the type or class of objects found in a set of images. The four tools are ClassifierBuilder (the classification application front-end which is a stand-alone application) and three classifier plug-ins: Fuzzy Logic, Neural Network, and Random Forest.

Click the **ClassifierBuilder** entry from the **Tools** menu to open the **ClassifierBuilder** graphical user interface.

The following actions can be performed within the ClassifierBuilder graphical user interface:



-  Creates a new classification project.
-  Opens a classification project.
-  Saves a classification project.
-  Adds class.
-  Adds training files (ObjectSets).
-  Selects measurements to compute.
-  Generates a classifier.



Once a classifier has been defined in ClassifierBuilder, it can be called in Aphelion Dev using the function **Classify** (see [5.2.5 Classification](#) for its description).

6.3.1. ClassifierBuilder

Classifier Builder (CB) is a stand-alone program that enables its users to create an application that classifies objects extracted from an image using Aphelion Dev.

Note: CB can also be used to classify objects that do not have a visual representation (i.e., objects that are not extracted from an image). The format of the data to be classified has to be compatible with the Aphelion Imaging Software Suite (i.e., .aso and .tks file structure, see the Dev User Guide for more information).

CB is not a classifier application. Rather, it is a set of tools for building a specific classifier application. Those tools include a front-end for classifier engines, a classifier engine, and a Training Database generation capability. As a front-end device for classifier engines, CB helps users quickly create object classes, assign user-defined names to those classes, populate the classes with representative objects, and select the measurements to be computed using attributes (e.g., area,

average pixel intensity, convexity) of those objects. These measurements are then used as the input to the classifier engines.

The included classifier engine, *Fuzzy Logic*, is a basic capability that utilizes fuzzy logic analysis to differentiate between object types extracted from an image. *Neural Network Toolkit* (NNTK) and *Random Forest* classifier engines are optional extensions of CB. They both are more advanced classifiers that are better suited for more challenging classification applications. From time to time we may provide additional classifier engines. Please check our website for future releases.

Installation of a classification engine – Installation process for a specific classification engine varies depending on the classifier selected.

Fuzzy Logic Installation – This classifier is included on the DVD as an integral part of the CB software. Thus, Fuzzy Logic is installed when CB is installed.

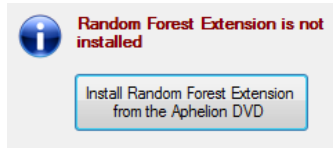
Neural Network Toolkit (NNTK) Installation – NNTK is an optional Aphelion extension. Its software is included on the Aphelion DVD, but a new License Code is needed to enable its execution by a user. After purchasing NNTK, the user is issued a new Aphelion License Code. This License Code must be installed either by reinstalling Aphelion 4.X or by special instructions that can be provided by the Aphelion Support Team. After the new License Code has been installed, the NNTK classifier is automatically made available in CB.

Random Forest Extension Installation - The Random Forest classifier type an optional Aphelion extension. After purchasing the Random Forest Extension, the user is issued a new Aphelion License Code. This License Code must be installed either by reinstalling Aphelion 4.X or by special instructions that can be provided by the Aphelion Support Team. However, unlike the NNTK extension, the Random Forest Extension is not then automatically available in CB. The user must perform a one-time installation of the Random Forest Extension.

To install the Random Forest Extension, open the Aphelion installation DVD on the computer and double-click on the file:

Extension\Classification\Random Forest for Aphelion Setup.exe.

If the Random Forest Extension has not been installed, then the warning message above pops up when the Build Classifier function is invoked from inside CB. Follow the instructions in this message to install the Random Forest Extension.



CB can also be used as the front-end for any classification process where the knowledge of an expert is required to first manually classify objects into categories or classes, a technique commonly called "supervised classification." In the medical field, a typical application would be classification of cells into different categories such as lymphomas, sarcomas, mitosis, melanomas, etc. In the field of security, an example would be the automatic detection of characters on moving vehicles and then the reading of those characters.

Once the Training Database is built and the classifier engine is generated using the tools available in CB, an automatic classification can be performed on the targeted objects extracted from images.

6.3.2. A Classifier Builder Project

CB organizes a user's work in terms of a data-structure called a classifier project, or simply a project. A project exists as a folder that contains various files that were created or accessed by the user during the CB work. Those files include the project file, the ObjectSet files (.aso or .tks), and the Classifier file.

Project File - This file is an xml file that lists the names of the ObjectSet files used in the project, the object attributes used, and the measurement types applied to those attributes.

Classifier File - This binary file, with a .classifier extension contains the parameters that will configure and guide the automatic classification process. These parameters are generated by the classifier building process.

ObjectSet Files - An ObjectSet file is actually a database of objects extracted from one or more images. It contains descriptive information about the objects, including a set of object attributes, and a set of measurement functions that are used to evaluate each object's attributes. For more information on the structure of an ObjectSet, refer to the Aphelion Dev user guide.

None, one, or multiple images can be associated with one aso ObjectSet (not available with tks ObjectSets). If no images are associated with an aso ObjectSet, then only shape, intensity, and texture measurements are used as input for the classifier. Other attribute measurements present in an Aphelion ObjectSet prior to its use as a training file can also be used as input to the classifier.

Note: The .aso format is only compatible with version 4.0 or later of Aphelion software products. Aphelion Dev or certain other Aphelion Imaging Suite products must be used to generate aso ObjectSets and to create the association between an ObjectSet and its source image(s).

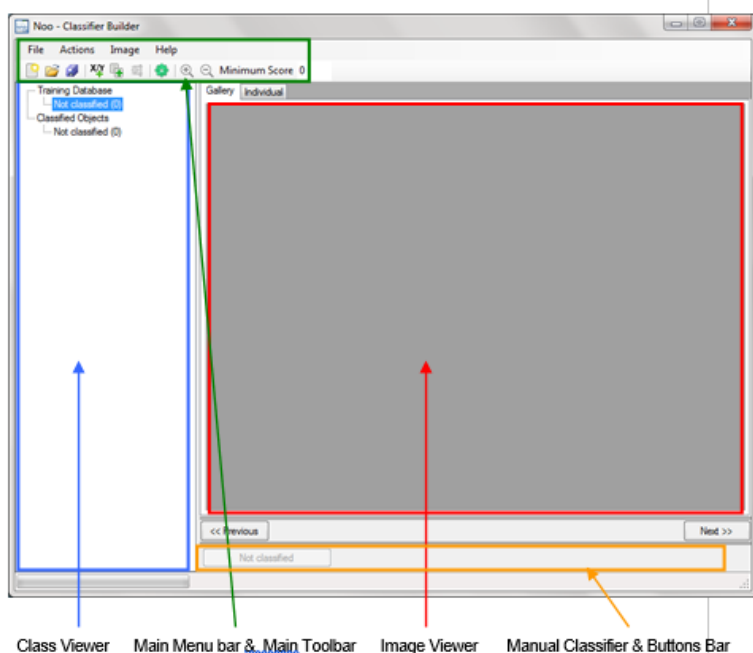
CB includes a C# segmentation project, delivered as source code, to help users quickly generate a set of aso files. The project can be found in the folder:

*<Aphelion Installation Path>\Aphelion
4.x.y\Dev\Example\dotnet\Applications\
Classification\DataSets\Noodles\Segment.csproj or Segmentx64.csproj*

for 32-bit and 64-bit environments, respectively.

Building a classification application begins with creating a new or opening an existing CB project. Note that if a project is opened that previously performed a manual classification, then the result of that classification will be automatically displayed in the user interface.

When the CB software is launched, the CB user interface window opens.



Classifier Builder User Interface

The user interface is composed of the Main Menu bar and Main Toolbar, and three windows, the Image Viewer, the Class Viewer, and the Manual Classifier Buttons Bar. The above screen capture identifies the location of three windows. The Image Viewer displays images of individual objects. It is generally the largest of the three windows. Clicking on its Individual tab displays a single object image corresponding to a specific object in an ObjectSet. Clicking on the Gallery tab displays an array of single object images.

The number of objects concurrently displayed in the Image Viewer window depends on the size of the Image Viewer window, the size of the individual object images, and the number of objects to be

displayed. If there are more objects than can fit into the Image Viewer window, the user can scroll through the entire set of objects by using the "Previous" and "Next" scroll buttons at the bottom of the window.

Note: The Gallery display is especially useful during the manual classification process because it permits the user to select multiple objects and then move them simultaneously into the desired object class.

The Class Viewer window displays a database tree that provides two lists of classes and the number of objects in each class. The two lists are labeled Training Database (used to generate a classifier) and Classified Objects (results from a non-training classification).

The Manual Classifier Buttons window displays a button for each object class defined for the project's Training Database, plus a default class called "Not classified." When one of these buttons is clicked, the object(s) currently selected by the user in the Image Viewer window are moved into the class labeled on the button.

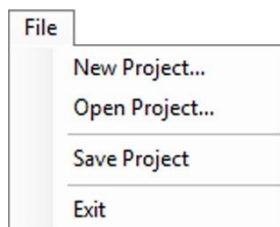


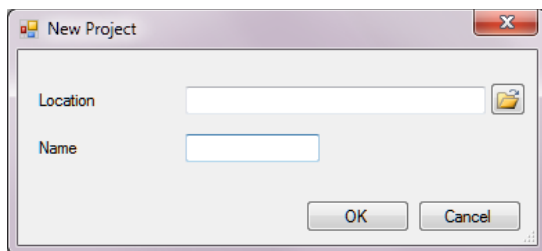
CB Main Menu bar

File Menu

The File menu provides operations for managing project files. A project file contains all of the data and files used for a specific classifier generation process.

New Project: Creates a new CB project. Clicking on this menu entry pops up a window with two dialog boxes: Location and Name (of the new project folder). In the former, enter the path to the folder into which the project folder should be saved. In the latter, enter the name to give to the project folder when the folder is created.





Clicking on the icon at the far right of the Location dialog box opens a files browser window to aid the specification of the path for the new Project Folder.

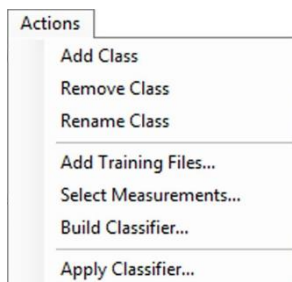
Open Project: Opens an existing project. Clicking on this menu entry causes a file browser window to open to assist selection of an existing project.

Save Project: Saves the current project. A project can be saved at any time during a CB process. If a manual classification has been performed on the Training Database, then the class of each object will be saved in its ObjectSet. All training data are saved when executing the Save Project menu entry (i.e., training files, selected attributes, generated classifier are saved).

Exit: Exits the current project and closes CB. The state of the open project can be saved if it has been changed since the last time it was saved.

Actions Menu

The Actions menu provides the tools that define the project and perform the processing to generate classifier engine. This menu is disabled until a project is either created or opened.



Add Class: Adds a new class to the current classifier project. By default, the name of the class is New Class. The class name can be changed by the user (see Rename Class).

Rename Class: Renames the selected class. In addition to using this menu entry, a class can be renamed by using the F2 key; by left clicking the class name, pausing briefly, and then left clicking the class name again. The class name can also be changed using any standard Windows file name change method.

Remove Class: Deletes the currently selected class. A dialog box appears to permit cancelling the class delete operation.

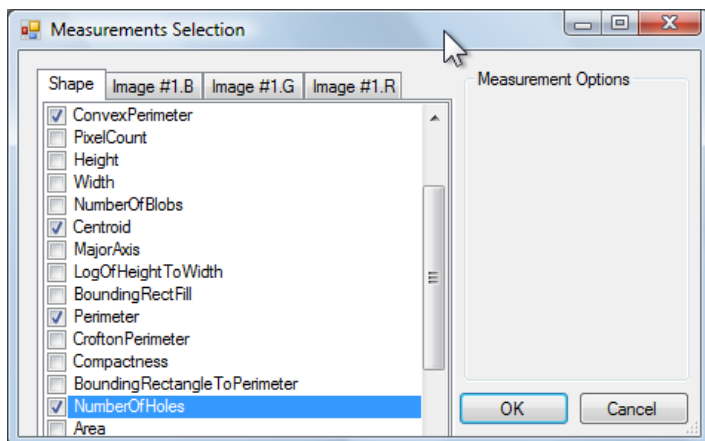
Add Training Files: Copies each selected training file into the project folder and then loads all of the objects in those ObjectSets into the appropriate class for each object. If an object has previously been given an attribute named "CLASS," then it will be placed in the class folder having the name formed by the character string assigned to the object's CLASS attribute. If the class does not yet exist in the project, CB will add it. If the object does not have an attribute named "CLASS," then the object will be placed in the default class named Not classified. All of the class folders will display in the Training Database section of the Class Viewer window.

Clicking on a class in the Class Viewer window will display in the Image Viewer window all of that class' objects. If source images were saved in the ObjectSets, the objects will be displayed as image ROIs (regions of interest). Each ROI is defined by the minimum bounding rectangle that contains its object. Any object whose source image was not saved in its ObjectSet will be represented in the Image Viewer by its ObjectSet index number only.

Select Measurements:

Displays a list of measurements (see panel at right) from which the user selects the measurements to be used in the current project (e.g., length, area, centroid, convexity). When the user has finished selecting measurements, clicking on the OK button closes the panel and computes the selected measurements for all objects. Measurements already present in a project's ObjectSet are not re-computed. A progress bar located in the left bottom section of the main window of the user interface shows the progress of any long

operations, such as the loading of files, the computation of the measurements, or the Apply Classifier process.



Build Classifier: Generates the classifier engine based on the classifier type (i.e., Fuzzy Logic, Neural Network, or Random Forest) selected by the user, the measurement values computed for the Training Database objects, and the user specified values for various other parameters specific to the classifier type chosen by the user. During the generation process, the Training Database is split into two disjoint sets of objects on a random basis, a training set (~25% of the objects) and a validation set (~75% of the objects). The training set is used to generate the classifier and the validation set used to validate the classifier parameters. Each time the Build Classifier operation is performed, the objects in the Training Database are reassigned to the two sets of objects, on a random basis.

Apply Classifier: Applies the generated classifier on a set of objects to be classified. These objects may be members of one or multiple ObjectSets. This step in the CB process gives the user an opportunity to verify the effectiveness of the generated classifier. It is also the method the user can use to classify any other ObjectSets for which the classifier has been generated. The content of the ObjectSets used for

this operation is immediately updated after this operation is performed.

Image Menu

Zoom In: Zooms into the image.

Zoom Out: Zooms out of the image.

Extend ROI: Extends the size of the ROI image of each object in the project ObjectSets by a small increment along each of the ROI image edges. The result of this operation is only a visual effect that displays more of the original image from which the ROI image was copied. This operation provides greater separation between an object and the edges of its ROI image.

Reduce ROI: Reduces the size of the ROI image of each object in the project ObjectSets by a small increment along each of the ROI image edges. This operation is the inverse of the Extend ROI operation. However, the ROI cannot be made smaller than the contained object's minimum bounding box.

Help Menu

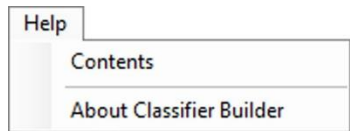
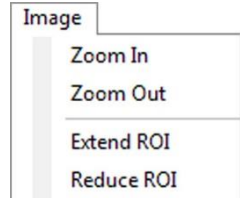
Contents: Displays this CB User Guide.

About Classifier Builder: Provides information and copyright notices about CB.

Main Toolbar



The **Main Toolbar** provides shortcuts for many of the operations provided by the menus on the **Menu bar**. These are described below.



File Menu Shortcuts

Respectively: Create new project / Open existing project / Save current project

Classifier Shortcuts

Respectively: Add a class / Add training files / Select measurements / Build classifier

Display Shortcuts

Respectively: Zoom in / Zoom out

Output Shortcut

Minimum Score 0

Object score threshold qualifying objects for membership in a class. Value is set to zero by default.

Creating a Classifier

This section of the document explains how to generate a Fuzzy Logic, Neural Network, or Random Forest classifier, starting from a set of aso files (ObjectSets).

Creating a Project

First, create a new classification project using the **File→New Project** menu entry. In the dialog box that appears, specify the location (i.e., path) where you want the new project file to reside. Then provide a name for the project file. Click OK.

Add Training Files

To provide your project with a Training Database, copy one or more aso ObjectSet files into your project using the **Actions→Add Training Files** menu entry. A file browser pops up. Navigate to the location of your training files. Be sure to only select those aso files that are to be used as the Training Database.

Note: When a project is saved after a manual classification, the project's Training Database (i.e., its aso ObjectSets) is saved, including the class of each object. To keep the original aso ObjectSet files unchanged, make a copy of those files in another folder before performing the manual classification.

All of the objects belonging to the aso files that were added to the project compose the Training Database and are used to generate and validate the classifier. CB automatically divides these objects into two, disjoint bins. The first bin, called the training set, contains about 25% of the Training Database and is used to define the classifier parameters. The second bin, called the validation set and containing the remaining objects (about 75%), is used to validate those classifier parameters. The two bins are randomly defined each time the Action→Build Classifier process is executed.

After the Training Database is created, the training set of objects are automatically placed in the default class named "Not classified" as can be seen in the Training Database portion of the Class Viewer. If one or more images have been included in the underlying aso ObjectSet files, then the objects in the training set can be viewed in the Image Viewer window by left-clicking on the default class, Not classified. Use the window scroll buttons, Next and Previous, as necessary to view all of the objects.

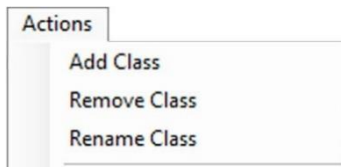
Note: The Build Classifier process requires that all classes contain at least two objects. If any class contains zero or one object, the Build Classifier process terminates and displays an error message. The effectiveness of a classifier engine is highly dependent on the number of objects in the Training Database and their distribution into the specified classes.

Manual classification of the training set

The next step in building an automatic classifier engine is to perform a manual classification on the training set of objects. To do this, the

user must first specify the classes into which the input objects are to be sorted.

Do this by adding executing the Actions→Add Class operation or right click on an existing class icon and choosing Add Class from the pop-up, contextual menu. A newly added class will be named "New Class (0)" where (0) indicates the class has no objects.



Create two or more classes depending on how many different object types are to be classified (e.g., Good Cells, Bad Cells, or Defect A, Defect B, No Defect, etc.) and rename them with meaningful names. For each class created, a button labeled with that class' name appears on the Manual Classifier Buttons bar (see example below).

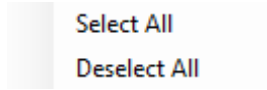


If an object has an attribute whose name is CLASS and whose data structure is "string," CB will add a class to the project and assign a name to it whose characters are the text string, provided that a class with that name does not already exist in the project. Each object having a CLASS attribute will be moved into the class folder whose name matches the object's CLASS attribute. Objects not having a CLASS attribute will be moved into the default class named Not classified.

After the project classes have been defined and the training set objects have been moved into the appropriate class folders based on the presence or lack of a CLASS attribute, the manual classification can be performed. Manual classification is accomplished by the user visually examining each class and moving any object into the class best suited for that object, including the Not Classified class.

To move an object from the class displayed in the Image Viewer, left click the object to select it (a red box appears around the object's image). Next, click the Manual Classifier button for the class to

which you want the object moved. To select and move multiple objects to a different class, hold down the Ctrl key when selecting the objects.



To deselect a single object, simply click the object again while holding down the Ctrl key, or click on a different object without holding down the Ctrl key. It is also possible to select all or deselect all objects currently displayed in the Image Viewer by right clicking in the Image Viewer and selecting the appropriate entry from the contextual menu (see adjacent graphic).

As objects move from one class to another, the object counters for the two classes are automatically updated to reflect the number of objects they contain after the move operation.

Carefully review each object in the training set and move it into the appropriate class. It may be useful to create an Other class for objects that do not reasonably belong to any of the targeted classes. You may wish to leave objects in the Not classified class that are not identifiable as a valid object.

The Previous and Next buttons move from page to page in Multiple Objects mode and from Object to Object in Single Object mode. A warning window pops up when the last page or object is displayed prompting the user if the first page or object should be redisplayed to resume the manual classification process.

Tip: We recommend only using objects with good characteristics for the classifier generation. A minimum of a few hundred objects is required to generate a credible classifier.

Select Measurements

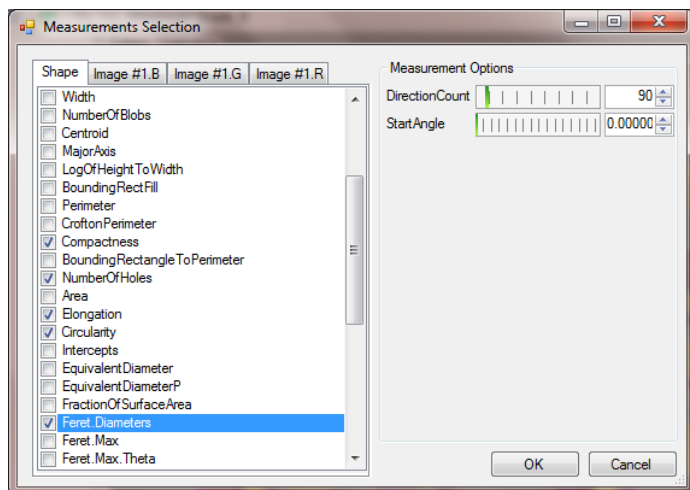
After the training set has been manually classified and the validation set has been successfully processed, the list of measurements to be used for the classifier generation has to be defined. Begin by clicking

on Actions→Select Measurements. A window pops up, having a tab labeled Shapes, that displays a list of all shape-related measurements that can be used for classification. The measurements listed are from the Measurement function group found in Aphelion Dev, including image statistics. Select only those measurements that are to be available for the classifier generation process.

If one or more color images are associated with the ObjectSets, then three additional, tabbed windows are added to the Shapes window. The tabs for these windows are labeled Image-R, Image-G and Image-B. Each of these contains only image statistical measurements for each color band (e.g., minimum, maximum, mean, standard deviation). Any of these can also be selected for the classifier generation process.

For some of the measurements such as Feret Diameters, the right-panel is then populated with options that can be altered by the user.

After the desired measurements have been check-marked, including the measurement listed on any of the tabbed window, click on the OK button. The values of selected measurements for the manually classified objects are then computed.



Generate a Classifier

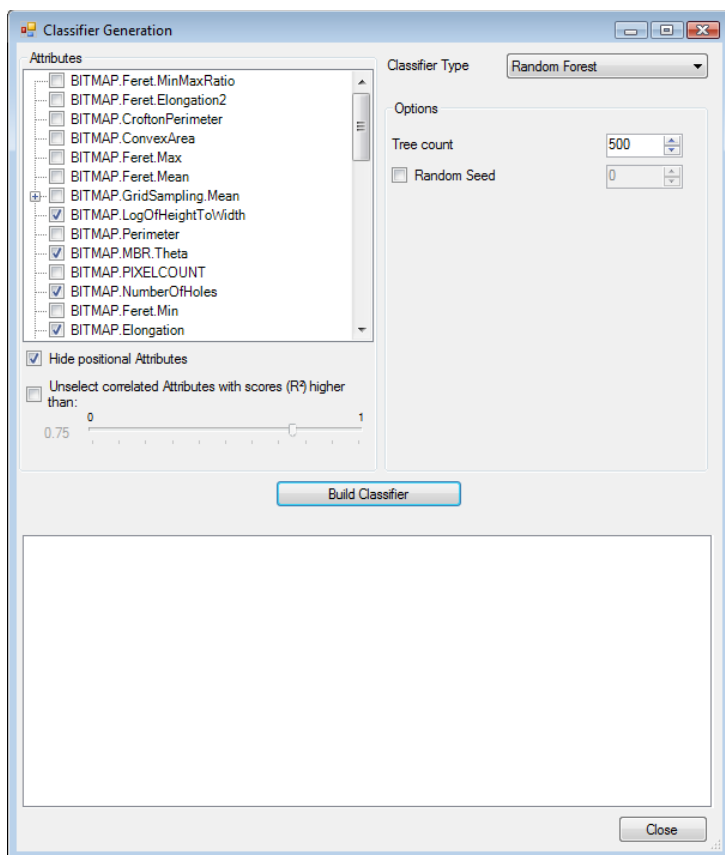
The first few steps in building a classifier engine using CB are the same, irrespective of the classifier type chosen:

- Use the Actions→Add Class, Remove Class, or Rename Class menu entries to specify the project classes;
- Use the Actions→Add Training Files menu entry to load object files into the current project;
- Use the Actions→Select Measurements menu entry to choose the measurements that will be used to qualify objects for membership in a class.
- Execute the Actions→Build Classifier menu entry to open the Classifier Generation window (see below).

To generate a classifier for your data, begin by clicking on the Actions→Build Classifier menu entry. The Classifier Generation window opens to enable the user to configure the classifier generation process (see example window following).

