NI Vision

NI Vision Assistant Tutorial

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About This Manual

The *NI Vision Assistant Tutorial* describes the Vision Assistant software interface and guides you through creating example image processing and machine vision applications. This tutorial is designed for Windows users with varied levels of vision experience.

Conventions

The following conventions are used in this manual:

» — The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **Options»Settings»General** directs you to pull down the **Options** menu, select the **Settings** item, and select **General** from the last dialog box.

This icon denotes a tip, which alerts you to advisory information.

This icon denotes a note, which alerts you to important information.

bold — Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.

italic — Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.

`monospace` — Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

Related Documentation

The following documents contain information that you may find helpful as you use this manual. To access the NI Vision Assistant documentation, select **Start»All Programs»National Instruments»Vision Assistant**.

- *NI Vision Development Module Release Notes*—Contains information about new functionality, minimum system requirements, installation instructions, and descriptions of the documentation for NI Vision Assistant.
- *NI Vision Assistant Help*—Contains descriptions of the Vision Assistant features and functions and provides instructions for using them. To open the help file in Vision Assistant, select **Help»Online Help**.
- *NI Vision Concepts Manual*—Describes the basic concepts of image analysis, image processing, and machine vision. This document also contains in-depth discussions about imaging functions for advanced users.

1

Vision Assistant Environment

This chapter introduces the NI Vision Assistant environment and describes resources you can consult for more information about NI Vision software and NI image acquisition devices.

Launching and Exiting Vision Assistant

To launch Vision Assistant, select **Start»All Programs»National Instruments Vision Assistant**.

To exit Vision Assistant, complete the following steps:

1. Close the Setup window.
2. Save the open script and images, if necessary.
3. Click **File»Exit**.

Vision Assistant Environment

Vision Assistant is a tool for prototyping and testing image processing applications. To prototype an image processing application, build custom algorithms with the Vision Assistant scripting feature. The scripting feature records every step of the processing algorithm. After completing the algorithm, you can test it on other images to make sure it works.

The algorithm is recorded in a script file, which contains the processing functions and relevant parameters for an algorithm that you prototype in Vision Assistant. Using the LabVIEW VI Creation Wizard, you can create a LabVIEW VI that performs the prototype that you created in Vision Assistant.

Note You must have LabVIEW 7.1 or later and the NI Vision 8.6 Development Module or later installed to use the Vision Assistant LabVIEW VI Creation Wizard.

For more information about LabVIEW VI creation, refer to the *Creating a LabVIEW VI* section of Chapter 3, *Using Particle Analysis to Analyze the Structure of a Metal*.

Using the C Code Creation Wizard, you can generate a C function that performs the prototype that you created in Vision Assistant. For more information about C Code creation, refer to the *Creating a C Program* section of Chapter 3, *Using Particle Analysis to Analyze the Structure of a Metal*.

Note If you have LabWindows™/CVI™ 7.0 or later, you can create a project for the generated C code.

You also can implement the algorithm defined by the Builder file into any development environment, such as Microsoft Visual Basic, using the NI Vision machine vision and image processing libraries.

Features

Vision Assistant offers the following features:

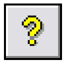
- **Script window**—Records a series of image processing steps and the settings you use for each of those steps. You can run scripts on single images or in a batch to analyze a collection of images. You also can modify and save scripts. Refer to Figure 2-2, *Processing an Image*, for an example of the Script window.
- **Image Browser**—Contains all of the images currently loaded in Vision Assistant. You can select an image to process by double-clicking it in the Image Browser. Refer to Figure 2-1, *Image Browser*, to view images loaded into the Image Browser.
- **Processing Window**—Updates the image as you change parameters. Because this view immediately reflects the changes you have made in the Setup window, you can continue modifying parameters until you get the result you want. Refer to Figure 2-2, *Processing an Image*, to view an image loaded into the Processing window.
- **Processing Functions Window/Setup Window**—Displays a list of image processing functions you can use to develop an algorithm, or displays parameters that you can set for an image processing function. Each function available through the Processing Functions window has a Setup window in which you set the parameters for that function. Refer to Figure 2-3, *Thresholding an Image*, to view an example of the Setup window for the Threshold function.
- **Reference Window**—Displays the image source as you manipulate it in the Processing window. Refer to Figure 2-2, *Processing an Image*, to view an image in the Reference window.
- **Solution Wizard**—Displays a list of industries and corresponding quality-assurance tasks that those industries perform. The wizard loads an NI Vision-based solution for the task you select.
- **Performance Meter**—Estimates how long a script will take to complete on a given image.
- **LabVIEW VI Creation**—Creates a LabVIEW VI corresponding to the algorithm you prototype in Vision Assistant. Based on the options you select, the LabVIEW VI Creation Wizard creates a new VI that implements the image processing steps of the current script or of a saved script file.
- **C Code Creation**—Creates a C file corresponding to the algorithm you prototype in Vision Assistant. Based on the options you select, the C Code Creation Wizard creates a C function that implements the image processing steps of the current script.
- **Builder File**—ASCII text file that lists the Visual Basic functions and parameters for the algorithm you prototyped in Vision Assistant.