Attributes - From the list provided, choose the attributes that should be used for the classifier generation. The attributes displayed are either those for which measurements were chosen in the Select Measurements step or were computed during the ObjectSet formation process performed outside of CB. Right-clicking anywhere in the Classifier Generation window pops up a contextual menu that provides two entries, Select All and Deselect All, to aid the user.

Hide positional Attributes – Select this feature to remove from the Attributes list those that are based on the position of an object (i.e., X and Y coordinates and coordinates of the bounding box). Usually, such attributes should not be used in a classification since their values depend on the exact position of the objects in the image.



Automatically select uncorrelated Attributes – This feature minimizes bias in the classifier by removing from the Attributes list any attribute that is either not significant in the correlation process (i.e., has a standard deviation less than .005) or is highly correlated to at least one other attribute. The user adjusts the slider to define the largest allowable value for the correlation score “ R^2 ” between attributes (R^2 ranges between 0 for uncorrelated attributes and 1 for perfectly correlated attributes).

Attribute selection based on correlation is an iterative process. At each step of the process, the following happens:

- 1) The list of highly correlated pairs of attributes is built, where two attributes are considered highly correlated if their correlation factor exceeds R^2 .
- 2) The “most correlated” of such attributes is removed from the list highly correlated attributes, where the “most correlated” attribute :
 - a) Belongs to at least one most highly correlated pair; and
 - b) In the case of equality between the pair, is the one that reaches the highest correlation factor with another attribute; and
 - c) When such equality exists (typically, when there is a single highly correlated pair), the choice is arbitrary.

The process is then repeated until no highly correlated attribute pair remains in the list of attributes that are to be used to build the classifier.

Classifier Type – Click on the Classifier Type dropdown list and select the classifier to be generated. Only those classifiers licensed to the installed Aphelion Dev product are displayed.

Options – This is a list of additional classifier parameters that are specific to the Classifier Type selected. These parameters are described in the sections following below for Fuzzy Logic and for each of the optional classifier extensions available for purchase.

Build Classifier – Click this button to start the building of the selected classifier type and observe the classifier building progress in the chart area below the button. The information displayed in the chart area depends on the classifier type selected. For Neural Network and Random Forest, tabbed plots are constructed for each class of objects. These plots show the convergence of the classifier generation process. For Fuzzy Logic, a grid is displayed to show the attribute ranges. During the building process, a Cancel button appears to enable the user to halt the build if the progress is not satisfactory. When the build

completes, the overall error ratio for the classifier is displayed above the chart and the Cancel button is replaced by the Build Classifier button.

Note: Building an effective classifier is highly dependent on having enough objects during the training phase to sufficiently characterize each of the classes. As the number of classes increases, the number of objects needed for training also increases. It is not unusual to use a few hundred or more objects during a typical training process.

If the Training Database is too small, CB's random distribution of its objects between the training and validation sets may result in one or more classes having too few objects to properly characterize the class. This can result in generating an ineffective classifier. For this reason it is very important that the Training Database be large enough to assure that all classes will have sufficient objects for a reliable classification.

Multiple executions of the Build Classifier process will generate different results. It is often useful to run the Build Classifier process multiple times to get a sense of the range of error results that can occur. Remember, the contents of the training and validations sets automatically changes with each subsequent run of the Build Classifier process. In general, a classifier can be considered as well defined if, during the validation process, the Error Ratio value reaches zero.

The Error Ratio value for the Fuzzy Logic, Neural Network, and Random Forest classifications are displayed in the Classifier Generation window (see sections 3.3.6 Fuzzy Logic Classifier, 3.3.7 Neural Network Classifier, and 3.3.8 Random Forest).

Except as noted in the Classifier Generation process described above, the next steps in building a classifier engine differ depending on the Classifier Type selected previously. These remaining steps are described in the following three sections, 3.3.6 (Fuzzy Logic), 3.3.7 (Neural Network Toolkit), and 3.3.8 (Random Forest).

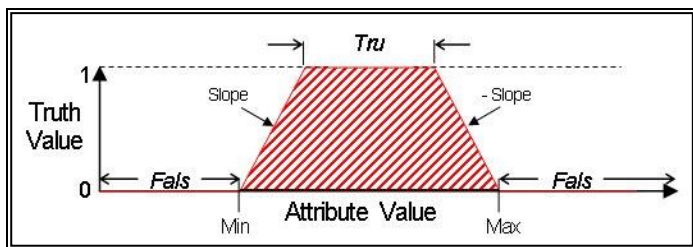
The process of building a classifier from the training sets, or applying the newly built classifier on the validation sets is such that each object

belonging to those sets will be surrounded by a colored bounding box. The color of the box is directly correlated to the classification score, and ranges from red (score equal to zero), to green (score equal to one), with a yellow color for a score equal to 0.5, following the color scheme defined below.



Fuzzy Logic Classifier

Background - A fuzzy logic classification is based on a linear combination of the attribute values of an object, with relative weights assigned to attributes, and with veto parameter settings possible. The fuzzyness results from the estimation of the extent to which an attribute of an object qualifies it for membership in a specific class. This estimation is reflected in the graph example following below.



Defining the parameters to be used to generate a fuzzy logic classifier is done by configuring a set of graphs of the type pictured above such that for each class there will be one such graph for each selected attribute measurement. If the classifier will have three classes and five attribute measurements have been selected, then there will be 15 graphs specified. For each class, the graphs for that class specify to what extent an object's attribute measurements qualify it for membership in that class.

The graph specifies that for all values of an attribute measurement below the attribute minimum ("Min") value or above the attribute maximum ("Max") value, the likelihood of that object belonging to the

associated class is zero. For all attribute measurement values between the Min and Max attribute values, the likelihood of membership in the associated class is greater than zero, rising from zero at the Min point to a value of one and then decreasing to zero again at the Max point.

For a given pair of Min and Max values, the range of attribute measurement values that result in a truth value greater than zero equals Max minus Min. The portion of that range resulting in a truth value of one depends on the slopes (i.e., Fuzzy Factor or just Factor) of the lines rising up from the Min and Max points.

Note: The fuzzy logic graph explained in the above paragraphs is one of four possible graph types. The other three are, in effect, variations of the one described and these are described briefly below.

Confidence Level Threshold - This minimum confidence level parameter, a value between 0 and 1, allows an object to be placed in a class even if the likelihood of that classification is low. This parameter is global to all attribute measurements. Setting this parameter to zero causes all objects to be assigned to a class other than the default Not classified class. However, in this case the object assignments to classes will be arbitrary.

Default Fuzzy Factor - This parameter specifies the slopes of the two graph lines that connect the Truth Value lines 0 and 1 at the Min and Max values of the selected attribute (see graph above). This parameter is global, but can then be individually modified in the grid by editing the Factor value of each attribute.

Autoweights - Checkmark this parameter enables the software to browse through all attributes and either discard non-relevant attributes, or effect a higher weight (above value 1) to significant attributes. The weight values appear in the attribute analysis grid displayed at the bottom of the Classifier Generation window.

Random Seed - The generation of the training set is a randomized process. However, that process can be made repeatable by enabling the Random Seed function. When this function is enabled, the number

provided in the Random Seed dialog box is used as a seed for the randomizing of the training set generation. If the seed number is the same as in a prior training session, then the training set generated will be identical to training set generated in that prior session. This enables the user to repeat the use of a training set while changing classifier generation parameters (e.g., a different selection of attributes or a different confidence threshold).

Build Classifier

Error Ratio: 49.2%

Build Classifier

Two	Other	Star	Zero	Variable	Type	Min	Max	SD	Factor	Weight
				BITMAP.COMPACTNESS		0.270618	0.301527	0.0117	0.2	0
				BITMAP.CONVEXITY		0.692645	0.797691	0.0399	0.2	1
				BITMAP.CONVEXPERIMETER		165.151	185.68	7.43	0.2	1
				BITMAP.NUMBEROFBLOBS		1	1	0	0.2	1
				BITMAP.NUMBEROFHOLES		0	1	0.4	0.2	1





Close

After setting the displayed fuzzy logic parameters described above, click on the Build Classifier button to define the fuzzy logic parameters specific to qualifying an object for membership in one of the defined classes. When Build Classifier is clicked, a tabbed grid appears in the white rectangle of the Generate Classifier window. The grids contain parameters that are used to qualify an object for membership in a class based on the object's attribute values. For each measurement attribute, the Min, Max, Factor and Weight can be altered if desired.

Once the values are changed, the classifier should not be rebuilt, else it would reset edited values to their original values. The only action that can then be performed is an Apply Classifier on a new series of ObjectSets. There is one grid for each class and a class' grid is selected by clicking on its labeled tab. Each grid lists the attributes (Variables column in the grid above) the user selected earlier in the

classifier generation process. For each selected attribute, the grid displays the following values:

Type - A drop-down list of graph types. The four graph types provided are shown in the next table. For the associated attribute, the user selects the graph type that best fits the attribute

	Rising from 0 up to 1 then dropping down to 0
	Dropping from 1 to 0 then rising to 1
	Dropping from 1 to 0, remaining at 0
	Rising from 0 to 1, remaining at 1

Min - The minimum value computed for the associated attribute in the training set of objects.

Max - The maximum value computed for the associated attribute in the training set of objects.

SD - The standard deviation of values computed for the associated attribute in the training set of objects.

Factor - The fuzzy factor, initially set to the Default Fuzzy Factor. Determines the leading or trailing slope factor, or both, depending on the graph type chosen.

Weight - Specifies the relative weight assigned to the associated attribute. This is a measure of the importance of the attribute in determining the members of a class.

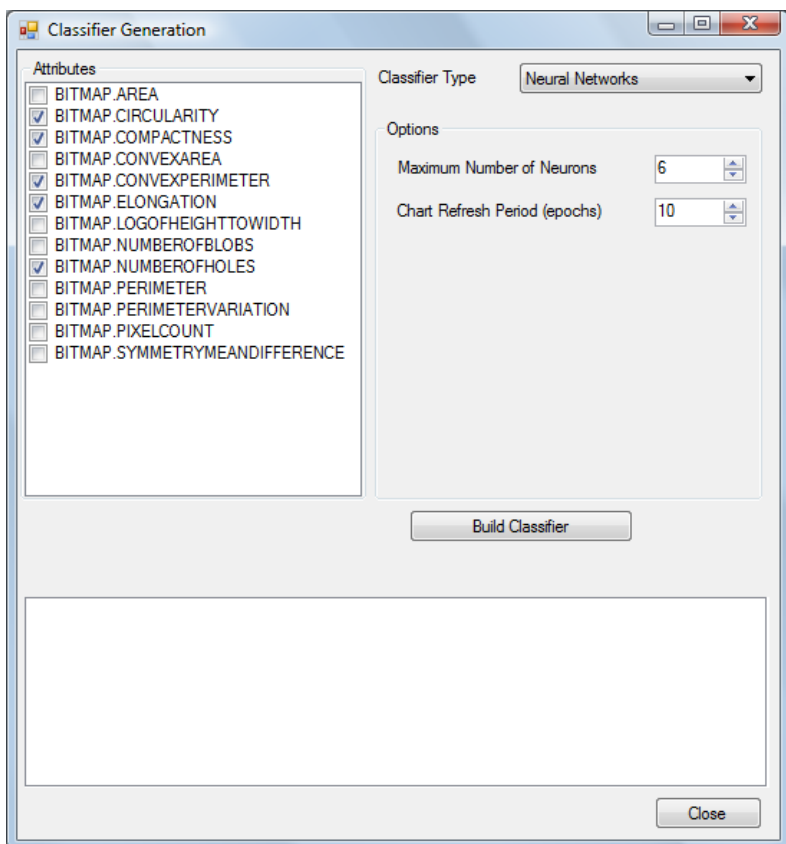
All of these grid fields can be edited by the user with the exception of the standard deviation (SD) field.

Error Ratio - The Error Ratio value displayed immediately above the grid is the classifier error calculated after the Actions→Apply Classifier operation has been executed (see section 3.3. The goal of a CB project is to achieve results with a very low Error Ratio.

Neural Network Classifier

Since the first few steps in classifier generation process are the same irrespective of which classifier is selected, please review these steps in the last paragraph of section 3.3.5.

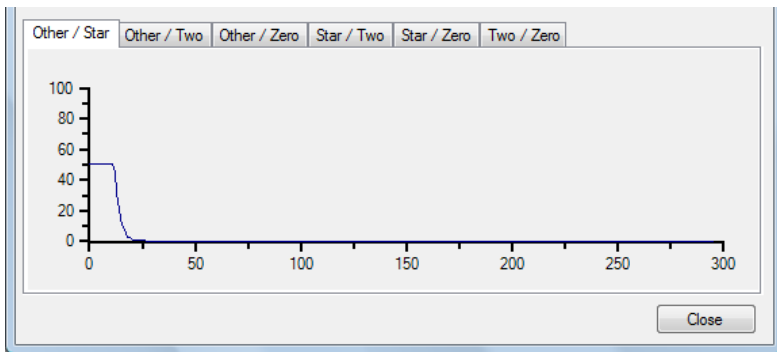
In the Classifier Generation window (see figure below) review the Attributes list and make sure the desired attributes are check-marked. Next, use the Classifier Type dropdown list to select Neural Network. The data options specific to Neural Network classifiers is now displayed in the Classifier Generation window.



Next, specify the Maximum Number of Neurons to be used in building the classifier engine. Then specify the Chart Refresh Period. Just above that white rectangle is the Build Classifier button. When you have selected the object attributes to be used and have specified the classifier Options, click the Build Classifier button.

Tip: We recommend increasing the number of neurons if the different classes are not well separated.

While the neural network classifier build process is running, a set of charts appears in the white rectangular area of the Generate Classifier window. Following below is an example of these charts.



The refresh rate of the charts depends on the value of the Chart Refresh Period parameter. The number of charts computed equals

$$N*(N-1)/2 \text{ (N = number of classes).}$$

A labeled tab identifies each chart. Click on the tab to display its chart. The X axis corresponds to the number of iterations of the training engine, and the Y axis is the error ratio as a percentage.

When all of the charts have been generated, click on the Close button to finalize the classifier generation process. Be sure to execute File→Save Project if you want access the current project's classifier for future use. After the Save Project operation completes, the project folder will contain the following files:

- *<ProjectName>.classifier* - This is a binary file that holds the classifier code and configuring parameters of the classifier engine.
- *<ProjectName>.xml* - This is Project File. It contains the names of all files and other information used to build the classifier engine. This file may be edited if necessary, for example to remove Training Database files (i.e., also ObjectSets). A typical file is provided in an appendix to this document.

Random Forest Classifier

In the Classifier Generation window review the Attributes list and make sure the desired attributes are check-marked. Next, use the Classifier Type dropdown list to select Random Forest. The data options specific to Random Forest classifiers are now displayed in the Classifier Generation window (see figure beside).

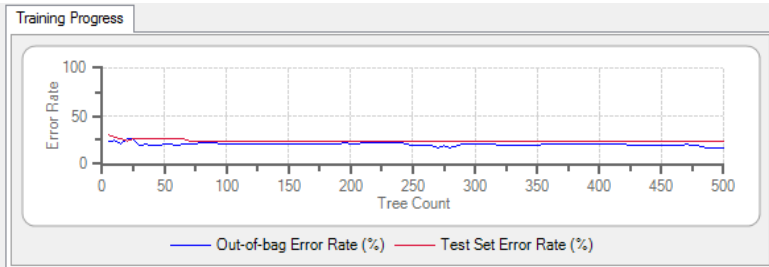
The screenshot shows a software window titled 'Classifier Type' with a dropdown menu set to 'Random Forest'. Below this, under the 'Options' section, there are two settings: 'Tree count' with a value of 500 and a 'Random Seed' checkbox which is unchecked, with a value of 0. A note at the bottom states: 'Note: Random Forest is not sensitive to correlated attributes'.

Tree count - Specify the number of trees to be used in building the classifier engine. The more trees the Random Forest contains, the longer the training and the classifying process lasts, but the more accurate the prediction is.

Random Seed - The generation of the training set and the training of the Random Forest classifier are randomized processes. However, that process can be made repeatable by enabling the Random Seed function. When this function is enabled, the number provided in the Random Seed dialog box is used as a seed for the randomizing of the training set and classifier generation.

When you have specified the Random Forest classifier Options, click the Build Classifier button to generate the classifier.

While the Random Forest classifier building process is running, the chart area displays the evolution of the computed error rate for both the training and the validation sets. Expand the width of the Classifier Generation window to view the chart's Tree Count axis in more detail.



- For the training set with a blue curve (“Out-of-bag Error Rate”);
- For the validation set with a red curve (“Test Set Error Rate”).

The time required to complete the classifier generation process can vary significantly depending on the number and type of Attributes selected and the value of the Tree Count parameter. When the process completes, the Cancel button will be replaced by the Build Classifier button.

Note: The Random Forest extension to the Aphelion Classifier Builder program executes functions available in the programming system known as “R” and in its randomForest package. Performing Random Forest classifier generation launches an R script using a command-line executable installed with R. No R code has been rewritten or recompiled, and no R library is integrated in Classifier Builder or Aphelion Dev.

Performing an automatic classification

This section explains how to classify objects once a classifier has been generated, as described in the previous sections.

Begin by clicking on the Actions→Apply Classifier menu entry to run the classification process on new sets of objects stored in one or more Aphelion ObjectSets. A file browser pops up that enables the user to

select the `.aso` ObjectSet files that are to be classified. When the files have been highlighted, click the browser's Open button. The classification process begins execution.

As the classifier is running, one can observe the class counters in the Class Viewer window incrementing as the classifier moves objects into their assigned class folders. The contents of the individual classes can be seen in the Image Viewer window.



When an object is assigned to a class, the object receives three new attributes:

- **CLASS** – The index of the assigned class (0 for the first class, N-1 for the Nth class);
- **CLASS_NAME** – Name of the assigned class as a text string; and
- **CLASS_SCORE** – Object's classification score, ranging from 0 to 1.

The object, with its added attributes, remains in its original ObjectSet file (`.aso`). The object's classification score (i.e., **CLASS_SCORE**) can be reviewed for each object by selecting the object while it is displayed in the Image Viewer in either of the two tabbed windows labeled Gallery or Individual. To select the object in the window whose tab is labeled Gallery, simply left-click once on the object. To select the object in the window whose tab is labeled Individual, use the Previous and Next buttons to bring the object into view. The classification score is displayed in the status bar at the bottom of the user interface, as shown below.

Picture 006 - Key = 35, Score = 0.958

In this example (above), the object is in the ObjectSet whose file name is Picture 006, the object's index number is 35, and its classification score is 0.958.

To help refine the classification results, the user can adjust the lower bound of the classification score can by entering a new value for the Minimum Score parameter in the main toolbar,   Minimum Score 0.6 .

Clicking again on the Actions→Apply Classifier menu entry reruns the classification process on the same set of ObjectSets.

Visual Studio Project for Image Segmentation

A C# project is provided on the Aphelion DVD as a programming example that shows how to generate a set of aso ObjectSet files from a set of images. This C# project is located at:

"Examples\dotnet\Applications\Classification\DataSets\Woodles \Segment"

The example project performs the following steps:

- Open a set of color images (TIFF, BMP, JPG, or any other format supported by Aphelion)
- Select one color band
- Perform an automatic threshold to detect objects of interest
- Generate an aso ObjectSet
- Display the set of images with the associated ObjectSet in the image overlay

This project should be used as a starting point for further editing.

Visual Studio Project for Using a CB Classifier

A second C# project is provided as a programming example. This C# project shows how to execute a CB generated classifier engine to classify objects in one or more aso ObjectSets. This C# project is located at:

"Examples\dotnet\Applications\Classification\DataSets\Woodles \Classify"

This example project performs the following steps:

- Load an existing classifier
- Open an ObjectSet file
- Run the classification on this ObjectSet
- Save the resulting ObjectSet

Each object will now possess the attribute "CLASS" whose value is the name of the class to which the object was assigned.

XML File

Below is an example of the XML file created during the Build Classifier process. This file contains all of the data used in that process.

```
<?xml version="1.0" encoding="utf-16"?>
<Projet>
  <Version>4.0.9</Version>
  <Files>
    <File Type="Adcis.ClassifierBuilder.File">
      <Name>Noodle1.aso</Name>
    </File>
    <File>
      <Name>Noodle2.aso</Name>
    </File>
    <File>
      <Name>Noodle3.aso</Name>
    </File>
    <File>
      <Name>Noodle4.aso</Name>
    </File>
    <File>
      <Name>Noodle5.aso</Name>
    </File>
    <File>
      <Name>Noodle6.aso</Name>
    </File>
    <File>
      <Name>Noodle7.aso</Name>
    </File>
    <File>
      <Name>Noodle8.aso</Name>
    </File>
  </Files>
  <MeasurementLists>
```

```

<MeasurementList Type="Adcis.System.LIStringCollection">
  <Items>
    <Item Value="Measurement.Shape.Convexity" />
    <Item Value="Measurement.Shape.TwoD.PerimeterVariation" />
    <Item Value="Measurement.Shape.TwoD.ConvexArea" />
    <Item Value="Measurement.Shape.TwoD.ConvexPerimeter" />
    <Item Value="Measurement.Shape.NumberOfBlobs" />
    <Item Value="Measurement.Shape.TwoD.CroftonPerimeter" />
    <Item Value="Measurement.Shape.TwoD.NumberOfHoles" />
    <Item Value="Measurement.Shape.TwoD.Area" />
    <Item Value="Measurement.Shape.TwoD.Elongation" />
    <Item Value="Measurement.Shape.TwoD.Circularity" />
  </Items>
</MeasurementList>
<MeasurementList>
  <Items>
    <Item Value="Measurement.Shape.Mean" />
  </Items>
</MeasurementList>
<MeasurementList>
  <Items>
    <Item Value="Measurement.Shape.Mean" />
  </Items>
</MeasurementList>
<MeasurementList>
  <Items>
    <Item Value="Measurement.Shape.Mean" />
  </Items>
</MeasurementList>
</MeasurementLists>
<Attributes>
  <Attribute Value="DS.IMAGE #1.B.MEAN" />
  <Attribute Value="DS.IMAGE #1.G.MEAN" />
  <Attribute Value="DS.IMAGE #1.R.MEAN" />

```

```

<Attribute Value="MEASUREMENT.SHAPE.PIXELCOUNT" />
<Attribute Value="DS.REGION.AREA" />
<Attribute Value="DS.REGION.CIRCULARITY" />
<Attribute Value="DS.REGION.CONVEXAREA" />
<Attribute Value="DS.REGION.CONVEXITY" />
<Attribute Value="DS.REGION.CONVEXPERIMETER" />
<Attribute Value="DS.REGION.CROFTONPERIMETER" />
<Attribute Value="DS.REGION.ELONGATION" />
<Attribute Value="DS.REGION.NUMBEROFBLOBS" />
<Attribute Value="DS.REGION.NUMBEROFHOLES" />
<Attribute Value="DS.REGION.PERIMETERVARIATION" />
<Attribute Value="DS.REGION.PIXELCOUNT" />
</Attributes>
<Classes>
  <Class Type="Adcis.ClassifierBuilder.Class">
    <Name>Letter</Name>
  </Class>
  <Class>
    <Name>Digit</Name>
  </Class>
  <Class>
    <Name>Other</Name>
  </Class>
</Classes>
</Project>

```

6.4. Color Segmentation Extension

This extension includes a set of functions to convert color images from one color space to a different color space. Color spaces supported include RGB, HIS (Hue, Saturation and Intensity), LAB, YIQ, YUV, and more. Color segmentation functions such as region growing, morphological partitioning, color cube, and color sphere are also included in this extension.

6.4.1. Overview

Detecting changes in pixel intensities in binary and gray-scale images is the basis for many powerful algorithms for detecting objects in those images. Applying these techniques to the three bands or channels of color images increases the effectiveness of detection, discrimination, and measurements of objects in color images.

Aphelion Dev provides a broad range of individual algorithms that can be combined by the Dev user to create such powerful techniques for object detection. Dev also includes one tool that provides the user with a simple and effective, parameter-driven method for many object detection problems. It detects objects using Color Interval segmentation, the color equivalent of gray-level threshold.

The Aphelion suite of products also includes an optional Dev extension product that seamlessly integrates three additional color segmentation tools that use different techniques: color distance, region growing, and morphological partitioning.

While these four techniques are previously described, more technical detail is provided in the following paragraphs.

6.4.2. Color Interval

The Interval algorithm is based on processing of the three color bands independently in the user-selected color space (e.g., RGB). An object is defined to be a set of adjacent pixels having color band values that

are each within a given band tolerance factor of a reference color. The reference color value is defined by the user clicking (i.e., selecting a pixel) inside an object that is representative of the objects to be detected. The user can vary the tolerance factors by adjusting three, on-screen dials. The band tolerances can be adjusted individually or collectively (as a single factor). The effects of tolerance factor changes are displayed in real-time in the Visualization window as a graphics overlay, in a user-selected color (see color button adjacent to the Opacity slider).

A color pixel is in an object if its color band values lie in their respective band intervals as defined below:

$$[Va - Ta, Va + Ta]; [Vb - Tb, Vb + Tb]; [Vc - Tc, Vc + Tc]$$

Where

a, *b*, and *c* are the 3 bands in the color space.

Va, *Vb*, and *Vc* are the color band values of the reference pixel.

Ta, *Tb*, and *Tc* are the tolerance values for each color band (defined by the three, band dials). The tolerance values for any band can range between the minimum and maximum values for the selected color band. For example, the range of the tolerance dials for RGB color bands is 0 - 255 (assuming 8-bit color pixels) and for the Hue band is 0 - 2π .

Furthermore, if $Vx < Tx$, then $Vx - Tx = 0$ and if $Tx > Vmax$, then $Vx + Tx = Vmax$

The Window Size parameter defines the size of the neighborhood used to estimate the color at a given pixel location (in the Tools→Options→Advanced→Behavior→ObjectExtraction window). The Color Estimation Method parameter can take the following values: cemAverage, cemMinMax, and cemMean (in the Tools→Options→Advanced→Behavior→ObjectExtraction window).

Note: It is often the case that the interesting objects in an image have more than one significant color interval. After selecting the first reference pixel and setting the interval dials, additional color intervals can be added to the segmentation. This is done by control right-clicking on additional reference pixels as needed. Thus, each added color interval forms a union of intervals with the first color interval.

6.4.3. Color Distance

This segmentation method is based on the generalized Euclidean formula for measuring distance between two points (i.e., square root of the sum of the squares). For example, the distance between two color pixels is the square root of the sum of the squares of the distances between the pixels in each color band. When there is a scaling difference between the bands of a color space, the bands are first normalized before distances are computed. Various distance formulae are available depending on the color space chosen **Tools→Options→Advanced→Behavior→ObjectExtraction→ColorSpace** window. A threshold is performed in the *Color Space* based on the sphere whose center is a user-specified reference point and whose radius is the computed distance value. The pixels contained by the sphere form the object defined by the distance formula and the reference point.

The reference point is either a single pixel or a neighborhood of a single pixel depending on the value specified by the parameter **Tools→Options→Advanced→Behavior→ObjectExtraction→ColorEstimationWindowSize**. If the neighborhood contains more than one pixel, the color of the reference point is defined by the *Color Estimation Method* parameter which can take the following values: Average, Median, and MinMax (see **Tools→Options→Advanced→Behavior→ObjectExtraction→ColorEstimationMethod**).

Note: 1.) If an object contains multiple, significant colors, then multiple color space spheres can be created and combined. To do this, hold down the control key while clicking a reference point for each

such color in an area of the object representative of that color. The threshold operation will then be performed using the union of the spheres.

2.) All spheres will have the same radius, namely, the value of the *Distance* parameter.

3.) The effects of adding reference points and changing the *Distance* value are displayed in real-time in the Image Viewer window.

6.4.4. Region Growing

The Region Growing algorithm is a semi-automatic segmentation based on user-defined seed points placed either inside objects of interest (left-click) or in non-object regions (shift-left-click). A seed point is either a single pixel or a neighborhood of a single pixel depending on the parameter *Seeds Size* found at the Tools→Options→Color screen.

A seeded region's color is defined to be either a) the average color of the starting seed or b) the current average color value of the seeded region's pixels, depending on the *Adaptive Colors* parameter found at the Tools→Options→Color screen.

Starting from the seed points as initial regions, other qualifying pixels are iteratively added to each seeded region until no further qualifying pixel can be found. A pixel is qualified to be added to a seeded region if all of the following are true:

- The pixel is not part of an existing seeded region;
- The pixel is adjacent to at least one of the region's boundary pixels; and
- The pixel's color value is within the specified color *Distance* setting of the seeded region's color.

The growth of a seeded region ends when there are no remaining pixels qualified to be in that region.

A typical Region Growing object extraction proceeds as follows.

1. Place an object seed in a structure you want to extract as an object.
2. Vary the color *Distance* value for that seed so that the object is extracted as close as possible to the desired result.
3.
 - a) If the color *Distance* value chosen does not completely extract the object, then repeat step 1 and add a new object seed in an area where the current object is not yet extracted.
 - b) If the chosen *Distance* value extracted regions not interior to the object, then unextract such a region by dropping a non-object seed on it. It may be necessary to repeat this step multiple times to completely unextract a region. When you are satisfied with the current object's extraction, return to step 1. This three-step process is repeated until all structures of interest are satisfactorily extracted (i.e., covered by the graphics overlay with the selected *Opacity* color such that no non-object areas are covered).

Note that at least one object seed must be placed in each object of interest. Each time a new seed is dropped in the image, the then current *Distance* value is permanently fixed for the immediately prior seed and that value becomes the initial value for the new seed. The *Distance* value can then be varied for the new seed without affecting the results for the prior seeds.

6.4.5. Morphological Partition

The Morphological Partition method is a semi-automatic segmentation based on a watershed transform. A partition of the color image into a set of regions is computed, using the color gradient. Only the *N* dominant regions are kept, or in other words, only the last *N* lakes (in terms of lake volume) of the watershed are kept in the result of the segmentation. The *Number of Regions* slider is used to specify the maximum number of dominant regions of the partition that will be kept in the final result.

When the mouse pointer is moved into a region, that region turns green in the object overlay to preview the region as an object. The

green color is removed when the mouse pointer moves out of the region.

The user must identify each region that forms an object of interest by left-clicking or control-left-clicking in those regions. If the user left-clicks in a region, it will become selected as an object and all other objects previously selected will become unselected. If the user control-left-clicks in a region, that region becomes selected as an object, but any previously selected regions remain selected as objects. A selected object will switch from the green preview color to the color specified in the Opacity color box when the mouse pointer is moved out of the selected region.

Note: The Morphological Partition is first computed when this segmentation method is selected. It is a process that may take a while depending on the image size and the number of maxima and minima in the image. Once it is computed, the effects of moving the Number of Regions slider are displayed immediately.

6.4.6. Color Space Definitions

Aphelion Dev supports the following color spaces:

RGB:	Red, Green and Blue
HSI:	Hue, Saturation and Intensity
HSV:	Hue, Saturation and Value
YUV:	Luminance and Chrominance
Lab:	Lightness and Red/Green and Yellow/Blue Chrominance
YIQ:	Luminance and Chrominance
XYZ:	Virtual primary color space
Luv:	Lightness and Chrominance
LCH:	Lightness, Chromaticity/Saturation, Hue

YIQ color space

RGB→YIQ conversion

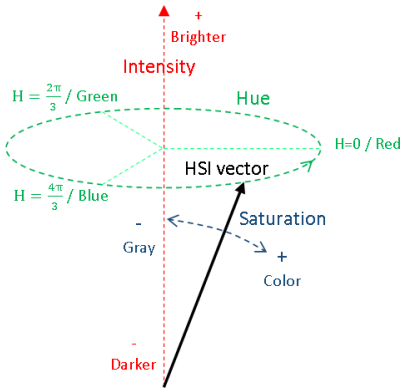
$$Y = 0.299 \times R + 0.587 \times G + 0.114 \times B$$

$$I = 0.596 \times R - 0.275 \times G - 0.321 \times B$$

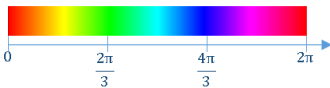
$$Q = 0.212 \times R - 0.532 \times G + 0.311 \times B$$

HSI color space

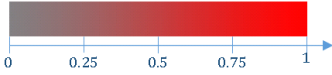
A color of a pixel is defined, in the Hue-Saturation-Intensity space, by a vector. This vector is defined by its length (intensity), the angle between the vector and the intensity axis (saturation), and its yaw angle around the intensity axis (hue).



Hue is defined between 0 and 2π modulo 2π .



Saturation is defined between 0 and 1. A pixel with a saturation value set to 0 is black. A pixel with a saturation set to 1 is white.



Intensity is defined between 0 and the maximum value of the datatype (255 for a 8-bit image).

RGB→HSI conversion

$$\text{Intensity} = I = \frac{(R + G + B)}{3}$$

$$S = 1 - \left(\frac{3}{(R + G + B)} \right) * \text{Min}(R, G, B)$$

$$H = 0 \text{ if } I = 0 \text{ or } S = 0$$

$$H = \begin{cases} 2\pi - \arccos\left(\frac{0.5(2R - G - B)}{\sqrt{R^2 + G^2 + B^2 - RG - RB - GB}}\right) & \text{if } B > G \\ \arccos\left(\frac{0.5(2R - G - B)}{\sqrt{R^2 + G^2 + B^2 - RG - RB - GB}}\right) & \text{if } B \leq G \end{cases}$$

HSV color space

RGB→HSV conversion

$$\text{Max} = \text{Max}(R, G, B)$$

$$\text{Min} = \text{Min}(R, G, B)$$

$$V = \text{Max}$$

$$S = \frac{\text{Max} - \text{Min}}{\text{Max}} \text{ if } V > 0 ; S = 0 \text{ if } V = 0$$

$$R' = \frac{\text{Max} - R}{\text{Max} - \text{Min}}$$

$$G' = \frac{\text{Max} - G}{\text{Max} - \text{Min}}$$

$$B' = \frac{\text{Max} - B}{\text{Max} - \text{Min}}$$

If saturation, S, is equal to 0, then H is undefined (i.e., the color has no hue therefore it is monochrome), otherwise:

$$\text{If } R = \text{Max} \text{ and } G = \text{Min}: \quad H = 5 + B'$$

$$\text{Else if } R = \text{Max} \text{ and } G \neq \text{Min}: \quad H = 1 - G'$$

$$\text{Else if } G = \text{Max} \text{ and } B = \text{Min}: \quad H = R' + 1$$

$$\text{Else if } G = \text{Max} \text{ and } B \neq \text{Min}: \quad H = 3 - B'$$

$$\text{Else if } R = \text{Max}: \quad H = 3 + G'$$

$$\text{Otherwise:} \quad H = 5 - R'$$

XYZ color space

RGB→XYZ conversion

$$X(\lambda) = 2.7690 R_c(\lambda) + 1.7518 G_c(\lambda) + 1.1300 B_c(\lambda)$$

$$Y(\lambda) = 1.0000 R_c(\lambda) + 4.5907 G_c(\lambda) + 0.0601 B_c(\lambda)$$

$$Z(\lambda) = 0.0565 G_c(\lambda) + 5.5943 B_c(\lambda)$$

Note: The conversion above depends on the color temperature. Refer to technical papers to learn more about this color conversion.

xyz color space

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

$$z = \frac{Z}{X + Y + Z}$$

Note: The **xyz** corresponds to the new color space and **XYZ** the old color space.

L*u*v* color space

XYZ→L*u*v* conversion

$$L^* = \begin{cases} 116\sqrt[3]{Y/Y_w} - 16 & \text{if } Y/Y_w > 0.008856 \\ 903.3 \cdot Y/Y_w & \text{if } Y/Y_w \leq 0.008856 \end{cases}$$

$$u^* = 13 \cdot L^* (u' - u'_w)$$

$$v^* = 13 \cdot L^* (v' - v'_w)$$

$$u' = \frac{4X}{X + 15Y + 3Z}$$

$$v' = \frac{9Y}{X + 15Y + 3Z}$$

u'_w and v'_w have the same definitions as u' and v' but are applied to the white point reference.

$$u'_w = \frac{4X_w}{(X_w + 15Y_w + 3Z_w)}$$

$$v'_w = \frac{9Y_w}{(X_w + 15Y_w + 3Z_w)}$$

YUV color space

RGB→YUV conversion

$$Y = 0.299 R + 0.587 G + 0.114 B$$

$$U = -0.147 R - 0.289 G + 0.436 B$$

$$V = 0.615 R - 0.515 G - 0.100 B$$

La*b* color space**RGB→L*a*b* conversion**

$$\text{Luminance} = L = 0.2989 R + 0.5866 G + 0.1145 B$$

$$a^* = 500 \times \left[f\left(\frac{X}{X_w}\right) - f\left(\frac{Y}{Y_w}\right) \right]$$

$$b^* = 500 \times \left[f\left(\frac{Y}{Y_w}\right) - f\left(\frac{Z}{Z_w}\right) \right]$$

$$f(x) = \begin{cases} \sqrt[3]{x} & \text{if } x > 0.008856 \\ 7.787x + 16/116 & \text{if } x \leq 0.008856 \end{cases}$$

LCH color space**Lab→LCH conversion**

$$L = L^*$$

$$C = \sqrt{a^{*2} + b^{*2}}$$

$$H = \begin{cases} 0 & \text{if } a^* = 0 \\ \left(\arctan(b^* / a^*) + k\pi / 2 \right) / 2\pi & \text{if } a^* \neq 0 \end{cases}$$

$$k=0 \text{ if } a^* \geq 0 \text{ and } b^* \geq 0$$

$$k=1 \text{ if } a^* > 0 \text{ and } b^* < 0$$

$$k=2 \text{ if } a^* < 0 \text{ and } b^* < 0$$

$$k=3 \text{ if } a^* < 0 \text{ and } b^* > 0$$

6.5. Deep Learning Extension

The TensorFlow Deep Learning extension is an add-on to Aphelion Dev letting the user run a Convolutional Neural Network (CNN) in the software. It can be run from the Graphical User Interface of Aphelion Dev or from a program developed in using Aphelion SDK.

The CNN must have been previously generated and stored in a Tensorflow-compatible format (protobuf).

The generation of an annotated database and the training of the CNN with this database must be done outside the software.

Note: We recommend using the Annotate tool available in the Aphelion Imaging Software Suite to benefit its highly configurable graphical user interface that enable to quickly make any kind of annotation and that provide a database directly usable from TensorFlow.

Applying a CNN on an image in Aphelion Dev or from software application based on Aphelion SDK generates an Aphelion ObjectSet. In the case of a classification CNN, the resulting ObjectSet contains the class (or classes for multi-class classification) that was detected and an associated confidence level per class. In the case of a detection network, the resulting ObjectSet contains the boxes detected in the image and the class assigned to each box with a confidence level for the detection.

Examples of use can be found at <https://www.adcis.net/en/example-download/>.

6.6. *Hardware interfaces*

Optional software drivers are available to interface Aphelion to acquisition devices that do not meet the DirectShow protocol. These provide the capability to control an image acquisition device from within the Aphelion GUI. Video images can be captured within the Aphelion environment if the acquisition device is supported in Aphelion Dev. Contact an Aphelion representative to find out if a specific acquisition device is compliant with an Aphelion device interface.

Important note: The Allied Vision camera driver, the Peak camera driver, and the Teledyne camera driver are both compliant to the Gige

Vision and USB3 Vision standards. These drivers can not be loaded together.

If your license includes more than one of these drivers then it is recommended to only load the proper driver by unselecting the not proper drivers from the Extensions tab of the Aphelion options (Tools>Options... menu in the Administrator mode) and restarting Aphelion.

6.7. *Image Registration*

This application was originally developed to register retinal images of different modalities, such as color and infrared images. This registration process has been adapted to work effectively with any image domain. The process is based on an algorithm called the Price method. It takes two images as input and generates their registration matrix.

6.8. *Kriging Extension*

This extension aids in the removal of acquisition noise in an image. The extension uses filtering techniques based on Kriging Analysis and Geostatistics. The underlying technique is based on the computation of experimental variograms, and the approximation of these experimental variograms using a linear combination of functions. The extension performs computation of the variograms and their approximation by functions, then utilizes user interaction to match a model on the real data, and generates a filtered image.

This User Guide provides basic information about using the Kriging Extension (“KES”) software product. KES is a highly effective tool for the removal of random acquisition noise from digital images. Its processing is based on Kriging analysis used in geo-statistics. It was developed for imaging applications in a collaboration between the

GeoScience Research Group, an R&D laboratory at the Paris School of Mines in France, and imaging software developer ADCIS SA.


User Background - A user of Dev should be experienced at the use of Aphelion™ Dev software. For questions about Dev, please refer to the Dev User Guide and Dev's extensive on-line Help.

Installing KES - KES is an optional extension of the Aphelion Imaging Software Suite. It is included on the Aphelion Dev 4.x DVD. When installed, it is a seamless component of the Aphelion Dev software. After KES is purchased, you will be issued a new License Code that will unlock the KES software. Then, update the **License Code** parameter in the **Tools→Options→Advanced→General→Identification** window and restart Aphelion to enable the KES software.

Note: All Aphelion documentation can be accessed without installing the software by opening the Help folder on the DVD.

The KES availability can be verified by clicking on the **Tools→Options→Extensions** from the Main Menu bar in Aphelion Dev. A window is opened that displays a list of Aphelion's optional extensions. An installed Extension will have a checkmark next to its name and show a status of **Available (loaded)**. Clicking on an Extension name that is underlined will open online documentation explaining the use of that Extension. An Extension not having a checkmark has not been licensed. In this case, contact an Aphelion Dev sales representative for information on how to purchase this extension.

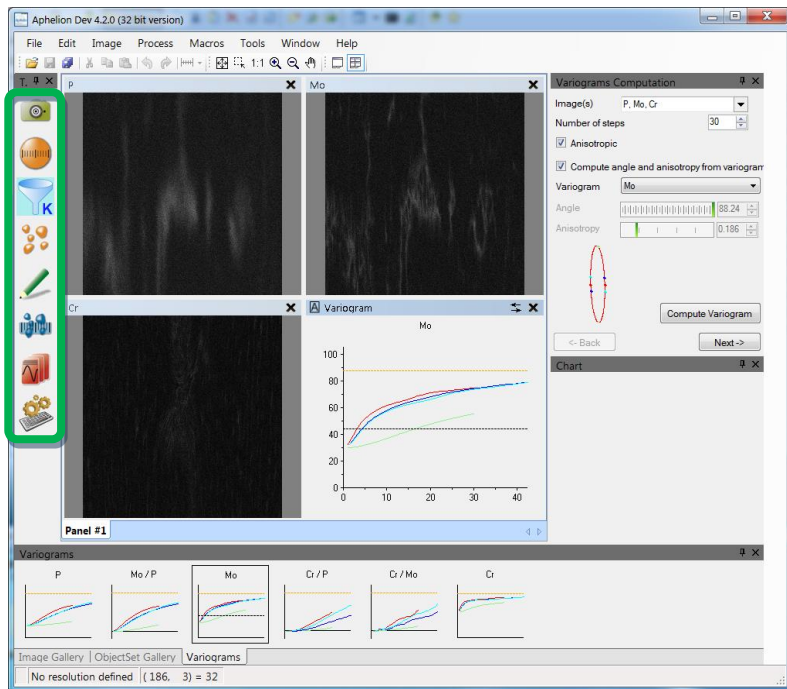
6.8.1. Kriging Task

After KES has been licensed, it operates as a Dev Task. Its task icon () appears on the Task Bar, and is located between the **Calibration** Task and the **Object Extraction** Task since image filtering is optimally performed before the image is segmented.

Before or after invoking the **Kriging** Task, use the **File→Open** menu to load the images to be filtered with KES. Select the **Image Gallery** tab at

the bottom of the user interface to view thumbnails of the opened images.

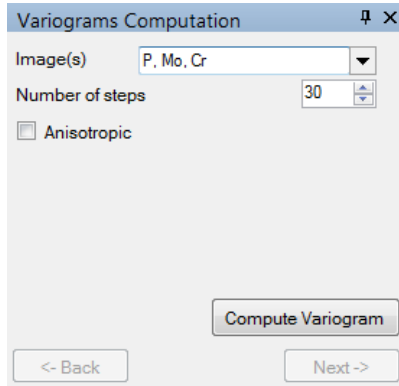
Once the desired images are loaded (i.e., thumbnails are in the **Image Gallery**), start the **Kriging** Task by clicking on its Task Bar icon. The **Variograms Computation** panel appears at the top right of the Aphelion Dev graphical user interface, and a Variogram tab is added to the Image View panel.



The KES process is composed of a sequence of three control interfaces (window panels). This sequence is executed in the following order: **Variograms Computation**, **Model Fitting**, and **Filtering**. These window panels provide on-screen, interactive tools that implement the Kriging filter methodology.

Variograms Computation

When KES starts, **Variograms Computation**, the first step in the Kriging process, is displayed in the upper right window panel (its default location). Begin by opening the dropdown menu, **Image(s)**, and selecting the image(s) to be used to produce the variogram(s). The images appearing on this menu are those displayed in the **Image Gallery**. Check the box in front of each image name to select it. If a multi-band image or multiple grey-scale images are selected, a set of covariograms is computed for each combination of two of the selected images or bands.



Next, set the counter, **Number of steps**, to the number of translated images computed from the original image to form the variogram. Note that this parameter determines the number of increments on the variogram's X axis. Setting the parameter to a high value elongates the variogram, but increases the processing time. The benefit of having an elongated variogram is to generate a better model. We recommend leaving the parameter set to its default value.

After an image or images are selected and the **Number of steps** has been specified, clicking on the **Compute Variogram** button will cause the KES to compute and display the variogram(s). Each variogram is given a name based on its source image (or source images for covariograms) and displayed in the **Visualization** and **Gallery** (thumbnail format) windows if the **Variogram** tab is selected.

If the structures to be analyzed in the image are anisotropic (e.g., the structure orientation can be easily perceived and is unique), then click the **Anisotropic** checkbox, else uncheck the box. When **Anisotropic** is selected, the following fields are added to the window: a selection box (checked by default) labeled **Compute angle and anisotropy from variogram**, a **Variogram** dropdown menu listing the variograms computed during the current use of KES, two slider controls, one each for the **Angle** and **Anisotropy** parameter values.

If **Compute angle and anisotropy from variogram** checkbox has been checkmarked, the **Compute Variogram** process will generate the variogram(s) and will also compute the optimum values for the **Angle** and **Anisotropy** parameters and display their values for the variogram selected from the **Variogram** dropdown menu. The user can clear this checkbox in order to manually vary the values of the **Angle** and **Anisotropy** parameters to improve filtering results.

If the **Anisotropic** and **Compute angle and anisotropy from variogram** checkboxes are both selected when the **Compute Variogram** button is clicked, then an ellipse is displayed in the window with four, color-

coded pairs of points. The orientation of the displayed ellipse depends on the anisotropy value. The ellipse and its points are discussed below. If the shape of the ellipse is close to a circle, then the main structure in the image is isotropic, and there is no obvious directional orientation, also called privileged direction, for that structure. In this case, the **Anisotropic** checkbox can be cleared.

Tip: We recommend starting with the **Anisotropic** checkbox selected. The shape, orientation of the ellipse, and the location of the four, color-coded point pairs on the ellipse help the user to perceive the orientation of the main structure present in the image.

Four variograms are computed using four directional angles (specifically: 0, 45, 90, 135 degrees). The four variograms are color-coded: red for the 0° angle, green for 45°, blue for 90°, and cyan for 135°. A single, horizontal line (displayed as black and dashed) is automatically computed that intersects each variogram at a single point. Each of these four intersection points corresponds to one of the four angles and is mapped onto a pair of points on the red ellipse. The color of each pair of points is the color of their source variogram and, therefore, the directional angle used to compute the variogram. Their position on the ellipse is mapped in polar coordinates where the abscissa value at an intersection point on a variogram is the polar range and the theta angle is the directional angle used to compute the source variogram.

As mentioned earlier, selecting the **Compute angle and anisotropy from variogram** checkbox causes the **Angle** and **Anisotropy** parameters to be automatically computed for the displayed variogram. If multiple variograms were computed, use the **Variogram** dropdown menu to display the desired variogram. To adjust the **Angle** and **Anisotropy** parameters, unselect **Compute angle and anisotropy from variogram** and use the corresponding slider controls. The **Anisotropy** parameter is defined as the ellipse's minor axis divided by its major axis. Its value ranges between 0 and 1. The **Angle** value ranges from -90 to +90 degrees.

Finally, click on the **Compute Variogram** button to generate the variogram(s), and covariogram(s) if multiple input images or multi-band images were selected. When the computation completes, select the **Variograms** tab in the **Gallery** window to view the computed variogram graphs. Click **Next** to move to the **Model Fitting** process.



Model Fitting

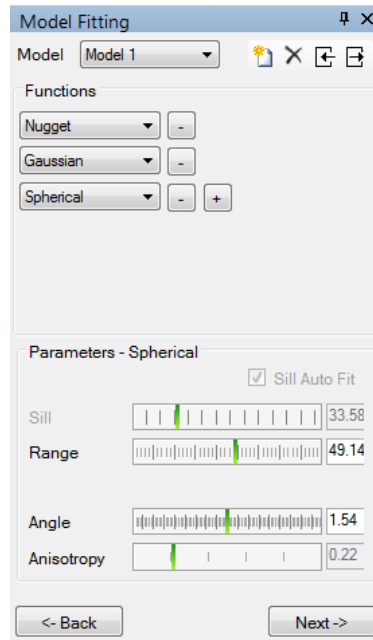
After the variogram(s) are computed, a sequence of functions are assembled to create a model of each variogram. A model can be generated automatically by KES or the user can manually assemble the model using the **Functions** dropdown menus provided in the KES interface. To select between automatic and manual model generation, go to the **ModelAutoFit** parameter in the **Tools→Options→Advanced→Kriging** window and set this parameter to:

- **True** to have KES automatically create the model,
- **False** to enable the user to create the model manually.