Getting Help

As you work with Vision Assistant, you may need to consult other sources if you have questions. The following sources can provide you with more specific information about NI Vision software and NI image acquisition devices.

Vision Assistant Context Help and Tooltips

Vision Assistant displays context-sensitive help in the Context Help window when you call any image processing function. The Context Help window contains several tabs that describe when to use image processing functions, how to perform an image processing function, and descriptions of the controls that appear in the Setup window for the function. Click the **Context Help** button on the Vision Assistant toolbar to launch the Context Help window.



Vision Assistant also provides tooltips in the Vision Assistant interface. Tooltips briefly describe buttons in the toolbar, Script window, Reference window, or Image Browser when you move the cursor over the buttons.

National Instruments Web Site

The National Instruments Web site provides information about NI Vision hardware and software at `ni.com/vision`.

From the NI Vision site, you can locate information about new NI Vision features, machine vision problems and solutions, and selecting the appropriate NI Vision hardware, cameras, lenses, and lighting equipment for applications.

The NI Developer Zone, available at `ni.com/zone`, is the essential resource for building measurement and automation systems. The NI Developer Zone includes the latest example programs, system configurators, tutorials, and technical news, as well as a community of developers ready to share their own techniques.

Vision Assistant Scripts

The Vision Assistant installation program installs several example scripts. You can run these scripts to learn more about Vision Assistant scripting capabilities. You also can customize these scripts for your applications. By default, the scripts are installed to `<Vision Assistant>\Examples` and at `<Vision Assistant>\solutions`, where `<Vision Assistant>` is the location to which Vision Assistant is installed.

2

Introduction to Image Processing with Vision Assistant

This chapter describes how you can use Vision Assistant to create and test image processing algorithms. For detailed information about digital images, refer to Chapter 1, *Digital Images*, of the *NI Vision Concepts Manual*.

Getting Started in Vision Assistant

This section describes the software-specific terminology that you need to complete the tutorials in this manual and understand the online help. The best way to understand how Vision Assistant works and what you can accomplish with the software is to use it.

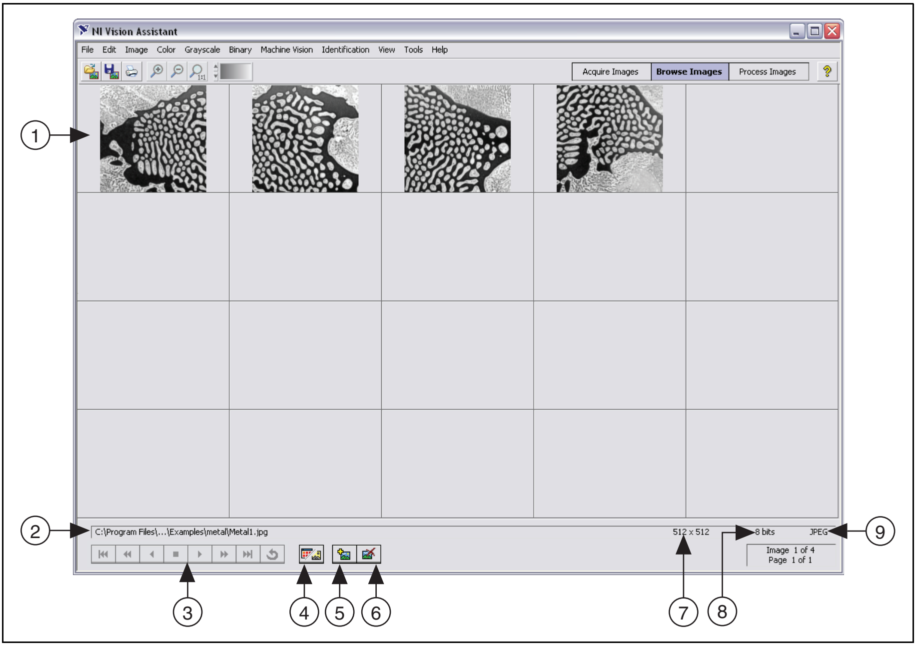
In this short example, you load images into Vision Assistant and perform a *threshold* on them. Thresholding isolates objects, keeping those that interest you and removing those that do not. Thresholding also converts the image from a grayscale image, with pixel values ranging from 0 to 255, to a binary image, with pixel values of 0 or 1.