If the **ModelAutoFit** parameter is set to **True**, and a new model is being created, after the user has entered a name for the new model and pressed **Tab** or **Enter** on the keyboard, KES will compute and display the new model overlaid on its variogram. Often times, the model will fit the variogram so closely, that it is very difficult to distinguish the model from the variogram graph. If the user is satisfied with the auto-generated model, clicking the **Next** button will move the Kriging process to the next panel, **Filtering**. If the auto-generated model is not

satisfactory, the user can adjust the model to achieve a better fit to the variogram. This is done by adjusting the sliders of the selected functions, by replacing or deleting selected functions, or adding additional functions. When the user is satisfied with the model's fit, clicking on the **Next** button advances the Kriging process to the **Filtering** panel. For more information on manual model fitting, see the next paragraph.

If the **ModelAutoFill** parameter is set to **False**, the user can manually create a model of a variogram by assembling an ordered set of functions, each of which fits (approximates) a specific range of the variogram. The user selects the functions from dropdown menus that appear in the **Model Fitting** interface. The menus include the following functions: Nugget, Linear, Exponential, Spherical, Gaussian, Cubic, Sinus Cardinal, Cauchy, Bessel J, and Bessel K. Each menu contains the same list of functions. Alternatively, user created models can be imported into KES by clicking on the icon . They can also be exported for later use by clicking on the icon .



Model Fitting

Model: **Model 1**

Functions

- Nugget
- Gaussian
- Spherical

Parameters - Spherical

☒ Sill Auto Fit


Sill: 33.58

Range: 49.14

Angle: 1.54

Anisotropy: 0.22

<- Back Next ->

Begin by creating a new model or by importing an existing model. To create a new model, click on the new model icon  located to the right of the **Model** dropdown menu and enter a name for the new model. Clicking on the **X** button will delete the model from the dropdown menu.

A KES model is always a compound function (i.e., an ordered combination of two or more functions). A portion of the graph of each function type is suitable to conform to a different portion of a variogram graph. Functions have one or more, user-adjustable sliders that alter the shape of the function's graph. Use the sliders to fine-tune the model's fit to the variogram. By selecting specific functions and fitting them to appropriate ranges (ordinate regions) of the variogram, a compound function is assembled that closely approximates the variogram.

After selecting an existing model or entering a new model name, press the **Tab** or **Enter** key to display an ordered set of one or more dropdown menus, each containing the list of functions that KES provides (see below) under the heading **Functions**. Be sure to enlarge the window vertically to display all of the menus. The dropdown menus have identical entries.

When a function is chosen from a dropdown menu, a set of one or more parameter sliders appears in the lower portion of the window. Leave the parameters set at their default values, since KES is capable of performing an automatic adjustment of the model to the variogram, or adjust the sliders to better conform the shape of the compound function (i.e., model) to the variogram graph.

A slider common to all of the functions, except **Nugget**, is the **Range** slider. This slider defines the range segment of the variogram to which this function provides the model fit. The range of a selected function always starts where the immediately prior function's range ended and extends to the right the number of x axis increments specified by the function's **Range** parameter value.

Any **Functions** menu can be deleted by clicking on the “-” button to its right. The last (i.e., bottom) menu also has a “+” button that is used to add a new, last **Function** menu to the sequence.

Analyzing the shape of the variogram helps in determining the functions that will best compose the model. The nugget effect is the

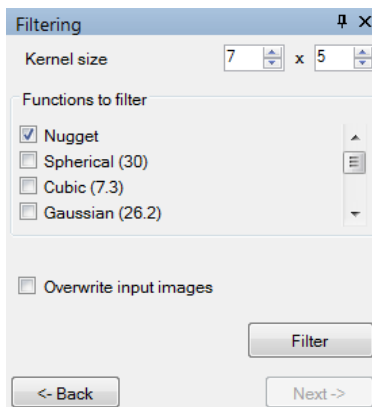
offset at the origin, and it corresponds to the white noise present in an image.

The Sill value, a horizontal line displayed in the upper region of a variogram, serves as an upper limit for a variogram graph. The **Sill Auto Fit** checkbox, which is disabled in the selected state by default, causes the Sill value to be automatically computed. To enable user control of this checkbox, set the **SillAutoFitLocked** parameter to **False** in the **Tools**→**Options**→**Advanced**→**Kriging** window. However, it is recommended the KES be used with the **SillAutoFitLocked** parameter set to **True**.

Note: Be sure to adjust the vertical size of the **Model Fitting** window to be sure that all of the **Functions** dropdown menus are displayed.

Filtering

Once the model has been specified, the user clicks on the **Next** button to proceed to the **Filtering** window (see adjacent). Since the primary purpose of a Kriging filter in image processing is to remove white noise from an image (i.e., to filter the nugget effect), this option is checked by default. Here the user has the option of filtering the image using the entire model (all of its functions in sequence) or any combination of one or more of the model's functions by selecting or clearing the function checkboxes accordingly. By default, the **Nugget** filter is selected when you first enter the **Filtering** window.



Note: If a scrollbar appears in the **Filtering** window, be sure to scroll the function list up or down to access all of the model's functions, (located under **Functions**).

The values displayed to the right of a function name correspond to the range of the function as defined in the **Model Fitting** panel. The size of the kernel can be manually edited by the user, as it would be done when performing a basic convolution or a Gaussian filter.

The user can chose to have the filtered image overwrite the original image by selecting the “**Overwrite input images**” checkbox or to have the filtered image appear as a new entry in the **Image Gallery** and in the **Visualization** window by clearing the **Overwrite input images** checkbox.

Clicking on the **Filter** button filters the images that were selected (i.e., checkmarked) in the **Image(s)** dropdown list on the **Variograms Computation** panel. If the **Overwrite input images** box is checkmarked, a filtered image will be overwritten on its source image in the **Image Gallery**. If the **Overwrite input images** box is not checkmarked, a filtered image will appear in the **Image Gallery** and have the name of its source image appended with **(filtered)**.

6.9. *Neural Network Toolkit*

The Aphelion Neural Network Toolkit enhances Aphelion Dev with an optional tool to automatically classify objects of interest based on a supervised classification. Objects are assigned to categories or classes based on a Neural Network algorithm. Probability and information based classifiers can be generated automatically, freeing the user from the necessity of specifying complex rules for object recognition and classification.

Classifier Builder (see *6.3 Classification Extensions*), delivered with Aphelion Dev, provides efficient tool to manually classify objects and generate a training database used as the input of any Aphelion classifier including Neural Network Toolkit.

6.10. *MultiFocus Extension*

This extension provides tools to generate a focused image from a stack of unfocused and registered images. Two methods are available in this extension: sharpness analysis and residue processing.

6.11. *Random Forest Extension*

Random Forest is one of the available extensions of Aphelion to generate a classifier. This classifier generator can be selected from the Classifier Generation task of ClassifierBuilder (see 6.3 *Classification Extensions*).

6.12. *Stage Controller interface*

The Stage Controller Interface provides convenient control of precision, optical and electronic microscope systems. For example, with this extension, users can fully control the motion of a microscope's stage in the X, Y, and Z directions.

6.13. *Stereology Analyzer*

Stereology Analyzer is a stand-alone software application based on some of the Aphelion components that implements long-standing, accepted stereology techniques that utilize a test grid overlaid on a slide image to characterize its microscopic structures. For example, with this application, accurate estimates of biomarker parameters can be computed, including volume fraction and length density. Stereology Analyzer's techniques can be easily applied to virtual slides acquired using a high throughput imaging system.

6.14. *Virtual Image Capture*

Virtual Image Capture is a stand-alone application to automatically generate a set of images by scanning a sample using an optical microscope equipped with a precision motorized stage* and a digital camera or a scanning electron microscope*. This application controls the stage and the camera, as well as the beam, the magnification, and other parameters that need to be set for a scanning electron microscope. The main control parameters are: scan mode, image size, overlap size, and scanning area definition. The images captured by Virtual Image Capture are saved together as a project, along with all scanning information, stage positions, and pixel size in real units.

- * Contact your Aphelion representative to verify that a specific stage controller and/or scanning electron microscope are supported by this application.

6.15. *Virtual Image Stitcher*

Virtual Image Stitcher is a stand-alone application used to reconstruct a larger image from a set of smaller overlapping images. By combining several smaller images, Virtual Image Stitcher builds a seamless composite image that can be larger than the available memory space of the computer. This new composite image can then be exported as a whole image (depending on the memory space of the computer) or as tiles. Virtual Image Stitcher includes a powerful and intuitive viewer that enables the user to browse virtually any size image.

For microscopy applications, Virtual Image Stitcher aids in the formation of an image from a set of high resolution subimages in order to have one single, high resolution image of the entire sample. Virtual Image Stitcher enables accomplishment of this process without the microscope having an expensive, automatic stage.

The stitching position of each individual image is saved in a project folder generated by Virtual Image Capture. Images captured by third party system can also be loaded in Virtual Image Stitcher.

6.16. *VisionTutor*

The VisionTutor Computer Vision Course is a combined theoretical and laboratory package intended for an introductory course in Image Processing and Image Understanding. The format of the course makes it possible for colleges, universities, research labs and in-house trainers to present computer vision techniques in a manner that will prepare students and end-users to both understand and apply the algorithms and techniques of this field. The format of this course is unique, as it consists of computer-based text, graphics, figures and images. Image Processing operators are illustrated in a stand-alone application that calls for the operators theoretically presented in the Lecture guide and applied on a set of typical images.

7. MACRO SCRIPTING (Dev version only)

Aphelion Dev supports three macro languages: C#, BasicScript and Python. Each language has a dedicated coding environment as a tabbed panel in window D. The tabbed panels enable the coding of macros without leaving the Dev user interface. Macros can be simultaneously open in the three coding panels.

The following table gives the main differences between the four scripting languages. The + sign ratings are an indication of the relative strength a language has with respect to a listed capability. The ratings are based on the collective experiences of the Aphelion engineering team.

Table 6.16-1: Main differences between macro languages supported in Dev

Language Capability	Visual C#	BasicScript	Python
Debug tools	No	Yes	No
Recording	Yes	Yes	No
Dialog generation	Yes ⁺⁺⁺	Yes ⁺	Yes ⁺⁺⁺
Interactive execution	No	Yes ⁺⁺	Yes ⁺⁺⁺
Reusability	Yes ⁺⁺⁺	No	Yes ⁺⁺⁺
Application automation	Yes ⁺⁺⁺	No	Yes ⁺⁺⁺
3 rd party components	Yes ⁺⁺	No	Yes ⁺⁺⁺

Dev provides a macro recording feature that enables a user to easily record sequences of functions without coding.

Executing and Debugging a Macro

A full macro execution and debug environment is included within Dev. User controls are provided for executing macros, stepping through macro instructions, monitoring variable values, and more. These facilitate macro debugging and can be used to create a demo

where the steps of the demo are recorded in a macro and executed one at a time.

For more information on this topic, open the online Help system and type *Macros* in the Index tab.

Creating Dialogs

C# and BasicScript includes a complete dialog building environment. You can create a dialog and add buttons, type-in areas, pull-down lists, etc. This is useful for creating applications, which present a limited number of options to the user, such as three filtering options, followed by measurement options. For more information, open the online Help system and type *Dialog Editor* in the Index tab.

7.1. Aphelion Macros

The following macros are provided in the standard Aphelion distribution. We recommend that you run each macro and view the results. For an annotated version of *Ceramic.apm*, see the section *7.1.5. Macro Example (Ceramic.apm)*. Macros are located in the *<Aphelion Installation Path>\Examples\Macros* folder. Three subfolders (BasicScript, CSharp and Python) contain the macros for each corresponding language. This section presents the Aphelion macros written in BasicScript (.apm), which are present in the BasicScript subfolder and subsequently separated in the following subfolders:

- **GUI Interactions:** macros using GUI and dialog elements;
- **Image:** macros using basic functions for opening, displaying and manipulating images;
- **Processing:** macros using different image and object sets processing functions;
- **Programming:** macros using more complex BasicScript programming (such as tests, loops, data IO, ...).

For a presentation of C# and Python macros, please refer to the sections *C# Programming Language* and *Python*. To load a BasicScript macro, select the **BasicScript** tab, right-click and select *Load* from the drop-down menu. Then choose a macro from one of the subfolders in the *Examples\Macros\BasicScript* folder.

7.1.1. GUI Interactions Macros

The GUI Interactions macros listed below are stored in the *Examples\Macros\BasicScript\GUI Interactions* folder.

Table 7.1-1: List of macros available in the <Aphelion Installation Path>\Examples\Macros\BasicScript\GUI Interactions folder

Macro Name	Purpose Demonstrated
Activity Control by macro.apm	Switches from an activity to another
BasicExamples.apm	A variety of useful programming examples using BasicScript
BrowseDirectory.apm	Browses a folder containing images from BasicScript
DemoLoop.apm	Loops to apply many operators to all images in a directory
Dialog.apm	Creates and displays a dialog box to run different steps of an image analysis application
GranulometryByOpening.apm	Computes granulometry measures and exports the data into a chart
InteractiveOverlay.apm	Allows to draw and select multiple objects onto an image
Process Selected	Enables the user to select image files

Images.apm	and automatically process these images
Switch to Object Editing to draw objects.apm	Switch to the Object Editing activity to draw and edit objects onto an image

7.1.2. Image Macros

The Image macros listed below are stored in the *Examples\Macros\BasicScript\Image* folder.

Table 7.1-2: List of macros available in the <Aphelion Installation Path>\Examples\Macros\BasicScript\Image folder

Macro Name	Purpose
BrowseDirectory.apm	Browses a folder containing images from BasicScript
ImgRead.apm	Loads an image. This macro can be used as a prefix in another macro to load an image from storage
SetOrigin.apm	Modifies the origin of an image

7.1.3. Processing Macros

The Processing macros listed below are stored in the *Examples\Macros\BasicScript\Processing* folder.

Table 7.1-3: List of macros available in the <Aphelion Installation Path>\Examples\Macros\BasicScript\Processing folder

Macro Name	Purpose
Blood.apm	Basic object creation & measurement

	computation (extraction of blood cells)
Ceramic.apm	Basic image processing & object extraction (extraction of fibers)
Chocolate Candies.apm	Basic color image processing & object extraction (extraction of blue candies)
Circuit.apm	Morphological operators to detect a defect in a circuit
Color.apm	Color processing
Confocal.apm	RGB to HSI conversion
ConvexHullToContourPoints.apm	Converts the contour of a convex hull obtained from a binary image to a set of points
Create objects.apm	Creates attributes into an ObjectSet
Define a structuring element.apm	Creates a custom structuring element to be used in morphology functions
FeretAccess.apm	Accesses the Feret diameters in an ObjectSet
GlobalMeasurements.apm	Computes the default global image measurements
GranulometryByOpening.apm	Computes granulometry measures and exports the data into a chart
Grille.apm	ObjectSet measurements and morphological operators
HistogramAccess.apm	Accesses a histogram's values from BasicScript
ImgBoxes.apm	Turns regions into their minimum

	bounding boxes and filters them
License Plate.apm	Extracts text information from a license plate image
Loop Over Images.apm	Load and display images from a selected folder
Muscle.apm	Morphological operators to detect cancerous cells based on their gray-scale intensities
Process Selected Images.apm	Enables the user to select image files and automatically process these images
RegionMorphology.apm	Morphology performed on an ObjectSet of bitmaps to extract fibers
RegionRotate.apm	Rotation of an ObjectSet
Regions2Lines.apm	Fits lines onto objects of an ObjectSet to draw the major axis of grape seeds
Road.apm	Computes boundary chains and demonstrates edgels, chains and lines
RoiProcess.apm	Demonstrates conversion of an ObjectSet of regions to ROIs to read time on different clocks
Volume Computation.apm	Computes the volume of an object extracted from an image after thresholding
WCCO.apm	Watersheds used to segment a multi-phase image to extract CO phase and WC grain boundaries

ZirconeAluminium.apm	Segments a 3D image of Zircone-Aluminium sample captured by a MicroCT and computes the grain size distribution and the neighbor count of every grain
----------------------	--

7.1.4. Programming Macros

The Programming macros listed below are stored in the *Examples\Macros\BasicScript\Programming* folder.

Table 7.1-4: List of macros available in the <Aphelion Installation Path>\Examples\Macros\BasicScript\Programming folder

Macro Name	Purpose
BasicExamples.apm	A variety of useful programming examples using BasicScript
BrowseDirectory.apm	Browses a folder containing images from BasicScript
DemoLoop.apm	Loops to apply many operators to all images in a directory
ExportToExcel.apm	Starts Excel and loads an image histogram into a worksheet
ExportToNotepad.apm	Starts Notepad and loads the target text into a Notepad text document.
ExportToWord.apm	Starts Word and loads an image and some text into a Word document.
ImportFromExcel.apm	Imports a new measurement computed in Excel back into a grid

7.1.5. Macro Example (Ceramic.apm)

This macro example is an annotated version of the macro Ceramic.apm, one of the application macros distributed with Aphelion (in *<Aphelion Installation Path>\Examples\Macros\BasicScript\Processing*). In this macro, the goal is to:

- Extract all fibers (dark, circular objects);
- Measure the surface, elongation and compactness of each fiber;
- Provide the fiber position in pixel coordinates.

The image, Ceramic.tif, was obtained with a scanning electronic microscope. The pixel values range from 1 to 255. In this macro, the fibers are segmented from the background using a threshold. Morphological functions are used to clean the image. Local analysis is performed to get measurements on each fiber. From the measurement data, the fibers are filtered.

This macro also shows how to use BasicScript to create dialog boxes.

Note: In this example, the macro code appears in boxes, with the annotations in regular text. For more information about a specific BasicScript command, refer to the online Macro Reference Guide, available from the Help menu in Aphelion.

In BasicScript, all comments made in a macro must start with a quote. An alternative is to use the rem command.

```
'-----
'* Ceramic.apm                                     *
'-----
'* Originator: GG                                   *
'* Date of creation: Jan 27, 1996                   *
'* Date of last modifications: March 25, 2010      *
'-----
```

Each subroutine must have a name. In Aphelion, the name by default is `main`, but any other name can be given to a subroutine. A subroutine can call another one, if the other subroutine is placed in the same file.

The main program is the subroutine named `main`. To be run, a macro should include a subroutine named `main`.

```
Sub main
'-----
'* Declarations
'-----
'The following declarations define two integer
variables breaktime and bt1000.
Dim breaktime As Integer
Dim bt1000 As Integer
```

The following is the definition of a dialog box to specify break time. The variables `OptionButton1`, `2`, `3` will contain the value `0` or `1`, depending on the selection. Other numerical values correspond to the size and position of the **OK** and option buttons.

```
Begin Dialog BreakTimeDialog , ,189,76,"Break Time
during the execution"
    OKButton 144,8,40,14
    GroupBox 4,4,132,68,"",.GroupBox1
    OptionGroup .OptionGroup1
    OptionButton 16,16,108,8,"No break during the
execution",.OptionButton1
    OptionButton 16,36,116,8,"messages displayed
during 3 sec.",.OptionButton2
    OptionButton 16,56,116,8,"messages displayed
during 5 sec.",.OptionButton3
End Dialog
```


The variable named *Breakbox* is defined as a dialog box of type *BreakTimeDialog*.

```
Dim BreakBox As BreakTimeDialog
```

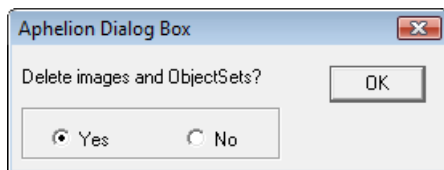
The following is the definition of a dialog box to specify whether all images are freed after you run the macro. The values 180 and 48 correspond to the size of the dialog box. The string "*Aphelion Dialog Box*" is the text which appears in the dialog box banner.

```
Begin Dialog YesNoDialog,,180,48,"Aphelion Dialog
Box"
    OKButton 132,8,40,14
    GroupBox 4,20,108,24,"",.GroupBox1
    Text 4,8,108,8," Delete images and
ObjectSets?",.Text1
    OptionGroup .OptionGroup1
    OptionButton 16,32,32,8,"&Yes",.OptionButton1
    OptionButton 72,32,32,8,"&No",.OptionButton2
End Dialog
```

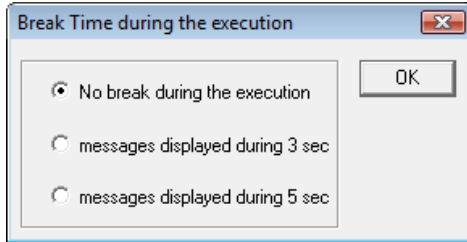
The variable named *ABox* is defined as a dialog box of type *YesNoDialog*.

```
Dim ABox As YesNoDialog
```

When this dialog variable is used in a dialog call, it will appear in Aphelion as:



When this dialog variable is used in a dialog call, it will appear in Aphelion as:



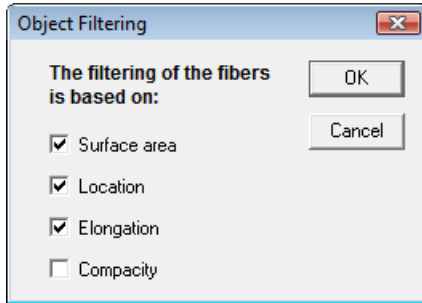
Following is a definition of a dialog box to specify which filters are applied on the measurements. All numerical values correspond to positions in pixels and sizes.

```
Begin Dialog FilterBox,,172,100,"Object
Filtering"
    OKButton 124,8,40,14
    CancelButton 124,28,40,14
    Text 16,8,92,20,"The filtering of the fibers
is based on:",.Text1,"Arial",9,ebBold
    CheckBox 16,36,68,8,"Surface area",.surface
    CheckBox 16,52,68,8,"Location",.location
    CheckBox 16,68,68,8,"Elongation",.elongation
    CheckBox 16,84,68,8,"Compacity",.compacity
End Dialog
```

The variable named *FBox* is defined as a dialog box of type *FilterBox*.

```
Dim FBox As FilterBox
```

When this dialog variable is used in a dialog call, it will be displayed in Aphelion as:



After all the declarations, the code begins.

```
'-----
' * Main program                                     *
'-----
```

Aphelion supports both 4- and 8-connectivity. The two following variables are used for the labeling operation, to specify the number of neighbors of each pixel.

```
graph4C = AphNgbGraph("2D 4-connected")
graph8C = AphNgbGraph("2D 8-connected")
```

First, the dialog box to select the time between two operators (break time) is displayed, using the *Dialog* function and the *BreakBox* variable. This dialog returns two values, -1 if the **OK** button is pressed, or 0 if the **CANCEL** button is selected. As there is no **CANCEL** button, the dialog can only return -1. When the **OK** button is selected, the variable *BreakBox.OptionGroup1* tells which option has been selected. This variable can take three values, 0, 1 and 2.

```
response = Dialog(BreakBox)
```

The *Select Case* command allows you to test a variable, and to branch to any line depending on the value. This is useful for handling the different button selections from a dialog.

```
Select Case response
  Case -1 ' OK button
    If BreakBox.OptionGroup1 = 0 Then
      breaktime=0
    Else
      If BreakBox.OptionGroup1=1 Then
        breaktime = 3
      Else breaktime = 5
      End If
    End If
  Case 0 ' Cancel button
    MsgBox "Cancel button doesn't exist!"
End Select
```

All time values in BasicScript are given in milliseconds. Thus the number of seconds specified by the variable *BreakBox.OptionGroup1* is multiplied by 1000.

```
bt1000 = breaktime * 1000
```

Load the image *Ceramic.tif* from disk and create a new image in Aphelion, using the *AphImgNew* operator. The full path to the image file has to be specified.

```
original = AphImgNew("original")
AphImgRead original, AphInstallationPath() +
"\images\Ceramic.tif"
```

The *Msg.Open* command will display a string in a pop-up box. The *Sleep* command creates a pause depending on the time lapse defined.

After opening a message window, you must close that window using *Msg.Close*.

```
Msg.Open "Composite material in a ceramics
matrix", breaktime, False, False,
150*Screen.TwipsPerPixelX,
150*Screen.TwipsPerPixelY
Sleep bt1000
Msg.Close
```

The following are a number of messages to guide the user. Usually, the call to *AphImgThreshold* has three parameters, the two images and the bounds. If one of the parameters such as threshold bounds has to be user specified while running the macro, then the parameter should be replaced by *Aph4MissingParameter()*. A default value can be specified by adding *AphThreshold (0,100)* between the two empty parentheses. In that case, as one of the three parameters has been omitted, Aphelion will prompt the user to enter those values.

```
Msg.Open "The gray level histogram of this image
includes two peaks", breaktime, False, False
Sleep bt1000
Msg.Close

Msg.Open "So, thresholding the image will segment
two phases", breaktime, False, False
Sleep bt1000
Msg.Close
```

The following lines show a threshold of the original image into a new image named *Binary1*. This name will appear in the window banner, and will also allow the user to work later on this image.

```
b1 = AphImgNew("Binary1")
Msg.Open "Low level is 1 and high level is 117",
0, False, False
```

```
AphImgThreshold original, b1, AphThreshold(0,117)
Sleep bt1000
Msg.Close
```

The binary image resulting from the threshold includes the fibers and also parts of the background (the darkest pixels). However, the fibers are much larger than the background noise, so you can apply a morphological dilation to the original gray-scale image (with a structuring element whose size is greater than the size of the objects in the background, but smaller than the size of the fibers) to remove the darkest pixels.

The following lines perform a gray-scale dilation of size 3, based on a square-structuring element. The dilation is performed on the original image, and the output image is named *Image1*.

```
i1 = AphImgNew("Image1")
AphImgDilate original,i1,AphSElement("Square",3)
```

A new threshold is performed to extract the core of the fibers. The two bounds are set to 0 and 117. The threshold is performed on the result of the previous dilation, and the output image is named *Binary2*. *Binary2* contains the seed points for the fibers, but not for the background noise.

```
b2 = AphImgNew("Binary2")
AphImgThreshold i1,b2,AphThreshold(0,117)
```

The following call to *AphImgReconstruct* performs binary reconstruction of the first binary image, using seeds detected after the second threshold. The output result will contain all blobs from the first threshold image which contain one or more seed pixels in the second threshold image. The binary reconstruction is based on the 4-connectivity, which means that every pixel in the binary image has four neighbors, in the 0, 90, 180 and 270 degree direction.

```
b3 = AphImgNew("Binary3")
AphImgReconstruct b1,b2,b3,graph4C
```

The following call to *AphImgFree* deletes the first two binary images, *Binary1* and *Binary2*, which are not needed anymore.

```
AphImgFree b1
AphImgFree b2
```

Some of the fibers in the remaining binary image are connected. The use of binary segmentation operators based upon mathematical morphology techniques will segment all the fibers. The following lines call *AphImgClustersSplitConvex*, an operator based on the watershed algorithm.

```
b4 = AphImgNew("Binary4")
AphImgClustersSplitConvex b3, b4, 10, graph4C
AphImgFree b3
```

Now *AphImgHoleFill* is used to fill the holes within blobs (fibers) in the previous binary image.

```
AphImgHoleFill b4, b4, graph8C
```

AphImgBorderKill will eliminate the objects intersecting the border of the image (partial fibers). Notice that both input and output images are identical. This feature is supported by Aphelion for all the operators which have input and output images of the same class and the same type. The operator is based on 4-connectivity.

```
AphImgBorderKill b4, b4, graph4C
```

The following *AphImgClustersToLabels* function takes a binary image as input, and generates a labeled image. In the labeled image, each object has a different gray-level value. All the pixels of the same connected object have the same value. The labels go from 1 to the number of

objects. The first object is the first one hit while scanning the image from top to bottom and left to right. The connectivity is very important while performing a labeling.

```
l1 = AphImgNew("Label")
AphImgClustersToLabels b4, l1, graph4C
AphImgFree b4
```

After a labeling, you can change the image representation from the pixel space to a symbolic representation. The *ObjectSet* named *FIBERS* is created after calling the Aphelion *AphImgLabelsObj* function. The *FIBERS* *ObjectSet* has a spatial representation of the fiber regions, and a few basic attributes (scalar attributes), such as the number of pixels in each bitmap. One way to examine this data is to use the grid feature available in Aphelion. A grid is similar to a spreadsheet, where each row corresponds to a label or object, and each column is an attribute or measurement.

```
AphImgLabelsObj l1, AphObjNew("FIBERS")
```

After creating the *FIBERS* objects, it is possible to analyze each bitmap, and compute their convex hull from the region representation. This is the best way to compute the convex hull of objects, from their boundary representation.

```
AphRegionConvexHullPolygons AphObj("FIBERS")
```

The *FIBERS* *ObjectSet* can be viewed in the grid (scalar attributes) or overlaid on top of the image (as a filled bitmap, or as the boundary of each object). The operator *AphObjDraw* overlays the *FIBERS* *ObjectSet*, seen as polygons, on top of the image named original.

```
AphObjDraw original, AphObj("FIBERS"), "POLYGON",
0, 0
```


The `ObjectSet` contains extensive information about the fibers. You can filter the objects based on their associated measurements, or use `AphObjComputeMeasurements` to compute more attributes of the fibers.

PIXELCOUNT	Number of pixels within each object
BITMAP	Coordinates of the bitmap bounding box (upper left and lower right corners)
POLYGON	Coordinates of the convex hull bounding box (upper left and lower right corners)

The `FBox` dialog box lets the user select which filter to apply. There are four types of filters available: surface, location, elongation, compactness.

```
response = Dialog(FBox)
Select Case response
    Case -1 ' OK button
        If FBox.surface Then
            i1 = AphImgNew("Surface")
            AphImgCopy original, i1
```

The following line filters the `ObjectSet` *FIBERS* into a new `ObjectSet` named *SURFACE*. The attribute involved in the filtering is *PIXELCOUNT*. The lower and upper bounds are set respectively to 1000 and 1400.

```
AphObjFilter AphObj("FIBERS"),
AphObjNew("SURFACE"), "PIXELCOUNT", 1000, 1400
```

`AphObjDraw` will overlay the resulting `ObjectSet` on top of the original image.

```

        AphObjDraw i1, AphObj("SURFACE"),
        "POLYGON"
    End If

```

The following lines filter based on the elongation of the objects. The elongation has to be measured on the regions, and not the boundaries. The two bounds of the filter are set to 0 and 0.05. A new ObjectSet named ELONGATION is created.

```

    If FBox.elongation Then
        i2 = AphImgNew("Elongation")
        AphImgCopy original, i2
        AphRegionShape AphObj("FIBERS"), "REGION"
        AphObjFilter AphObj("FIBERS"),
        AphObjNew("ELONGATION"), "ELONGATION", 0, 0.05
        AphObjDraw i2, AphObj("ELONGATION"),
        "POLYGON"
        Msg.Open "Fibers with elongation between
        0 and 0.05", breaktime, False, False
        Sleep 2000
        Msg.Close
    End If

```

The following lines filter based on the compactness of the objects. The first call to *AphObjAttributeRatio* generates a new attribute named *A1* which is equal to the *PERIMETER* divided by the *AREA* of each object. The second call defines a new attribute *A2* equal to *A1* divided by the *PERIMETER*, or the *AREA* divided by the square of the *PERIMETER*. The compactness is defined from this ratio. The two bounds of the filter are set to 0.045 and 0.06. This filter shows how new attributes can be defined from already computed ones. For further information on creating new attributes from BasicScript see the *Obj** macro functions. The final result is displayed on top of the original image.

```

If FBox.compactness Then
    i3 = AphImgNew("Compactness")
    AphImgCopy original, i3
    AphRegionShape AphObj("FIBERS"), "REGION"
    AphObjAttributeRatio AphObj("FIBERS"),
"PIXEL_COUNT", "PERIMETER", "A1"
    AphObjAttributeRatio AphObj("FIBERS"),
"A1", "PERIMETER", "A2"
    AphObjFilter AphObj("FIBERS"),
AphObjNew("COMPACITY"), "A2", 0.045, 0.06
    AphObjDraw i3, AphObj("COMPACITY"),
"POLYGON"
    Msg.Open "Fibers with shape closest to
the circle", breaktime, False, False
    Sleep 2000
    Msg.Close
End If

```

The following lines filter based upon the position of the objects in the image. As the lower labels are in the upper part of the image, it is sufficient to filter on the *INDEX* variable. The two bounds are set to 1 and 10. A new ObjectSet named *LOCATION* is created.

```

If FBox.location Then
    i4 = AphImgNew("Location")
    AphImgCopy original, i4
    AphObjFilter AphObj("FIBERS"),
AphObjNew("LOCATION"), "TOKEN_INDEX", 1, 10
    AphObjDraw i4, AphObj("LOCATION"),
"POLYGON"
    Msg.Open "Selection of the 10 first
fibers", breaktime, False, False
    Sleep 2000
    Msg.Close

```

```

End If
Case 0 ' Cancel button
MsgBox "Cancel button doesn't exist!"
End Select

```

The following dialog box asks whether to delete all the images and objects created during this macro. The first choice is to delete all images, and the value of the .OptionGroup1 is then 0. The variable response is the returned value of the dialog box.

```

response = Dialog(ABox)
If ABox.OptionGroup1 = 0 Then
  AphImgFree original
  If (Fbox.surface) Then
    AphImgFree i1
    AphObjFree AphObj("SURFACE")
  End If
  If (Fbox.elongation) Then
    AphImgFree i2
    AphObjFree AphObj("ELONGATION")
  End If
  If (Fbox.compactness) Then
    AphImgFree i3
    AphObjFree AphObj("COMPACTNESS")
    AphImgFree i3
  End If
  If (Fbox.location) Then
    AphImgFree i4
    AphObjFree AphObj("LOCATION")
  End If
  AphObjFree AphObj("FIBERS")
End If

```

This is the end of the macro and the subroutine main. The call to the function *End Sub* ends the subroutine.

End Sub

7.2. C# Programming Language

See *APPENDIX G - C# Programming Language* section for detailed information about the C# programming language in Aphelion.

Example macros in C# are provided in the folder <Aphelion Dev installation folder>\Examples\Macros\CSharp. The description and presentation of the C# macros distributed with Aphelion Dev is available in the document “CSharp Macros Help” available also in the folder <Aphelion Dev installation folder>\Examples\Macros\CSharp.

7.3. Python

Example macros in Python are provided in the folder <Aphelion Dev installation folder>\Examples\Macros\Python.

8. PROGRAMMING EXAMPLES (Dev and SDK only)

Users of Aphelion SDK should review the examples provided in the folder called *Examples* in the SDK folder. Aphelion DEV users need to install the Aphelion SDK if they wish to review those examples.

The examples provided as Microsoft Visual Studio solutions show how to develop an application that uses Aphelion's libraries. The examples include the following support:

- 32 and 64 bit architectures;
- Native and Managed code.

Note: We recommend reviewing the example called Pads. It is easy to understand and illustrates some basic image processing. Section *8.3 Pads Example (Visual C# code)* describes the managed code version of the Pads example.

There are three subfolders in *Examples*, one contains the programming examples as Native code, the second contains the examples as Managed Code, and the third contains temporary files “.obj” generated by the compiler. This latter folder does not exist immediately after the first installation of SDK.

8.1. Native Examples

The Native folder (Win32) includes two C++ examples, named Pads and Clocks. Visual C++ 2008 or newer is needed to compile these two examples. However, the executable versions of these files are provided for those who do not have the compiler. Both 32-bit and 64-bit versions of the executable files are included.

The *Pads* example illustrates how to use basic image processing and morphology to detect malformed solder pads (i.e., defects) on a circuit board. This is done by extracting the small, circular pads as objects,

computing their measurements, and then filtering the pads based on their shape.

The *Clocks* example demonstrates how to differentiate between six clocks in an image and locate the hands of the clocks. This example uses irregular regions of interest, derived from an edge detection function, to isolate each individual clock, and then extracts the dark objects on the clocks corresponding to the clock hands.

8.2. *.NET Examples*

The Managed Code folder (dotnet) includes two subfolders, one called *Applications* and the other called *Help.Examples*. *Help.Examples* is a C# project that calls for any Aphelion function. We recommend using this C# project to get the syntax of each Aphelion image and ObjectSet function. This project is the foundation for generating the Aphelion Online Help examples.

The *Applications* folder includes four subfolders corresponding to four distinct applications: *Ceramic*, *Clocks*, *Pads*, and *WCCo*. For each application, individual projects (*.csproj) are provided for both 32-bit and 64 bit systems. Visual Studio .Net or Visual C# Express (freeware product) are required to open and execute these projects. .Net components can also be called in Python, Visual C++, and Visual Basic projects.

Note: SharpDevelop is a free, open source programming environment that can be used to open and manage Aphelion C# projects.

The *Ceramic* example demonstrates the use of a threshold function, morphological operations, and ObjectSet management to extract dark, circular objects from an image. The *WCCo* example uses an image that contains carbide objects in a cobalt matrix, and illustrates how to extract multiple phases from an image. The *Pads* and *Clocks* applications were explained in the prior section.

Each example project includes a graphical user interface for entering parameters values required for proper execution of each phase of the project.

8.3. *Pads Example (Visual C# code)*

Following is a detailed description of the image processing code used in the *Pads* example.

```
// Define the image folder to be able to load the
// image in the GUI and process it

String imagePath = Application.ExecutablePath.
ToLower().Replace("pads.exe",
@"..\..\..\Images");

Adcis.Images.IO.Globals.ImageFolders.Add(imagePat
h);

// Create the input image and read the image file
Pads.tif from the disk. Other image formats are
supported in Aphelion (bmp, jpg, etc.). The image
is automatically loaded when starting the
application

m_imageInput = new Adcis.Images.Image();
m_imageInput.Read("Pads.tif");

// Keep the default resolution as pixels. If a
resolution is already defined for the image, then
there is no need to include the line below

m_imageInput.Resolution = null;
```



```
// Display the input image in the image window
that has been defined in the form

m_imageView.Data.Add(m_imageInput);
// Write some text in the text box located at the
bottom of the GUI to guide the user

richTextBoxComment.Text = "Click on Detect, Pads
to process the image";
richTextBoxComment.Refresh();

// User has selected the Execute entry in the
menu

private void padsToolStripMenuItem_Click(object
sender, EventArgs e)
{
    [...]

    // Top Hat transform to detect the pads even
    on a non uniform background. The input image
    is m_imageinput, the output image is called
    imageTophat and the structuring element
    involved in the process is a square of size
    15.

    // Create a new image

    Adcis.Images.Image imageTophat =
    new Adcis.Images.Image();
    Adcis.Images.Morphology.Segmentation.Functions
    .WhiteTophat(m_imageInput, imageTophat,
    PredefinedStructuringElementEnum.pseSquare, 15);

    // Threshold the result of the tophat
    transform between 101 and 232
```

```

Adcis.Images.Image imageThreshold =
new Adcis.Images.Image();
Adcis.Images.Segmentation.Functions.Threshold
(imageTophat, imageThreshold,
new Adcis.Math.IntervalD(101, 232));

// To remove small artifacts in the image,
perform an opening followed by a
reconstruction

Adcis.Images.Morphology.OpeningClosing.
Functions.ErodeReconsOpen(imageThreshold,
imageThreshold, new Adcis.Geometry.
StructuringElement(Adcis.Geometry.
PredefinedStructuringElementEnum.pseSquare,
7), PredefinedNgbGraphEnum.pngSquare8);

// Convert the binary image into an Aphelion
ObjectSet

Adcis.ObjectSets.ObjectSet osPads =
new Adcis.ObjectSets.ObjectSet();
Adcis.ObjectSets.Regions.Segmentation.
Functions.Clusters(imageThreshold, osPads,
PredefinedNgbGraphEnum.pngSquare4);

// Display the detected pads as an ObjectSet
in the graphics overlay

m_imageView.Data.Add(osPads.Attributes
["REGION"]);

```

```

// Compute the maximum Feret diameter (using
directions every PI / 180) to detect
irregular and faulty pads

Adcis.ObjectSets.Measurements.Functions.Feret
ShapeMeasurements(osPads.Attributes["REGION"],
new FeretShapeMeasurementEnum[]
{ FeretShapeMeasurementEnum.fsmFeretMax },
Math.PI / 180);
// Extract irregular pads defined as pads with
a maximal Feret >= 14.5

Adcis.ObjectSets.ObjectSet osIrregular =
new Adcis.ObjectSets.ObjectSet();
Adcis.ObjectSets.Filtering.Functions.
Filter(osPads, osIrregular,
osPads.Attributes["REGION.Feret.Max"], 14.5,
1000);

// Change the fill style and color to display
the irregular pads

(osIrregular.Attributes["REGION"] as
Adcis.Drawing.IDrawable).StandardProperties.
FillStyle = Adcis.Drawing.FillStyleEnum.fsSolid;

(osIrregular.Attributes["REGION"] as
Adcis.Drawing.IDrawable).StandardProperties.
LineColor = Color.Green;
(osIrregular.Attributes["REGION"] as
Adcis.Drawing.IDrawable).StandardProperties.
FillColor = Color.Green;
// Display the irregular pads in the graphics
overlay

```

```
m_imageView.Data.Add(osIrregular.  
Attributes["REGION"]);  
richTextBoxComment.Text = "Irregular pads are  
colored in green";  
richTextBoxComment.Refresh();
```


9. .NET COMPONENTS (Dev and SDK only)

The Aphelion Dev and SDK products both include a large set of .Net components called Aphelion Imaging Toolkits (TKs). Each TK contains a set of related functions and the TKs collectively contain all Aphelion image processing functions. Additional components are available to display images and ObjectSets before and after processing, and to interact with those objects in the Graphical User Interface.

- The Imaging Toolkits include all image and ObjectSet processing functions. There is an Aphelion .Net component for each group of Aphelion functions, such as *Filtering*, *Morphology*, and *EdgeDetection*.
- Other .Net components include the display of images and ObjectSets, interactive drawing in images, and object management.
- A complete list of the imaging groups can be found in the second-level dropdown menu for the **Process** entry on Dev's **Menu Bar**.

Note: The Aphelion 4.x online documentation includes a detailed description of each property and method of the .Net components.

APPENDICES

APPENDIX A APHELION DVD ARCHITECTURE

The Aphelion DVD root directory contains seven folders, one each for the Aphelion main software products called *AphelionDev*, *AphelionLab*, and *AphelionSDK*, one for the device drivers (*Dongle and acquisition device drivers*), one for the extensions, one for the documentation (*Help*), and an additional *Multimedia Demos* folder. Each product folder contains an installation program. The Aphelion Dev product has separate installation programs for 32-bit and 64-bit architectures. A different installation code is required to install each product.

For each product installed, the subfolders present on the disk are:

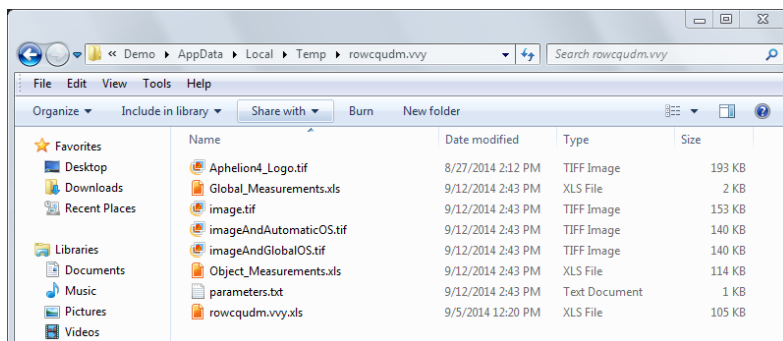
FILE TYPE	DESCRIPTION	DEV	LAB	SDK
bin	DLLs & Dev executable files	✓	✓	
Chart	Chart models	✓		
drivers	Acquisition device drivers		✓	
Examples	Programming and macro examples	✓		✓
Help	Online documentation	✓	✓	✓
Images	Sample images for tutorials, testing, and developing macros and applications	✓	✓	✓
Include	Include files for Native C++ programming			✓
Lib	Libraries for 32-bit and 64-bit architectures			✓
Redistribution Files	Microsoft products required to install and run Aphelion software	✓	✓	✓

APPENDIX B REPORT GENERATION

B. 1. How to modify report-template

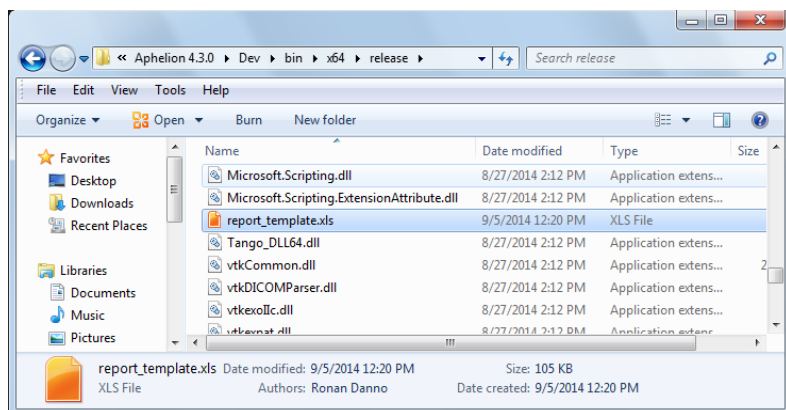
When generating a report, Aphelion looks for the different elements composing a report (images, objectsets, measurements, etc.) before creating a temporary folder containing the files needed to generate the report. This folder is located in `C:\Users<Username>\Appdata\Local\Temp`.

Aphelion uses Visual Basic macros to automatically generate the report. In the temporary folder, those macros are located in an xls file with a randomly generated name (e.g.: `da0leqfm.jy5.xls`). This file is a copy of the `report_template.xls` file and is only affects the report in the temporary folder.



The generated xls file contains three different sheets, one for histogram values, one for object measurements, and one for the main report ready for printing.

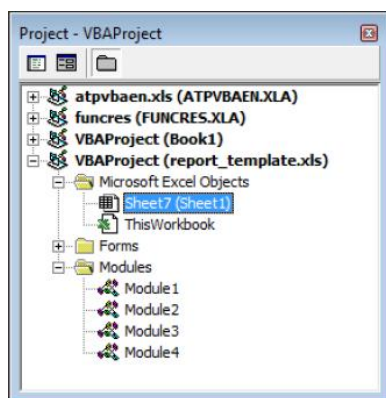
To permanently customize the reports you are generating, modify the `report_template.xls` file located in the `<Aphelion Installation Path>\Aphelion 4.x.y\Dev\bin\<x64> or <win32>\release` folder.



Once the file is opened, select the **Tools→Macro→VB Editor** menu, or press **ALT + F11**.

Once the editor is opened, files that need to be edited are located in the “*module*” folder.

Modules to be modified are modules 1, 2 and 3. All the files share a similar architecture, but **Module1** is used for object measurement reports (classic report), **Module2** for interactive measurement reports (measurement of interactive shapes defined in the measurement section of Aphelion) and **Module3** is used for global measurement reports (measures computed on the whole image).



Major changes will require some Visual Basic coding knowledge. Click on the following link to access the online Visual Basic documentation.

B. 2. Examples of small changes

B. 2. a. Change the Aphelion logo

Open the module to be edited (it can either be modules 1, 2 and 3), and look for the comment “Add the Aphelion Logo”. In `ActiveSheet.Pictures.Insert(“CurrentFilename.tif”)` and replace the current filename by the one you want to add:

```
' Add the Aphelion logo
.
    ActiveSheet.Pictures.Insert("Aphelion4_Logo.tif").Select
```

B. 2. b. Change the report title

Open the module to be edited (it can either be modules 1, 2 and 3), and look for the comment “Add the Aphelion Logo”. On the line `ActiveCell.FormulaR1C1 = "CurrentTitle"` replace the current title by the new one.

```
' Add the Aphelion logo
.
    ActiveSheet.Pictures.Insert("Aphelion4_Logo.tif").Select
    Range("C1").Select
    ActiveCell.FormulaR1C1 = "Object Measurement Report"
```

B. 2. c. Change displayed images

Open the module to be edited (it can either be modules 1, 2 and 3), and look for the comment “Insert images in the report”. Filenames, positions, and size can be modified, and images can be discarded.

```
' Insert images in the report
.
    ActiveSheet.Pictures.Insert("image.tif").Select
    SetImageSizeAndPosition ActiveSheet, 5, 1

    ActiveSheet.Pictures.Insert("imageAndAutomaticOS.tif").Select
    SetImageSizeAndPosition ActiveSheet, 5, 6
```

B. 2. d. Print report


Open the module to be edited (it can either be modules 1, 2 and 3). To automatically print the report into a PDF file, add the following code

at the end of the macro. Use the method called PrintOut to generate a PDF file or just print to a printer. Look for the active printer available on the PC and add the code below accordingly:

```
'Print file
'
'Check if printer is ready
Application.ActivePrinter = "MyPDFPrinter"
ActiveWindow.SelectedSheets.PrintOut ActivePrinter:="MyPDFPrinter"
```

B. 2. e. Add header/footer

Open the module to be edited (it can either be modules 1, 2 and 3), and look for the comment “Set the margins” at the end of the macro. Uncomment and change the needed lines, hand refer to the example below:

<pre>' Set the margins ' On Error Resume Next With ActiveSheet.PageSetup .LeftHeader = "" .CenterHeader = "" .RightHeader = "" .LeftFooter = "" .CenterFooter = "" .RightFooter = ""</pre>		<pre>' Set the margins ' On Error Resume Next With ActiveSheet.PageSetup .LeftHeader = "Company name" .CenterHeader = "Page &P of &N" .RightHeader = "Printed &D &T" .LeftFooter = "" .CenterFooter = "" .RightFooter = ""</pre>
--	---	--

To add a header/footer on every worksheet, add a loop in the code like so:

```
' Set the margins
'
Dim ws As Worksheet
For Each ws In ActiveWorkbook.Worksheets
    With ws.PageSetup
        .LeftHeader = "Company name"
        .CenterHeader = "Page &P of &N"
        .RightHeader = "Printed &D &T"
        .LeftFooter = "Path : " & ActiveWorkbook.Path
        .CenterFooter = "Workbook name &F"
        .RightFooter = "Sheet name &A"
    End With
Next ws
Set ws = Nothing
```

B. 2. f. Change histogram to scatter plot

Removing the histogram and replacing it with another diagram requires some Visual Basic knowledge. To avoid programming, the straightforward solution is to record a macro and add it to existing macros (e.g. modules 1, 2 and 3).