Complete the following steps to get started in Vision Assistant.

1. Select **Start»All Programs»National Instruments Vision Assistant**.
2. To load images, click **Open Image** in the Welcome screen.
3. Navigate to `<Vision Assistant>\Examples\metal`, where `<Vision Assistant>` is the location to which Vision Assistant is installed.
4. Enable the **Select All Files** checkbox. Vision Assistant previews the images in the Preview Image window and displays information about the file type and image depth.
5. Click **Open**. Vision Assistant opens the first image in the Processing window.

6. Click **Browse Images** in the upper right corner of the Vision Assistant window.

Vision Assistant loads the image files you opened into the Image Browser, as shown in Figure 2-1. The Image Browser provides information about the selected image, such as image size, location, and type.



1	Image Browser	4	Thumbnail/Full-Size Toggle	7	Image Size
2	Image Location	5	Open Image	8	Image Type
3	Navigation Buttons	6	Close Selected Image(s)	9	File Format

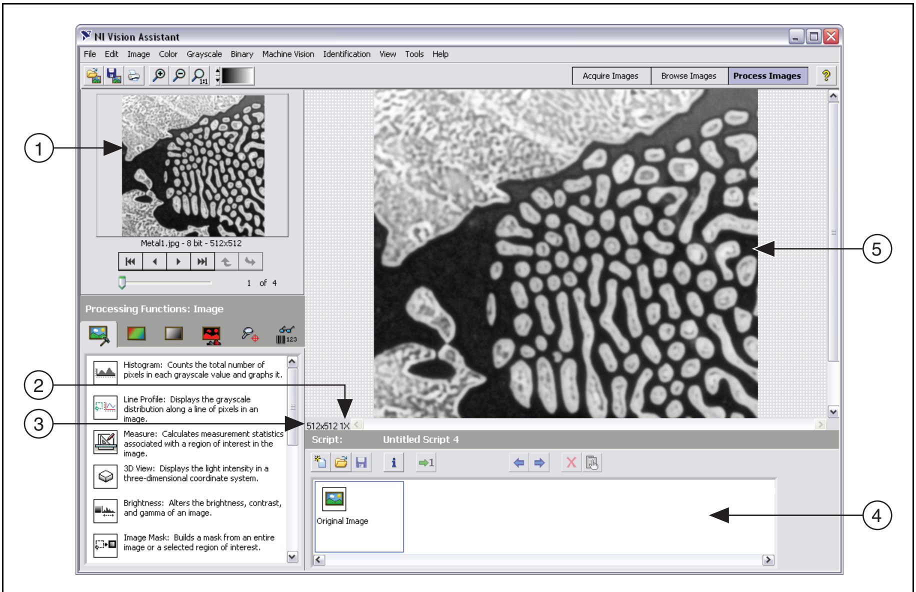
Figure 2-1. Image Browser

You can view images in either thumbnail view, as shown in Figure 2-1, or in full-size view, which shows a single full-size view of the selected image.

7. Click the **Thumbnail/Full-Size View Toggle** button to view the first image in full size.

8. Click **Process Images** in the upper right corner of the Vision Assistant window to begin processing images. Vision Assistant loads the image into the Processing window, as shown in Figure 2-2.