Start the recorder, selecting **Tools→Macro→Record new Macro** and enter the name of the new macro (e.g: “AddScattPlot”).

The basic concept is to edit the report sheet, substitute the 1D histogram by a 2D histogram or scatter plot, and at the same time record the modifications in a Visual Basic file containing the macro that automatically makes those changes.

Once the changes are completed, stop the recording process from the **Tools→Macro→Stop recording** menu.

Then open the Visual Basic Editor (**Alt + F11**) to locate the new file under the “*Modules*” folder. Move into the file to be modified (e.g. module 1, 2 or 3) and add the name of the recorded macro (“AddScattPlot”) at the end of the file (before the “End Sub” line).

Refer to appendix 1 for a Visual Basic code that generates a scatter plot.

Note that any other macro that may be recorded by the user to perform a specific task can be added in the existing macro.

```
'Recorded Macro
AddScatterPlot

End Sub
```

B. 3. Example

The following code generates a scatter plot of the area versus the perimeter on 84 objects of an objectset.


```
Sub Macro10()
'
' Macro used to generate a scatter plot of the
Area versus the perimeter
'

ActiveSheet.Shapes.AddChart.Select
ActiveChart.ChartType = xlXYScatter
ActiveChart.SetSourceData Source:=Range( _
    "'Object Measurements'!$B$2:$B$85,'Object
Measurements'!$D$2:$D$85")
ActiveChart.SetElement
    (msoElementChartTitleAboveChart)
Selection.Caption = "Area vs Perimeter"
ActiveChart.Legend.Select
Selection.Delete
ActiveChart.SetElement (msoElementPrimary
    CategoryAxisTitleAdjacentToAxis)
Selection.Caption = "Area"
ActiveChart.SetElement (msoElementPrimary
    ValueAxisTitleRotated)
Selection.Caption = "Perimeter"
End Sub
```


APPENDIX C TROUBLESHOOTING

C. 1. Troubleshooting for the dongle

Verify that the dongle is actually connected to a USB port. If it is not, then go back to Step 5 of section 2.4.4 *Installing the USB Dongle* of this guide. If it is connected, then unplug it, wait 10 seconds, and then reconnect the dongle.

1. After few seconds, open the **Windows Device Manager**.
2. Double click on the **Universal Serial Bus controllers** so that all connected USB devices are displayed.
3. If the entry *CBUSB Ver 2.0* is not available, then unplug the USB dongle and go back to Step 1 of section 2.4.4 *Installing the USB Dongle*. If the entry *CBUSB Ver 2.0* is always not available after these operations, then contact the Aphelion Support Team (see section 2.3 *Product Support*).
4. If a warning is displayed on top of the entry ( *CBUSB Ver 2.0*), then unplug the USB dongle, reboot your operating system, and plug again the USB dongle. Open the **Windows Device Manager** and check the entry *CBUSB Ver 2.0* is displayed without a warning sign. In the other case, contact the Aphelion Support Team (see section 2.3 *Product Support*).

C. 2. Invalid license

If the License window displays the message “*Invalid license!*” after starting Aphelion, then you should contact your Aphelion representative or the Aphelion support team and send them the following information:

- Your name;

- Company/Organization name;
- Your contact information;
- The message displayed in red in the License window.

Your representative or the Aphelion support team will contact you with a solution to reactivate your Aphelion license.

C. 3. Troubleshooting for the camera interface

Important note: The Allied Vision camera driver, the Peak camera driver, and the Teledyne camera driver are both compliant to the GigE Vision and USB3 Vision standards. These drivers can not be loaded together.

If your license includes more than one of these drivers then it is recommended to only load the proper driver by unselecting the not proper drivers from the Extensions tab of the Aphelion options (Tools>Options... menu in the Administrator mode) and restarting Aphelion.

C. 3. a. Checking the installation of the driver

To check that the Camera Device driver was installed properly, please follow the instructions below.

1. Check that the cable is properly connected to both the camera and the computer and, if the camera is not powered through this cable, that its power supply is plugged.

If the camera has a DirectShow interface:

2. Open the **Windows Device Manager**.
3. Open the *Imaging devices* item, check the camera is available in the list of devices and check it properly works (right-mouse click on the item and select *Properties*).
4. Check the camera works properly using the software application provided with the camera.

C. 3. b. Checking camera operation

Whatever the interface of the camera (DirectShow or proprietary driver), check that the camera and its drivers are properly installed using the software application provided with the camera.

1. Check that no other software application interfacing the camera is running, otherwise close it.
2. Run the software application provided with the camera by your reseller.
3. Check that the camera works properly.
4. Check that the Aphelion interface compliant to the camera driver is licensed and loaded (Look at the availability and the status of the interface in the list of extensions – See *2.9.3 Menu Bar - Tools Menu* to find how to access to this list)

If these conditions are all met and the camera still isn't recognized by Aphelion, or if you are unable to correct any of these conditions, then please contact the Aphelion Technical Support (see section *2.3 Product Support*), describing the problem you are experiencing as fully as possible, including which of the conditions are or are not being met.

C. 4. Troubleshooting for the Report Generation task

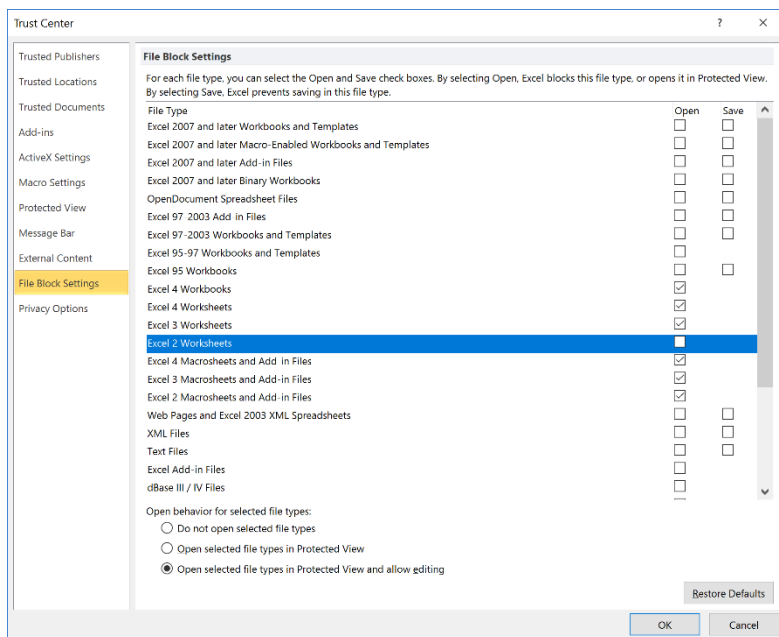
What to do if the Report Generation task is not working properly in Aphelion 4.3.x?

1. Start Excel
2. Select the File>Options menu
3. Select the Trust Center entry
4. Click on the Trust Center Settings button

Trust Center Settings...

5. Select the Protected View entry in the left panel
6. Unselect “Enable Protected View for files located in potentially unsafe location”
7. ☐ Enable Protected View for files located in potentially unsafe locations
8. Then select the File Block Settings entry in the left panel

Unselect Excel2 worksheets, and select “Open selected file types in Protected View and allow editing as depicted in the image below



C. 5. Troubleshooting Deep Learning

Aphelion DeepLearning module is compatible with GPU of the Nvidia series. If a GPU is installed on the user's computer, Aphelion DeepLearning module will automatically use it if compatible. If not,

the module will use the CPU instead. In general, the DeepLearning module will use the CPU instead of the GPU in the following cases:

- No GPU is found on the user's computer
- A GPU is found, but it is not compatible with the library. It may be too old or too recent, or it may not be from the Nvidia series. To check that your GPU is compatible, please go to <https://developer.nvidia.com/cuda-GPUs> and look for your GPU card. It should be in the list and have a compute capability between 3.0 and 7.5. Note that it is possible that Aphelion DeepLearning can work with GPU with a compute capability above 7.5, but it is currently not guaranteed.
- A GPU is found and is compatible, but its drivers are too old or not installed on the user's system. Please go to <https://www.nvidia.fr/Download/index.aspx>, enter the reference of your GPU card and search for drivers. The website should propose the downloading of the latest version of the drivers compatible with your GPU card. Please download the installation program and install the software. The Aphelion DeepLearning module have been tested with Nvidia drivers of version 451.48 or above (from 2020-06-24 or posterior). Its use with drivers of anterior versions is not guaranteed.

Note that the the use of Aphelion DeepLearning with a GPU is only guaranteed with GPU cards from Nvidia series listed here: <https://developer.nvidia.com/cuda-GPUs> with a compute capability between 3.0 and 7.5. Prior to using Aphelion DeepLearning for the first time, the user is recommended to:

1. Check his/her GPU compatibility using the link given above (<https://developer.nvidia.com/cuda-GPUs>)
2. Download and install the latest Nvidia drivers for his/her GPU card at <https://www.nvidia.fr/Download/index.aspx>

The user should select the right GPU models and the “Game Ready Driver” option.

APPENDIX D MAIN DIFFERENCES BETWEEN APHELION DEVELOPER 3.2 AND APHELION DEV 4.X

The main differences between Aphelion 4.x and its predecessor, Aphelion 3.2, are an all new graphical user interface (GUI), and a new architecture based on the Microsoft .Net Framework. The use of .Net components results in a more open and flexible product, benefiting from the new programming concepts. Note that all Aphelion functions have been totally rewritten in Visual Studio .Net and ported into both 32-bit and 64-bit environments.

The all new GUI was totally redesigned to offer a new *look and feel*, and a more structured operation paradigm based on tasks that make Aphelion 4.x especially easy to use. The tasks divide the image analysis process into its logical components, from image acquisition through report generation. The tasks are all accessible with one click from an always visible task bar.

Following the trend of “everything digital,” Aphelion 4.x now includes the DirectShow interface and proposes optional interfaces to cameras using proprietary drivers. Aphelion 4.x does not support frame grabber products. The list of supported proprietary acquisition devices is available at:

<https://www.adcis.net/en/applications/image-acquisition-device-interfaces/>

Since Aphelion 3.2 only supported 32-bit architectures, it could not process images larger than about 300MB. Aphelion Dev and SDK support both 32-bit and 64-bit architectures. With the 64-bit version, Aphelion 4.x imposes virtually no limit on the size of images that it can process.

Aphelion 3.2 only supported one macro language, BasicScript. While Aphelion 4.x continues support for BasicScript, it supports two additional macro languages: Visual C# and Python. BasicScript macro recording is still provided along with C#, but Python does not yet support macro recording. (Check Aphelion Readme files for information on macro recording support.)

Following is a brief description of the new features of version 4.x.

D. 1. Tasks

Aphelion Lab and Dev structure image processing and analysis work in terms of tasks. Each task corresponds to a coherent subset of the work steps necessary in performing image analysis. Lab and Dev share the same tasks, but Dev adds an additional task, **Developer**, that greatly expands the number and capability of the image processing and analysis functions and adds tools for developing deployable applications. We recommend that new users and users of Lab follow the sequence of tasks as laid out in Aphelion's GUI. With the Dev product, the complexity and goals of the image analysis project will dictate if and when the expanded capabilities of the **Developer** task are needed.

D. 2. Administrator rights

Aphelion 4.x provides a password protected mode for administrator users who have full control of all system configuration settings. The non-administrator user typically captures images using a system configured by an administrator and processes the images using preconfigured software procedures. All system calibration settings, camera selection, and other advanced parameters are typically not made available in the non-administrator user mode.

D. 3. Acquisition Task

In Aphelion 3.2, the image acquisition functions were spread out in the menus. In Aphelion 4.x, all image acquisition functions are together in a single task. **Calibration** tools and associated resolutions for imaging devices are now easily accessed in the GUI.

D. 4. Object Extraction Task

Many images can be easily segmented (e.g., using a threshold). For such images, the **Object Extraction** task will usually be sufficient. However, for more complex images the added capabilities included in Aphelion Dev's **Developer** task may be necessary. Note that an ObjectSet created with the **Object Extraction** task can be input for an ObjectSet function in the **Developer** task.

D. 5. Object Editing Task

This task enables a user to alter an ObjectSet generated by either the **Object Extraction** task or **Developer** task. Alteration of an ObjectSet includes using the mouse to draw new objects or modify existing objects, as well as delete objects.

D. 6. Measurement Task

The number of object measurements has been dramatically increased in Aphelion 4.x. The current release of Aphelion 4.x provides its users with about 50 measurements functions. The set of interactive measurement tools available in version 3.2 has also been enriched in version 4.x, with many, new tools such as angle measurement and caliper.

D. 7. Report Generation Task

This task provides a new capability that was not available in Aphelion 3.2. It generates analysis reports that use a Microsoft Excel template. The content and format of the report can be configured by the user who has some Visual Basic for Applications knowledge. This task also includes functions to copy images and ObjectSets to the

Windows clipboard, from where a user can easily import them into other applications (e.g., Word, Excel).

D. 8. Developer Task

D. 8. a. Function Selection

In Aphelion 3.2, all functions were selected in the Operator Dialog Box by clicking on a unique icon. Aphelion 4.x makes all functions accessible from the **Process** menu on the **Menu Bar**. Version 3.2's small icons containing images no longer exist. With version 4.x, images entered as either input or output parameters of a function are automatically displayed in the Visualization window.

Most of the functions available in Aphelion 3.2 are still available in Aphelion 4.x. While a few uncommon functions have not been ported to version 4.x, many new functions have been added.

D. 8. b. Macro Languages

As mentioned in many places in this User Guide, three macro languages are now supported: Visual C#, BasicScript and Python. Thus Aphelion users of the previous version can still develop and use BasicScript macros. However, new users may opt for a more modern macro language such as C#.

D. 8. c. BasicScript Command window

The History tab of the Information/History/Message window in version 3.2 of Aphelion is no longer available in version 4.x. It has been replaced by the BasicScript Command window (see *Immediate and Output Windows*). A BasicScript command can be written, edited, and run from this window.

D. 9. Aphelion 4.x User Interface

The MDI (Multiple Document Interface) available in Aphelion version 3.2 has been replaced by a fixed (i.e., non-floating) window (Visualization window) in which one or four images can be displayed. However, while all other Aphelion 4.x windows have a default, fixed location in the GUI, any of them can be easily floated as the user chooses, and just as easily re-fixed in the GUI, using simple mouse clicks. Floating windows can be dragged to any location in the Windows interface. All windows can be easily resized in the standard way for Windows applications.

D. 10. Image and ObjectSet Galleries

Two new features available in Aphelion 4.x are the Image Gallery and the ObjectSet Gallery. Every open image and ObjectSet, whether loaded from disk or created in the GUI, is displayed in its respective gallery as a thumbnail, labeled with its file name. Double-clicking on a thumbnail causes the corresponding image or ObjectSet to be displayed in the Visualization window. This can also be done through a thumbnail's contextual menu.

D. 11. Color space

The Color Space property of a color image could only be changed by calling the `AphImgColorConvert` image processing function in version 3.2 of Aphelion.

D. 11. a. Default Color Space

The default color space for an image is Blue-Green-Red (BGR) in version 4.x while it was RGB in version 3.2. This change have been made to improve the refresh of images, especially when images are very large.

D. 11. b. Color Space Conversion

Since the color space is one of the image properties, it has been added to the image properties available in the Image Properties window (right-click on the image thumbnail in the Image Gallery tab). This property can be edited by selecting a color space from the color space list that opens when clicking on the Color Space button in the Image Properties window.

Note: The color space change does not modify the image display in version 4.x. It changed the image display in version 3.2.

The color space of a color image can also be modified in a macro:


BasicScript syntax in version 3.2:

```
AphImgColorConvert AphImg("Image 1"),
AphImg("Image 1"), 1
```

BasicScript syntax in version 4.x:

```
Aph4ImgSetColorSpace AphImg("Image 1"), SpaceName
```

D. 11. c. Accessing the band of a color image

The display of a single band of a multi-band image has been improved. Clicking on  displays the previous or next band of a multi-band image (i.e. color, frequency, complex, and edge images).

A single-band image can also be extracted from a multi-band image by calling the *Images.Utility.ExtractBand* function in version 4.x instead of the *AphImgSplitBands* function in version 3.2.

A single-band image can also be copied as one of the bands of a multi-band image by calling the *Images.Utility.CopyBand* function in version 4.x instead of the *AphImgJoinBands* function in version 3.2.

D. 12. Running a macro when starting Aphelion Dev

In version 3.2 of Aphelion Dev, the Aphelion.apm macro was automatically run when launching the software.

To automatically run a macro when launching Aphelion Dev 4.x, add its name in the list available in the Startup tab of the **Tools→Options** menu.

D. 13. Structuring Element definition

Predefined structuring elements used by functions in the Image.Morphology group are defined in a different way than in version 3.x. The size of the structuring element now gives the width of the ball while it defined the "radius" in the previous versions (version 3.x). The relationship between the two sizes is the following:

$$Sv4.x = (Sv3.2 \times 2) + 1$$

Note the Basic Script functions of the Image.Morphology group exist in 2 versions:

- the version to keep the compatibility with the previous versions begins by Aph;
- the version provided by the Aphelion 4.x macro recorder begins by Aph4.

Here is an example of the same macro function in the 2 versions:

```
AphImgDilate  AphImg("Ceramic"),  AphImgNew("Image
1"),  AphNamedSElement("Square",2)
```

```
Aph4ImgDilate  AphImg("Ceramic"),  AphImgNew("Image
1"),  pseSquare, 5
```

APPENDIX E DIFFERENCES IN PROGRAMMING SYNTAX BETWEEN APHELION 3.2 AND APHELION 4.X (DEV VERSION ONLY)

E. 1. Programming syntax

Aphelion 4.x includes namespaces for functions libraries.

In version 3.2 of Aphelion, a function had the following syntax in BasicScript: *AphImgFunction* or *AphObjFunction*. The prefix *Aph* is no longer present in version 4.x, except in BasicScript (to maintain backwards compatibility). Aphelion 4.x syntax is now:

Adcis.Images.Group.SubGroup.FunctionName
Adcis.ObjectSets.Group.SubGroup.FunctionName

For example, erosion functions for images and ObjectSets are defined as:

Adcis.Images.Morphology.Basic.Erode
Adcis.ObjectSets.Bitmaps.Morphology.Erode

Refer to section 5 *List of functions (Dev and SDK only)* for the group and subgroup of each Aphelion function.

E. 2. BasicScript Editor

Most of the Aphelion 3.2 features for developing macros, such as:

- Execute code step by step;
- Watch a variable; and
- Set a break point

are still available in Aphelion 4.x.

E. 3. BasicScript syntax

The text below gives the major differences between the two Aphelion versions with respect to programming in BasicScript.

Note: BasicScript functions starting with the *Aph4* prefix are functions that are either new in version 4.x, not available in version 3.2 (e.g., *Aph4ImgClip*, *Aph4ObjOtsuThreshold*, *Aph4MissingParameter*), or an alternate version of functions that were available in version 3.2 (e.g., *Aph4ImgErode*).

Tip: There are new functions available in Aphelion 4.x (e.g., *Otsu Threshold*). Since these functions did not exist in version 3.2, the associated BasicScript function did not exist in the previous version. All new functions in Aphelion 4.x can be called in BasicScript using the following syntax:

Aph4<name of the Function> (e.g., *Aph4ImgOtsuThreshold*)

E. 3. a. Function to let the user enter function argument values during the macro execution

The function *Aph4MissingParameter* has been introduced to convert a BasicScript macro into an interactive macro in which some parameters can be omitted. In this case, a window pops up to let the user define the missing parameter(s)

E. 3. b. Function to retrieve argument values set during the macro execution

The *AphOperatorArgumentValue* function is replaced by the *Aph4OperatorArgumentValue* function. Below are the differences:

Aph4OperatorArgumentValue does not take the name of the function as the parameter. It is only possible to retrieve parameter values of the last executed version.

The returned value in version 4.x is a .NET object. It was an Active X object in version 3.2 defined as a simple type object (e.g. long, double,

string). To access properties of the .NET object, use the *Aph4GetProperty* and *Aph4ToBuiltinType* functions.

Example:

```
Binary = AphImgNew("Image 2")
AphImgShow AphImg("Image 1")
    ' Make sure the thresholded image is visible
AphImgThreshold AphImg("Image 1"), Binary,
Aph4MissingParameter()
AphImgShow Binary
threshold = Aph4OperatorArgumentValue(2)
minimum = Aph4ToBuiltinType(Aph4GetProperty(Aph4GetProperty(threshold, "Item", 0),
"Minimum"))
    ' Item is the name of the 'this[band]' indexer
of the .NET IntervalD class
maximum = Aph4ToBuiltinType(Aph4GetProperty(Aph4GetProperty(threshold, "Item", 0),
"Maximum"))
MsgBox "Minimum = " & minimum & ", Maximum = " &
maximum
```

E. 3. c. ObjectSet Attributes

In version 3.2 of Aphelion, some attribute names had an “_” such as *PIXEL_COUNT*. The underscore character has been removed in version 4.x. Although an attribute name with an underscore is valid in version 4.x, we recommend not using the underscore in new macros you develop in version 4.x as these names will disappear in future versions of Aphelion Dev.

Note: By default, in Aphelion 4.x, ObjectSet names are case sensitive.

Spatial attribute name of extracted objects

The spatial attribute default name of an ObjectSet generated by an object extraction applied to an image is “BITMAP” in version 4.x of Aphelion Dev while it was “REGION” in version 3.2. The default name can be altered by editing the ObjectSets > DefaultAttribute in the Advanced tab in the **Tools→Options** menu.

Sub-attribute access

Below is the new BasicScript syntax to access Aphelion version 3.2 pseudo-attributes that are sub-attributes in version 4.x.

Syntax to get the Bitmap object position.

Version 3.2 syntax:

```
AphObjGetAttributeD(AphObj("OS"), index,
"BITMAP.EXTENTS.LL.X")
AphObjGetAttributeD(AphObj("OS"), index,
"BITMAP.EXTENTS.UR.X")
```

Version 4.x syntax:

```
AphObjGetAttributeD(AphObj("OS"), index,
"BITMAP.X1")
AphObjGetAttributeD(AphObj("OS"), index,
"BITMAP.X2")
```

Syntax to get the Line object position.

Version 3.2 syntax

```
AphObjGetAttributeD(AphObj("OS"), index,
"LINE.P1.X")
```

Version 4.x syntax

```
AphObjGetAttributeD(AphObj("OS"), index,
"LINE.X1")
```

Syntax to get overlapping objects.

Version 3.2 syntax

```
AphObjGetAttributed(AphObj("OS"), index,
"NEIGHBORS.NUMENTRIES")
```

Version 4.x syntax

```
AphObjGetAttributed(AphObj("OS"), index,
"NEIGHBORS.Length")
```

Syntax to get sub-attributes from a vector attribute.

To get the mean computed on each band of a color image:

```
AphObjGetAttributed(AphObj("OS"), index,
"Mean[0]")
AphObjGetAttributed(AphObj("OS"), index,
"Mean[1]")
```

To get the index of each object overlapping the object from the ObjectSet named OS which the index is equal to the index variable:

```
AphObjGetAttributed(AphObj("OS"), index,
"NEIGHBORS_Overlap[2]")
```

In addition, if the AphObjGetAttributed function applied to a vector attribute returns the first vector element:

```
AphObjGetAttributed(AphObj("OS"), index, "Mean")
```

returns the same value as:

```
AphObjGetAttributed(AphObj("OS"), index, "Mean[0]")
```

E. 3. d. Histogram value access

The value storage of the histogram in a BasicScript array is different between versions 3.2 and 4. For each band, there is the exact number of values equal to the number of the band class. This number may vary between bands.

E. 3. e. Image list access

The *AphImageList* function is now created by '*MacroAddToLib'. It has to be declared before it is used. The associated parameter is a Variant array. Note it was a Long array in version 3.2.

E. 3. f. Value Output

The function *AphInfoWrite* outputs a value to the tabbed Output window in window B.

```
Dim volume() As Double  
AphImgVolume im, volume  
AphInfoWrite "volume: " & volume(0)
```


E. 3. g. List of non-supported functions in Aphelion 4.x

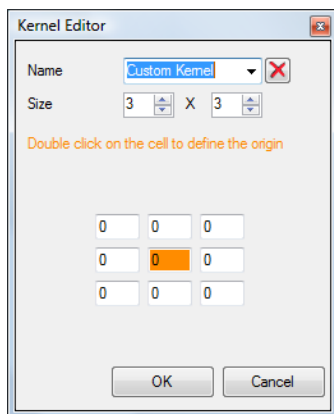
Most of the BasicScript functions available in version 3.2 that were specific to control the user interface no longer exist since the version 4.x GUI has been totally redesigned.

E. 4. Change of Syntax


Functions such as *AphImg*, *AphImgNew*, *AphObj*, *AphObjNew*, *AphNamedKernel*, and *AphNamedSElement* that are returning an object instance do not return an object of type Long. They are now returning an object of type Variant.

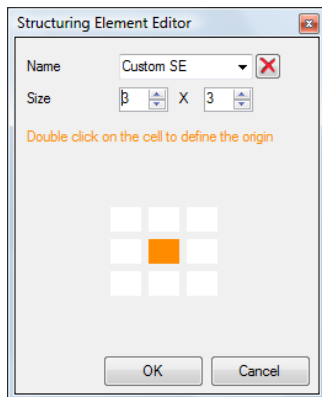
APPENDIX F KERNEL AND STRUCTURING ELEMENT EDITOR (DEV VERSION ONLY)

Kernel Editor – The Kernel Editor window is a graphic tool for easily specifying a kernel to be used by the convolution function. First, specify the name of the kernel in the *Name* dialog box. Next, in the *Size* boxes, specify the kernel's dimensions, and then enter kernel values from the keyboard. Use the **Tab key/Ctrl+Tab key** to move forward/backward through the parameter values. Double-clicking on a matrix cell will define this cell as the kernel origin. When done, click on the **OK** button. The name of the Kernel can be specified by the user; its default name is *Custom Kernel*. Clicking  deletes the kernel.



Structuring Element Editor – The Structuring Element Editor window is a graphic tool for easily specifying a structuring element to be used by a basic morphology function (e.g., erosion, dilation). First, specify the name of the structuring element in the *Name* dialog box. Next, specify the X and Y sizes, and then enter structuring values left-clicking inside each individual cell (cell values can be **X** for set and blank for not set). Double-clicking on one cell will define this cell as the Structuring Element origin. When done, click on the **OK** button. By

default, the name of the Structuring Element is *Custom SE*. Clicking  deletes the Structuring Element.



Tip: Select the overload that does not use predefined Kernels or Structuring Elements to be able to define a custom Kernel or Structuring Element.

APPENDIX G C# PROGRAMMING LANGUAGE

(Dev version only)

G. 1. Developing an Aphelion macro in C#

G. 1. a. Introduction

Writing an Aphelion C# macro is almost similar to writing a stand-alone C# executable, referencing Aphelion managed DLLs:

- ✓ Standard C# language is used
- ✓ The macro is compiled before being run

Differences are:

- ✓ Macros do not need to call `Adcis.Library.Initialize()` and `Adcis.Library.Terminate()`
- ✓ Macros have access to Aphelion internal memory. In particular, the `Aphelion4.Application` static class gives access to its current state. The list below gives a few of its useful members:
 - `Aphelion4.Application.Images`: collection of images displayed in the Image Gallery
 - `Aphelion4.Application.ObjectSets`: collection of `ObjectSets` displayed in the ObjectSet Gallery
 - `Aphelion4.Application.ImageView(Image)`: the `ImageView` (control handling the display of images, `ObjectSets` and user-drawn shapes) containing a specific image
 - `Aphelion4.Application.MainForm.CurrentImageView`: the active `ImageView`
 - `Aphelion4.Application.MainForm.CurrentImageView.Data[0]`: the image (or video) in the active `ImageView`

For example, to add an image to the Aphelion GUI, execute the following in a C# macro:

```
Image image = ...;
Aphelion4.Application.Images.Add(image);
```

This automatically adds the image to the Image Gallery and displays it in the Visualization Window.

G. 1. b. Referencing DLLs in a C# macro

To call functions from external DLLs in a C# macro, the external DLLs must be referenced in the “APHELION_HEADER” section at the beginning of the macro, using the `reference` keyword. For example, to reference a new DLL called `MyFunctions.dll`, add the following line:

```
reference "MyFunctions.dll"
```

Between

```
#if APHELION_HEADER
```

And

```
#endif
```

Note: The most common .NET and Aphelion DLLs are already referenced by default when a new C# macro is created in the C# macro window.

G. 1. c. Developing a C# macro using an external IDE

Developers who are used to developing in C# may notice that the Aphelion integrated C# macro window lacks some advanced functionalities, such as automatic completion (provided by Microsoft® Visual Studio® Intellisense, for example).

However, it is possible to have the benefit of such external Integrated Development Environments (IDEs) while developing an Aphelion macro. To do so:

- ✓ Create a new project
- ✓ Add the necessary `Adcis.*.dll` references (the DLL files loaded by the macro are the ones specified by the “reference” lines in the section starting by `#if APHELION_HEADER`).
- ✓ Add `AphelionDev.exe` as a reference
- ✓ Add the macro file to your project (tip: add it as a link to avoid duplicating the macro file).
- ✓ Edit the macro file in the IDE, without removing the `#if APHELION_HEADER ... #endif` section
- ✓ When editing is completed, save it
- ✓ Come back to Aphelion and click in the C# macro window: Aphelion automatically detects the file alterations and asks whether to reload it. Answer Yes.

G. 2. Adding a custom function to the Aphelion GUI in C#

G. 2. a. General conditions to be met by the macro function

Macro functions can be added to the list of Aphelion functions, and therefore may be called from the GUI, either from the Process menu or by typing its name in the Functions panel (in Developer task only). To achieve this, the following conditions must be met:

- ✓ The function must be a member of a public class;
- ✓ The class owning the function must have a `Adcis.System.Functions.Group` attribute, defining the sub-menu in which it will appear in the Process main menu;
- ✓ The function must be declared `public` and `static`;

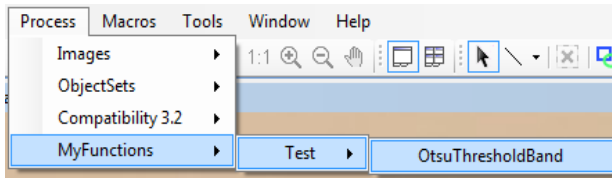
- ✓ The function must have no return value (type `void`);
- ✓ The function input parameters must all have one of the types listed below (see *Overloads*);
- ✓ The macro must be compiled without error in Aphelion C# macro window.

Note: If the function misses any of these conditions, it will not be added to the Aphelion functions list. However, no error message will be output.

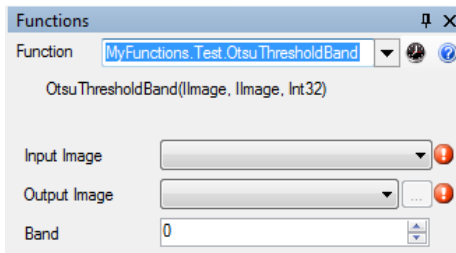
For example, let us look at the following function:

```
namespace MyNamespace
{
    [Adcis.System.Functions.Group("MyFunctions.
    Test")]
    public class Functions
    {
        static public void OtsuThresholdBand(
            IImage inIm, IImage outIm, int band)
        {
            Image bandIm = new Image();
            Adcis.Images.Utility.Functions.
                ExtractBand(inIm, bandIm, band);
            Adcis.Images.Segmentation.Functions.
                OtsuThreshold(bandIm, outIm);
        }
    }
}
```

Once compiled in Aphelion C# macro window, it will be available from the GUI through the menu: **Process**→**MyFunction**→**Test**→**OtsuThresholdBand**, as follows:



It will also be available from the Functions panel, with the name `MyFunctions.Test.OtsuThresholdBand` (see below for the variable naming conventions):



Note: Several Aphelion custom functions can be defined in a single macro file.

G. 2. b. Overloads

Inside a class, it is possible to have several methods with the same name. They are called overloaded methods, or overloads. When a function has several overloads, the user can select one in the list under the function name.

For example, in the following example:

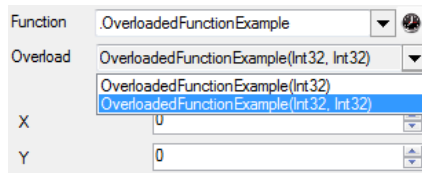
```
namespace MyNamespace
{
    [Adcis.System.Functions.Group(
        "MyFunctions.Test")]
    public class Functions2
    {
        static public void
            OverloadedFunctionExample(int x)
    }
}
```

```

{
    // ...
}
static public void
OverloadedFunctionExample(int x, int y)
{
    // ...
}
}

```

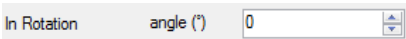
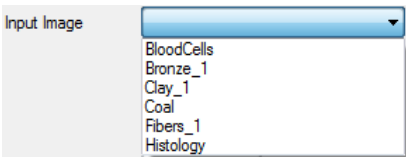
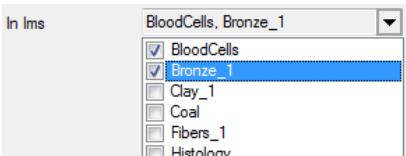
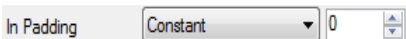
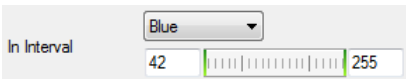
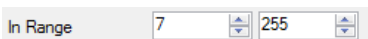
Both overloads will be available in the Functions panel as follows:

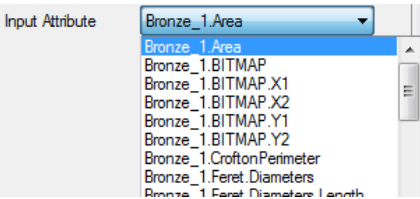
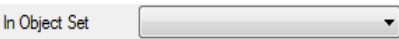

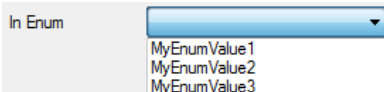
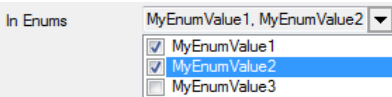
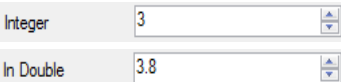




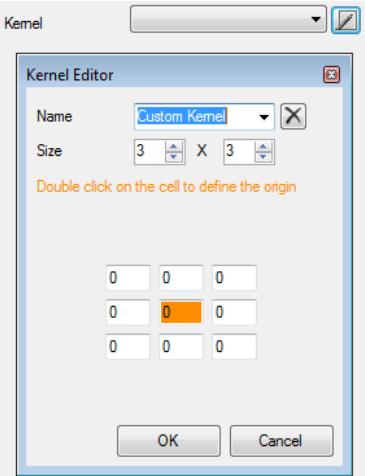
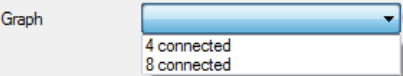
G. 2. c. Function input parameters

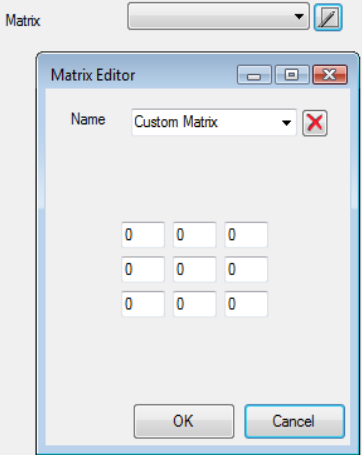
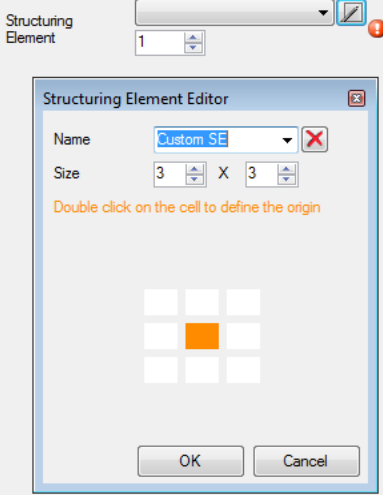
The function input parameters must belong to the following list. When the function is selected in the Aphelion Functions panel, the display is then automatically adapted to let the user specify an object of the required type. Depending on the argument types, different attributes can be used to customize the display (see *Additional attributes to customize the display of a parameter in the functions panel*).

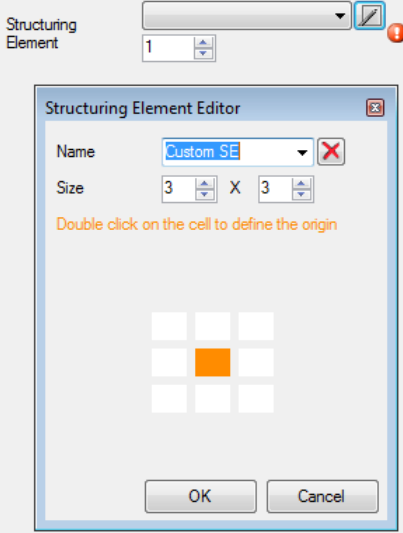
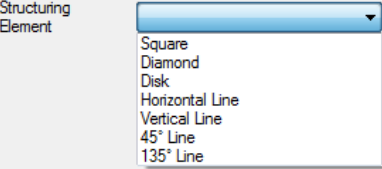
Function argument type	Definition and Display
Adcis.Geometry .ICoordinatesD	Coordinates of a point in an image In Coord <input type="text" value="0.00"/> <input type="text" value="0.00"/>
Adcis.Geometry .INgbLUT	Neighborhood configurations used by some Thinning and Skeletonization functions In Lut <input type="text" value="Centroid"/> <input type="text" value="4 connected"/>

Function argument type	Definition and Display
Adcis.Geometry .IRotation	An angle, displayed in degrees, with value retrieved in radians 
Adcis.Images .IImage	Image 
Adcis.Images .IImageCollection	List of images 
Adcis.Images .Padding	Padding value used by some transform functions (e.g. Rotate) 
Adcis.Math .IIntervalD	Multi-dimensional interval of floating-point values 
Adcis.Math .IRanged	One-dimensional interval of floating-point values 

Function argument type	Definition and Display
<code>Adcis.ObjectSets</code> <code>.IAttribute</code>	Attribute of an ObjectSet 
<code>Adcis.ObjectSets</code> <code>.IOBJECTSet</code>	ObjectSet 
<code>Bool</code>	Boolean value (true/false) 
<code>enum</code> type (e.g. <code>Adcis.System.NumericTypeEnum</code>)	A C# enumeration, defined by the <code>enum</code> keyword 
<code>Enum</code> type array (e.g. <code>Adcis.System.NumericTypeEnum[]</code>)	A C# array of an enumeration type 
System primitive types: <code>Byte</code> , <code>SByte</code> , <code>Int16</code> , <code>UInt16</code> , <code>Int32</code> , <code>UInt32</code> , <code>Int64</code> , <code>UInt64</code> , <code>Char</code> , <code>Double</code> , <code>Single</code>	.NET built-in integer and floating-point types 

Function argument type	Definition and Display
<code>String</code>	A character string 
<code>string[]</code>	An array of character strings 
<code>Adcis.Geometry.IKernel</code>	A user-defined kernel, used in convolution functions (see <i>Convolve function</i> help) 
<code>Adcis.Geometry.PredefinedNgbGraphEnum</code>	A 2D or 3D predefined connexity graph 

Function argument type	Definition and Display
<p>Adcis.Math .IMatrixD</p>	<p>A matrix (currently limited to 3x3 matrices)</p> 
<p>Adcis.Geometry .IStructuring Element</p>	<p>A 2D user-defined structuring element</p> 

Function argument type	Definition and Display
<p>Adcis.Geometry .IStructuring Element</p>	<p>A 2D user-defined structuring element</p> 
<p>Adcis.Geometry .Predefined Structuring ElementEnum</p>	<p>A 2D or 3D predefined structuring element</p> 

Note: the declared input parameters must be **exactly** the ones described above. For example, the following functions will be recognized and added to Aphelion functions list:

```
static public void
Function1(Adcis.Images.IImage inIm) {} // OK

using Adcis.Images;
static public void Function2(IImage inIm) {}
// OK
```

But the following will not:

```
// Function not recognized: Image is not the
expected IImage type
static public void
Function3(Adcis.Images.Image inIm) {}
```

G. 2. d. Function output parameters

Basic types output

Function results that need to be output must be passed as output parameters. For most output parameter types, this can be done using the standard C# `out` keyword. In the Functions panel, the parameter display is automatically adapted so that the user cannot enter a value for these parameters.

For example, let us look at the following function:

```
namespace MyNamespace
{
    [Adcis.System.Functions.Group(
        "MyFunctions.Test")]
    public class Functions
    {
        static public void
            OutputParametersExample(IImage image,
                out long width, out long height)
        {
```

```

        width = image.Size.X.Value;
        height = image.Size.Y.Value;
    }
}

```

When the user selects it in the Functions panel, the width and height parameters are grayed out, as follows. Their value is then automatically displayed when the function is executed.



Image and ObjectSet output

When a function outputs an image (Adcis.Images.IImage parameter type) or ObjectSet (Adcis.ObjectSets.ObjectSet parameter type), the `out` keyword is not suitable. The recommended method consists in displaying the list of existing images or ObjectSets (as for input parameters), adding a “New entry” to them.

Two methods can be used to achieve this:

- Have parameter names start with “out” (e.g. “outImage”, “outOS”); see *Implicit attribute definition*);

or

- Add a `Adcis.Images.NewImageAllowed` attribute to allow the creation of a new image: see *Adcis.Images.NewImageAllowed attribute*;
- Add a `Adcis.ObjectSets.NewObjectSetAllowed` attribute to allow the creation of a new ObjectSet: see *Adcis.ObjectSets.NewObjectSetAllowed attribute*.

G. 2. e. Conventions used for arguments display

Parameter names are displayed in the Functions panel, with the following alterations:

Case decomposition

The first letter of the argument name is automatically converted to upper case. Other upper case letters are automatically preceded by a space. For example, an argument named “inputArgument” is displayed “Input Argument”.

Automatic translation

A few argument names are automatically translated to a more complete name in the Functions panel. The most common translations are:

Parameter name	Display in the Functions panel (in English culture)
inIm	Input Image
inIm1	Input Image 1
inIm2	Input Image 2
inReferenceIm	Reference Image
seedIm	Seed Image
outIm	Output Image
im	Image
maskIm	Mask Image
inAt	Input Attribute
inAttribute	Input Attribute
outAt	Output Attribute
outAttribute	Output Attribute
inOS	Input ObjectSet
inOS1	Input ObjectSet 1
inOS2	Input ObjectSet 2

Parameter name	Display in the Functions panel (in English culture)
ioOS	Input/Output ObjectSet
outOS	Output ObjectSet
p1	Point 1
p2	Point 2
se	Structuring Element
nt	Numeric Type

Note: Argument type is not taken into account for these automatic replacements.

Automatic translation result depends on the current culture.

Implicit attribute definition

For simplification purposes, a few rules are applied, without requiring an explicit attribute (see *Additional attributes to customize the display of a parameter in the functions panel*) definition:

Arguments of type `Adcis.ObjectSets.Image` whose name begins with “out” are implicitly considered as having an `Adcis.Images.NewImageAllowed` attribute, hence displaying a “New Image” item at the beginning of the Image list.

Arguments of type `Adcis.ObjectSets.IObjectSet` whose name begins with “out” are implicitly considered as having an `Adcis.ObjectSets.NewObjectSetAllowed` attribute, hence displaying a “New ObjectSet” item at the beginning of the ObjectSet list.

Arguments of types `Int32`, `UInt64`, `Int64` are implicitly considered as having an `Adcis.System.Number` attribute

with property `DecimalPlaces=0`, hence no decimals can be entered by default for arguments of these types.

G. 2. f. Additional attributes to customize the display of a parameter in the functions panel

Adcis.System.Functions.ArgumentEditor attribute

Applies to: Any argument

Constructor arguments:

Type	Optional	Value	Comment
Int		Zero-based index of a function argument	
String		See example below	

This attribute is mainly used to specify how an argument should be displayed and edited by the user in the Functions panel. It is particularly suitable for user-defined structures.

Example:

```
public class MyClass
{
    private int m_count;
    private string m_name;

    public int Count
    {
        get { return m_count; }
        set { m_count = value; }
    }

    public string Name
    {
        get { return m_name; }
        set { m_name = value; }
    }
}
```

```

    public override String ToString() { return
        String.Format("Count={0} Name={1}",
            m_count, m_name); }
}

[ArgumentEditor(0, "Adcis.System.
    PropertyGridArgumentEditor, Adcis.UI.1" ) ]
[Adcis.System.Functions.DefaultValue(0,
    typeof(MyClass), null)]
static public void ArgumentEditorExample(
    MyClass myClassInstance)
{
    // ...
}

```

Adcis.Geometry.AxesProvider attribute

Applies to: Adcis.Geometry.PredefinedNgbGraphEnum,
 Adcis.Geometry.PredefinedStructuringElementEnum,
 Adcis.Geometry.IStructuringElement,
 Adcis.Geometry.IKernel, Adcis.Math.IMatrixD

Constructor arguments:

Type	Optional	Value	Comment
Int		Zero-based index of a function argument	
Int		Zero-based index of a function IImage, IAttribute or IObjectSet argument defining the axes (generally either XY or XYZ) along which the element is defined	

Example:

```
[Adcis.Geometry.AxesProvider(1, 0)]
static public void
    PredefinedStructuringElementExample (IImage
        image, Adcis.Geometry.Predefined
        StructuringElementEnum structuringElement)
{
    // ...
}
```

Adcis.ObjectSets.*Attribute* attribute

Applies to: Adcis.ObjectSets.*IAttribute*

Constructor arguments:

Type	Optional	Value	Comment
Int		Zero-based index of the function argument to which this attribute applies	

Optional properties:

Name	Type	Value	Comment
DataType	<i>string</i>	Full name of a data type	When set, only attributes of the selected data type are listed

Name	Type	Value	Comment
Dimension ProviderIndex	Int	Zero-based index of an IImage or IAttribute function argument that determine the dimension (2D or 3D) of the attribute to be selected or created.	
OwnerObject SetIndex	Int	Zero-based index of an IObjectSet function argument from which the attribute is selected	
Scalar	bool	true, false	If true, only scalar attributes are listed
Spatial	bool	true, false	If true, only spatial (i.e. displayable) attributes are listed

Name	Type	Value	Comment
TypeProvider Index	Int	Zero-based index of an Image or IAttribute function argument that determine the data type (e.g. Float, IChainF...) of the attribute to be selected or created.	

Example:

```
[Adcis.ObjectSets.Attribute(1,
    OwnerObjectSetIndex = 0, Spatial = true)]
static public void AttributeExample(
    Adcis.ObjectSets.IObjectSet inObjectSet,
    Adcis.ObjectSets.IAttribute inAttribute)
{
    // ...
}
```

Adcis.Geometry.Coordinates attribute**Applies to:** Adcis.Geometry.ICoordinatesD**Constructor arguments:**

Type	Optional	Value	Comment
Int		Zero-based index of the function argument to which this attribute applies	

Optional properties:

Name	Type	Value	Comment
AxesProvider ArgumentIndex	int	Zero-based index of an IImage function argument	When set, 2 or 3 coordinates will be displayed, depending on whether the selected image is 2D or 3D
BoundsProvider ArgumentIndex	int	Zero-based index of an IImage function argument	When set, the coordinate values are bound to the selected image extents. Not implemented yet.
DecimalPlaces	int	Number of decimal digits	

Name	Type	Value	Comment
Increment	double	Increment or decrement value when the up or down buttons are clicked	
Maximum	double	Maximum possible value	
Minimum	double	Minimum possible value	

Example:

```
[Adcis.Geometry.Coordinates(1,
    AxesProviderArgumentIndex=0, Minimum=0)]
static public void
    CoordinatesExample (Adcis.Images.IImage
        inIm, Adcis.Geometry.ICoordinatesD coord)
{
    // ...
}
```

Adcis.System.Functions.DefaultValue attribute**Applies to:** Any argument**Constructor arguments:**

Type	Optional	Value	Comment
Int		Zero-based index of an function argument	

Type	Optional	Value	Comment
Object		Default displayed value in the Functions panel	The object given must have the expected type for the selected argument

Or

Type	Optional	Value	Comment
Int		Zero-based index of an function argument	
Type		Type of the actual class to instantiate	
Object []		Array of values passed to the class constructor	

Note: the actual class to instantiate generally has the same name as the argument type, without the leading 'I', as in the following examples:

Argument type	Class to instantiate
Adcis.Geometry.ICoordinatesD	Adcis.Geometry.CoordinatesD
Adcis.Math.IRangeD	Adcis.Math.RangeD
Etc...	

Example:

```
[Adcis.System.Functions.DefaultValue(0, 1)]
static public void DefaultValueExample1(int
    number)
{
    // ...
}
```

```
[Adcis.System.Functions.DefaultValue(0,
"abc")]
static public void
DefaultValueExample2(string name)
{
    // ...
}

[Adcis.System.Functions.DefaultValue(0,
typeof(Adcis.Geometry.CoordinatesD),
new object[] { 100.0, 150.0,
Adcis.Geometry.AxisEnum.aXY })]
static public void
DefaultValueExample3(Adcis.Geometry.
ICoordinatesD coord)
{
    // ...
}
```

Adcis.System.Enum attribute**Applies to:** Enumerations (custom or built-in)**Constructor arguments:**

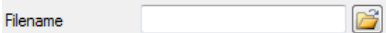
Type	Optional	Value	Comment
Int		Zero-based index of an function argument of an enumeration type	
Int[]		Allowed values of the enumeration type	

Example:

```
public enum MyEnum
{
    MyEnumValue1 = 1,
    MyEnumValue2 = 2,
    MyEnumValue3 = 3,
}
```

```
// ...
[Adcis.System.EnumAttribute(0, new int[]
{ 1, 3 })]
static public void EnumExample(MyEnum
inMyEnum)
{
    // ...
}
```

Adcis.System.FileName attribute**Applies to:** `string`, `string[]`**Constructor arguments:**

Type	Optional	Value	Comment
Int		Zero-based index of a function argument of a <code>string</code> (<code>string[]</code>) type representing a file name (respectively, an array of file names)	When set, an “Open file(s)” dialog button is available:
			

Optional properties:

Name	Type	Value	Comment
IsOutput	Bool	True if argument is an output value. Default is false.	

Example:

```
[Adcis.System.FileName(0)]
static public void FileNameExample(string
    filename)
{
    // Open image
    Adcis.Images.IImage image = new
        Adcis.Images.Image(filename);
    Aphelion4.Application.Images.Add(image);
}
```

Adcis.Math.Interval attribute**Applies to:** Adcis.Math.IIntervalD**Constructor arguments:**

Type	Optional	Value	Comments
Int		Zero-based index of the function argument to which this attribute applies	
Int		(Ignored)	
Int	✓	Zero-based index of a IImage function argument	The selected image band count and pixel values will be used to automatically adjust the display of the interval

Example:

```
[Adcis.Math.Interval(1, 0, 0)]
static public void
    IntervalExample(Adcis.Images.IImage inIm,
        Adcis.Math.IIntervalD inInterval)
{
    // ...
}
```

Adcis.Images.Padding* attribute*Applies to:** Adcis.Images.Padding**Constructor arguments:**

Type	Optional	Value	Comment
Int		Zero-based index of the function argument to which this attribute applies	
Int		Zero-based index of a IImage function argument	The entered value will not exceed the selected image data type maximum value (e.g. 255 for a 8-bit unsigned image)

Example:

```
[Adcis.Images.Padding(1, 0)]
static public void
    PaddingExample(Adcis.Images.IImage image,
        Adcis.Images.Padding padding)
{
```



```
// ...
}
```

Adcis.Images.NewImageAllowed* attribute*Applies to:** `Adcis.Images.IImage`**Constructor arguments:**

Type	Optional	Value	Comment
Int		Zero-based index of an <code>IImage</code> function argument for which a “New Image” entry will be proposed	
Int	✓	Zero-based index of an <code>IImage</code> function argument for which a “New Image” entry will be proposed	
Int	✓	Zero-based index of an <code>IImage</code> function argument for which a “New Image” entry will be proposed	

Or

Type	Optional	Value	Comment
Int[]		Zero-based indices of <code>IImage</code> function arguments for which a “New Image” entry will be proposed	

Note: This attribute is implicitly set if the argument name begins with “out”.

Example:

```
[Adcis.Images.NewImageAllowed(0)]
static public void
ImageExample1(Adcis.Images.IImage image)
{
    // ...
}

// Attribute is implicitly set because
// parameter name starts with "out"
static public void
ImageExample2(Adcis.Images.IImage outImage)
{
    // ...
}
```

Adcis.ObjectSets.NewObjectSetAllowed attribute

Applies to: Adcis.ObjectSets.IObjectSet

Constructor arguments:

Type	Optional	Value	Comment
Int		Zero-based index of an IObjectSet function argument for which a “New Object Set” entry will be proposed	
Int	✓	Zero-based index of an IObjectSet function argument for which a “New Object Set” entry will be proposed	

Type	Optional	Value	Comment
Int	✓	Zero-based index of an <code>IObjectSet</code> function argument for which a “New Object Set” entry will be proposed	

Or

Type	Optional	Value	Comment
Int[]		Zero-based indices of <code>IObjectSet</code> function arguments for which a “New Object Set” entry will be proposed	

Note: This attribute is implicitly set if the argument name begins with “out”.

Example:

```
[Adcis.ObjectSets.NewObjectSetAllowed(0)]
static public void
    ObjectSetExample1(Adcis.ObjectSets.
        IObjectSet objectSet)
{
    // ...
}

// Attribute is implicitly set because
// parameter name starts with "out"
static public void
    ObjectSetExample2(Adcis.ObjectSets.
        IObjectSet outObjectSet)
{
    // ...
}
```

Adcis.System.Functions.NullValueAllowed attribute**Applies to:** Any argument**Constructor arguments:**

Type	Optional	Value	Comment
Int		Zero-based index of an function argument	
String		typeName	

Constructor arguments:

Type	Optional	Value	Comment
Int		Zero-based index of a function argument for which an empty value is accepted	
Int	✓	Zero-based index of a function argument for which an empty value is accepted	
Int	✓	Zero-based index of a function argument for which an empty value is accepted	

Or

Type	Optional	Value	Comment
Int[]		Zero-based indices of the function arguments for which an empty value is accepted	

Example:

```
[Adcis.System.Functions.NullValueAllowed(0)]
static public void NullValueExample(IImage
    image)
{
    if (image != null)
        MessageBox.Show("Image name is: " + (image
            as Adcis.Images.Image).Name.ToString());
    else
        MessageBox.Show("Image is null");
}
```

Adcis.System.Number attribute

Applies to: System primitive types (integer of floating-point value numbers).

Constructor arguments:

Type	Optional	Value	Comment
Int		Zero-based index of a function argument	

Optional properties:

Name	Type	Value	Comment
DecimalPlaces	int	Number of decimal digits	Automatically set to 0 for integer types
Increment	double	Increment or decrement value when the up or down buttons are clicked	

Name	Type	Value	Comment
Maximum	double	Maximum possible value	
Minimum	double	Minimum possible value	
RangeArgIndex	int	Zero-based index of an IImage function argument	When set, the selected image first band minimum and maximum values override the Minimum and Maximum properties, respectively

Example:

```
[Adcis.System.Number(0, Minimum=0,
    Maximum=100, Increment=0.1,
    DecimalPlaces=2)]
static public void NumberExample(float
    percent)
{
    // ...
}
```

Adcis.Math.Range* attribute*Applies to:** `Adcis.Math.IRangeD`**Constructor arguments:**

Type	Optional	Value	Comment
Int		Zero-based index of the function argument to which this attribute applies	
Int		Zero-based index of a IImage function argument	The selected image pixel values will be used to automatically adjust the default values of the range

Example:

```
[Adcis.Math.Range (1, 0)]
static public void
RangeExample (Adcis.Images.IImage inIm,
Adcis.Math.IRangeD inRange)
{
    // ...
}
```

G. 2. g. Additional attributes to customize the behavior of a method***Adcis.System.Functions.DefaultOverload* attribute****Applies to:** Any method declared as public static.**Constructor arguments:** None

When a function has several overloads, the one that has this attribute will be selected by default (see the *Overloads* section).

Example:

```
static public void
    OverloadedFunctionExample(int x)
{
    // ...
}

[Adcis.System.Functions.DefaultOverload]
static public void
    OverloadedFunctionExample(int x, int y)
{
    // ...
}
```

Adcis.System.Functions.Exclude attribute**Applies to:** Any method declared as public static.

The functions that have this attribute will NOT be added to the Aphelion functions list.

Adcis.System.Functions.NoProgress attribute**Applies to:** Any method declared as public static.**Constructor arguments:** None.

When this attribute is set, the pop-up window indicating the function progress is not displayed. This is particularly useful while debugging a function (see the *Debugging an Aphelion macro* section).

Example:

```
[Adcis.System.Functions.NoProgress()]
static public void NoProgressExample()
{
    // User can interact with Aphelion
    // interface while this debug window is open
    Debugging.Tools.ShowDebugDialog();
}
```


G. 3. Loading a macro as an Aphelion plugin

When one or more custom functions have been defined in a macro, it is usually practical to have them automatically loaded when Aphelion starts. To do so, the macro must be compiled as an Aphelion plugin and added to Aphelion plugins list:

G. 3. a. Compiling a macro as a plugin

At the beginning of the C# macro, in the APHELION_HEADER region, add a line such as:

```
output "MyFunctions.dll"
```

Or:

```
output auto
```

Where “MyFunctions.dll” can be replaced by any other suitable DLL file name.

Then, compile the macro in the C# macro window: a MyFunctions.dll file is generated in the same folder as the macro file.

If auto is specified as an output filename, then Aphelion generates an automatic output filename, based on the source file name, (e.g. MyFunctions.1.dll, MyFunctions.2.dll, etc., if the source filename is “MyFunctions.cs”).

Note: the same output DLL name can be used only once in an Aphelion session. If you wish to recompile the same macro file, it is necessary to change this name, or use the auto keyword.

G. 3. b. Load the generated DLL as a plugin

Copy the generated DLL to any suitable directory on your computer. Then, in Aphelion Tools→Options window, select **Plugins** and add the path to the generated DLL file name.

Note: if a full path is not provided, Aphelion will search the folder where AphelionDev.exe is placed.

G. 4. Debugging an Aphelion macro

G. 4. a. Useful functions to debug a macro

The `Debugging.Tools` class offers a set of useful static methods to debug a macro. To have them available, the `Adcis.DebuggingTools.dll` library must be referenced (see *Referencing DLLs in a C# macro*).

For example:

```
Debugging.Tools.ShowDebugDialog();
```

displays a pop-up window with the specified text. The macro execution is interrupted until the user closes the window. However, on the contrary to a standard modal dialog box, the user has the possibility to interact normally with Aphelion interface (display images, change the Visualization Window properties, display/undisplay ObjectSets, etc.) while this window is open.

Note: The debugged function must have a `Adcis.System.Functions.NoProgress` attribute (see the `Adcis.System.Functions.NoProgress` attribute section) for interactions to be possible with the Aphelion GUI;

Even if the function progress window is not displayed, the mouse cursor generally has a “wait” shape during macro execution. However, this does not prevent interactions with Aphelion GUI.

Other useful functions are:

```
Debugging.Tools.Add(Adcis.Images.IImage image)  
Debugging.Tools.Add(Adcis.ObjectSets.  
    IObjectSet os)
```

to add an image or ObjectSet into Aphelion GUI.

G. 4. b. Using an external debugger

Aphelion C# macro window has no embedded debugging tools. However, an external debugger can be used to debug a macro. For example, use the following steps to debug a C# macro using Microsoft® Visual Studio®:

- Compile and load the macro as a plugin (see *Loading a macro as an Aphelion plugin*)
- Start Microsoft® Visual Studio®
- Attach Microsoft® Visual Studio® to the AphelionDev.exe process (through Tools→ Attach to Process...). Make sure the “Managed code” is selected in the “Attach To” text box.
- In Microsoft® Visual Studio®, open the C# macro file
- Set a breakpoint in the function to debug
- Select the function to debug in Aphelion C# Macro window, set its parameters and click Apply.

Note: For Microsoft® Visual Studio® to be able to debug, the C# source file, DLL file and PDB file must not be altered or moved after they have been compiled and loaded in Aphelion.

The function execution stops when the breakpoint is hit. At this point, you can see and alter variable values, or use the Immediate Window to execute statements, e.g. call the Debugging.Tools.* methods (see *Useful functions to debug a macro*).

APPENDIX H OPTIONS→ADVANCED MENU

Appearance		
Sub-Category	Parameter Name	Description
Drawing	DefaultArrow Properties	Graphic properties of arrows associated with Line shapes. See below for the description of the properties
	DefaultArrow Properties > AutoScale	Automatically scale the arrows when a zoom in or a zoom out is applied to the image
	DefaultArrow Properties > EndSize	Default size of the arrow at the end of the line
	DefaultArrow Properties > EndStyle	Default style of the arrow at the end of the line
	DefaultArrow Properties > Proportion	Scaling factor applied to the arrows when ProportionSize is set to True
	DefaultArrow Properties > ProportionalSize	The arrows are automatically rescaled depending on the line length when the parameter is set to True. The arrow size is applied without rescaling when it is set to False

Sub-Category	Parameter Name	Description
Drawing	DefaultArrow Properties > StartSize	Default size of the arrow at the start of the line
	DefaultArrow Properties > StartStyle	Default style of the arrow at the start of the line
	DefaultCenterProp erties	Default properties applied to shape centers
	DefaultCenterProp erties > ApplyToLines	Boolean defining if the default center properties are applied to lines
	DefaultCenterProp erties > AutoScale	Automatically scale the centers when a zoom in or a zoom out is applied to the image
	DefaultCenterProp erties > CenterVisible	Boolean defining if the centers are displayed or not
	DefaultCenterProp erties > InnerSize	Inner size of the symbol used to draw the centers
	DefaultCenterProp erties > Size	Size of the symbol used to draw the centers
	DefaultCenterProp erties > Symbol	Symbol used to draw the centers among the predefined symbols
	DefaultEllipseProp erties	Default graphic properties applied to ellipse or circle shapes

Sub-Category	Parameter Name	Description
Drawing	DefaultEllipseProperties > ArcDrawingStyle	Style used to draw an ellipse arc
	DefaultPoint Properties	Graphic properties of Point shapes. See below for the description of the properties
	DefaultPoint Properties > AutoScale	Automatically scale Point shapes when a zoom in or a zoom out is applied to the image
	DefaultPoint Properties > InnerSize	Default size of the reticle in the cross defining a point. Only used when Symbol is set to CrossHairs ³
	DefaultPoint Properties > Size	Default size of the cross defining a point
	DefaultPoint Properties > Symbol	Default style of Point shapes
	DefaultStandard Properties	Graphic properties of any shapes. See below for the description of the properties

³ If the parameter Symbol is set to either psCrossHairs1, psCrossHairs2, or psCrossHairs3

Sub-Category	Parameter Name	Description
Drawing	DefaultStandard Properties > BackColor	Default background color applied to objects computed in the Object Extraction and/or Object Editing tasks
	DefaultStandard Properties > BackMode	Default background mode applied to objects computed in the Object Extraction and/or Object Editing tasks
	DefaultStandard Properties > FillColor	Default color that fills objects computed in the Object Extraction and/or Object Editing tasks. No filling is done if Style is set to Null
	DefaultStandard Properties > FillStyle	Default style filling objects computed in the Object Extraction and/or Object Editing tasks
	DefaultStandard Properties > HatchStyle	Default style of hatch filling objects computed in the Object Extraction and/or Object Editing tasks
	DefaultStandard Properties > LineColor	Default boundary color of objects computed in the Object Extraction and/or Object Editing tasks
	DefaultStandard Properties > LineStyle	Default boundary style of Line shapes

Sub-Category	Parameter Name	Description
Drawing	DefaultStandard Properties > LineWidth	Default width of objects computed in the Object Extraction and/or Object Editing tasks
	DefaultStandard Properties > RasterOp	Raster operation used to draw the graphical object
	DefaultStandard Properties > Visible	Define if objects computed in the Object Extraction and/or Object Editing tasks are visible or not
	DefaultText Properties	Graphic properties of text. See below for the description of the properties
	DefaultText Properties > AutoScale	Automatically scale the text when a zoom in or a zoom out is applied to the image
	DefaultText Properties > Font	Default font and size of the font applied to a text
General Appearance	AngleDisplayUnit	Unit used when displaying angle values
	ListSeparator	Symbol used when displaying arrays (e.g. ObjectSet attributes containing arrays)
Geometry	Location	Position of the upper left corner of the user interface
	Size	Size of the window of the user interface

Sub-Category	Parameter Name	Description
Images	AutoDisplayTwoDImages	Define if 2D images created by Aphelion should be automatically displayed or not
	BlinkEnable	Enable object blinking when selecting a 3D object
	ClipImageView	Clip shapes and text defined outside the image frame
	DefaultColorSpace	Default color space when reading image files
	DefaultIsoValue	Default IsoValue when creating a new IsoSurface viewer
	DefaultSubSamplingFactor	Default subsampling factor when displaying a 3D image
	DefaultThreeDViewer	Default viewer used when displaying a 3D image
	DisplayThreeDImagesOnOpen	Automatically display a 3D image when opening the image from disk
	FitToWindow	Fit the image to the window size when displaying the image
	JPEGQuality	Compression quality when writing JPEG images (0 = worst, 100 = best)

Sub-Category	Parameter Name	Description
Images	MaximumImageSizeInBytes	Maximum size in bytes of an image totally stored in memory. Note value -1 means no limit is applied to this size
	MaximumVoxelCount	Automatically display 3D images in a subsampling mode when its size in voxels exceeds this limit
	MIVTColumnCount	Number of columns in the Visualization window. Value 2 for this parameter and 1 for the next displays 2 images side by side. Value 1 for this parameter and 2 for the next one displays 2 images on top of each other.
	MIVTRowCount	Number of rows in the Visualization window
	ScrollToSelectionMode	Define the way the image view is automatically scrolled when objects are selected in the grid. Options are: No scrolling, make the object visible, or center the object

Sub-Category	Parameter Name	Description
Images	UseDepthPeeling	Define if the depth peeling implementation to render polygons is applied. The rendering of intersecting shapes is better using this implementation but it requires more computing power
	UseImageBounds Only	Limit the scrollable zone to the image
	UseMemory SavingImage View	2D ImageView controls to minimize the amount of memory used
	UseMemory SavingIsoSurface	Select a memory saving implementation of the IsoSurface viewer (very useful on PCs with a small amount of memory)
	WindowBack Color	Background color of the Visualization window
ObjectSets	CaseSensitive Attributes	Specify if attribute names are case sensitive or not
	CSVDelimiter	Delimiter used when exporting an ObjectSet as a CSV file
	DefaultAttribute	Name of the default attribute (BITMAP by default)

Sub-Category	Parameter Name	Description
ObjectSets	SynchronizeThreeDSelection	Define if synchronization between ObjectSet grid and image view is applied or not
	ThreeDSelectionColor	Define the color used to display selected 3D objects when ThreeDSelectionMode is set to Color
	ThreeDSelectionMode	Define how the selected 3D objects are marked out (Outline or color)

Behavior		
Sub-Category	Parameter Name	Description
Acquisition	AutoFreeze	Freeze the live image when the window is no longer active
	AutoStop	Complete all on-going captures when selecting a new Task
	SelectCaptured Image	The captured image view is automatically activated when the Snap button is pressed.
Calibration	Bar	Settings to use when showing a calibration bar (see the contextual help to learn more about all the settings)
Developer	BasicScript HistoryRecording Enabled	Functions run from the Function Panel are automatically recorded in the BasicScript Command window
	InputImage SelectionMode	Define the way input images are selected in the Functions Panel
	RecentlyUsed Functions MaximumSize	Maximum function number stored in the recently used function list

Sub-Category	Parameter Name	Description
Developer	ShowCompatibilityGroups	Add a menu to display functions in the Process menu as in version 3.2 of Aphelion
	TrackOutput Image	Automatically display the output image after applying a function
	TrackSelected Image	Automatically display the image when it is selected in the Input Image dialog box
Editing	Color	Set the color applied to the mask displayed in the Editing task
	Connectivity	Connectivity of shapes generated in the Object Editing task
	Opacity	Set the opacity applied to the edited mask in the Editing task
Importation	BandCount	Value of the “Number of bands” field
	Color	Value of the “Color image” checkbox
	Colorspace	Value of the “Color space” field
	HeaderSize	Value of the “File header size” field

Sub-Category	Parameter Name	Description
Importation	Height	Value of the “Image size” field (first parameter)
	Interleaved	Value of the “Interleaved bands” field
	PixelDataType	Value of the “Pixel data type” field
	SwapBytes	Value of the “Swap bytes” field”
	ThreeD	Importation mode (3D or 2D)
	Width	Value of the “Image size” field (second parameter)
Kriging	DefaultMaximum Offset	Value of the maximum offset used for variograms
	IncludeSinus Cardinal	Use Sinus Cardinal functions when automatically generating a model
	KernelSize	Kernel definition for the filtering process
	ModelAutoFill	Automatically generate the settings of the kriging model during model creation
	ModelAutoFill ModelAutoFill Maximum FunctionCount	Maximum number of functions allowed when automatically generating a model

Sub-Category	Parameter Name	Description
Kriging	ModelAutoFill MinimumError Variation	Convergence criterion when automatically generating a model
	OverwriteImages	Flag to overwrite input images when applying the filter
	SillAutoFit Locked	Flag to disable sill autofit (advanced parameter)
Measurements	AutomaticMeasure mentsColor	Color used to draw shapes generated by the Object Extraction task
	HistogramClassCo unt	Number of classes used in ObjectSet histograms
	InteractiveMeasure mentsColor	Color used to draw interactive shapes (drawn in the Measurements task)
	LabelsFont	Font used to display measurements overlaid on the image
MultiThreadin g	ConversionThread PoolThreadCount	Number of threads used when performing conversions
	ProcessingThread PoolThreadCount	Number of threads used when performing image or ObjectSet operations

Sub-Category	Parameter Name	Description
Object Extraction	ColorEstimation Method	Estimate the color at the seed location when performing a user- assisted Object Extraction
	ColorEstimation WindowSize	Window size used to estimate the color at the seed location when performing a user-assisted Object Extraction
	ColorSpace	Default color space used when extracting objects
	ConnectedTo SeedsOnly	Keep only objects connected to the seeds when performing a user- assisted Object Extraction
	Connectivity Graph	Connectivity used when performing a user-assisted Object Extraction
	FillHoles	Fill holes when performing a user- assisted Object Extraction
	Opacity	Opacity value used when performing a user-assisted Object Extraction
	Partition MaximumRegion Count	Maximum number of regions when performing morphological partition based Object Extraction

Sub-Category	Parameter Name	Description
Object Extraction	RegionGrowing AdaptiveColors	Select the adaptive color method when performing a Region Growing segmentation
	RegionGrowing SeedSize	Seed size when performing a Region Growing segmentation
	RegionGrowing SeedsVisible	Display seeds when performing a Region Growing segmentation
	TransparentColor	Color value used when performing a user-assisted Object Extraction

Files		
Sub-Category	Parameter Name	Description
Files	LastOpenFolder	Last folder used when opening files
	LastFolder	Last folder used to save any Aphelion data as a file. This value is automatically set when a file is saved.
	ReloadImages And ObjectSets	Reload images and ObjectSets created during the last Aphelion session
	RootProjectFolder	Root folder for all project sub-folders
	SaveImages	Prompt the user to save images when set to True
	SaveObjectSets	Prompt the user to save ObjectSets when set to True
	SaveScripts	Prompt the user to save scripts/macros when set to True

General		
Sub-Category	Parameter Name	Description
Identification	Administrator Password	Password required to enter in Administrator Mode
	AutoEnter Administrator Mode	Automatically enter in Administrator Mode when starting Aphelion if the Administrator password is empty
	CompanyName	Company Name
	Culture	Culture information as defined in Windows
	ForceEnglish Translation	Enforce the translation to English for every character string in the user interface
	ProductName	Aphelion Dev/Lab
	UserName	User's name
	Version	Version number

Misc		
Sub-Category	Parameter Name	Description
Diagnostics	LogFileMaximumLineCount	Maximum number of lines to keep in the log file
	ShowVTKLogWindow	Display the VTK log window when set to True
	TraceLevel	Level of tracing. From 0 to 3 (0: highest priority information, 3: lowest priority information)
	VerboseExceptions	Flag to display stack information when an exception occurs