Tip You can double-click an image in the Image Browser to being processing it in the Processing window.

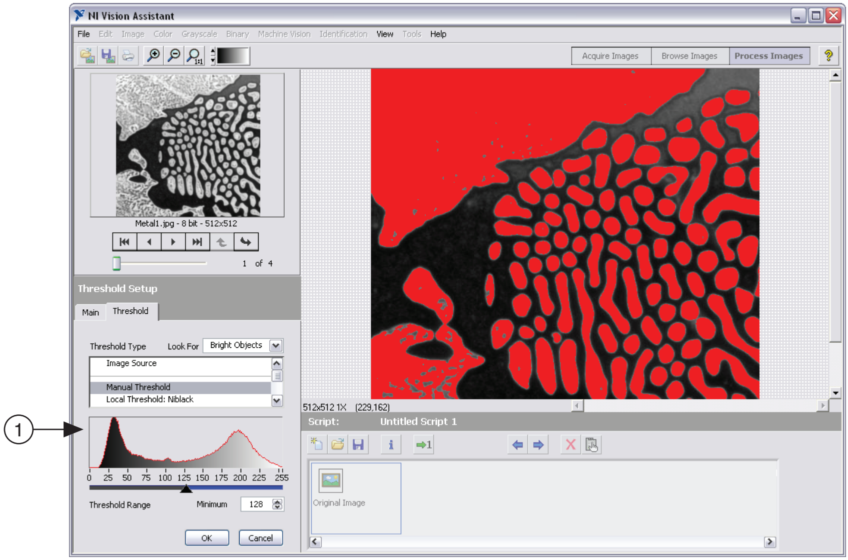


1	Reference Window	3	Image Size	5	Processing Window
2	Zoom Ratio	4	Script Window		

Figure 2-2. Processing an Image

Tip The Reference window displays the original version of the image as you manipulate it in the Processing window.

9. Click **Threshold** in the **Grayscale** tab of the Processing Functions, or select **Grayscale»Threshold**. The Threshold Setup window opens in the lower left corner of the Vision Assistant window, as shown in Figure 2-3.



1 Threshold Setup Window

Figure 2-3. Thresholding an Image

The Threshold Setup window displays a histogram. A histogram counts the total number of pixels at each grayscale value and displays the data in a graph. From the graph, you can see if the image contains distinct regions of certain grayscale intensities. Thresholding isolates these regions from the rest of the image. For example, if the image contains bright objects on a dark background, you can isolate the objects and remove the background by selecting **Bright Objects** from the Look For drop-down list and setting a minimum threshold value close to 255 (white).

The Processing window displays a preview of the default threshold operation, Manual Threshold, using the current set of parameters. The pixels depicted in red have intensities that fall inside the threshold range. The threshold operator sets their values to 1. The pixels depicted in gray have values outside the threshold range. The threshold operator sets their values to 0.

10. To threshold this image, set the **Minimum** value to `130` to select all of the objects.

Tip You may need to manipulate the Minimum value several times to find the one that works best. Rather than enter a number in the **Minimum** field, you can select the value using the pointer on the histogram. Adjust the pointer until all of the objects you want to select are red.

11. Click the **Main** tab.
12. Enter `Threshold Image` in the **Step Name** control.
13. Click **OK** to apply the manual threshold to the image. The image is converted to a binary image where all of the selected pixels in the threshold range are set to 1 (red) and all other pixels are set to 0 (black).

    Refer to Figure 2-4 to see what the image looks like after applying the threshold.

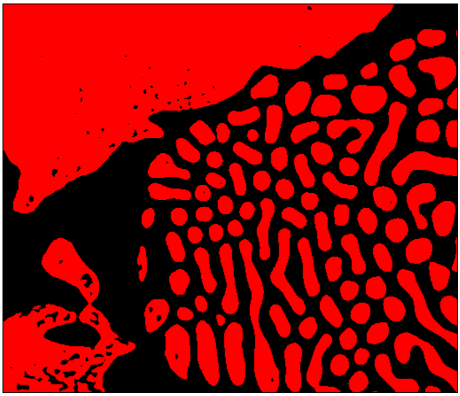


Figure 2-4. Thresholded Image

The thresholding step is recorded in the Script window. The script records the processing operation and all of its parameters. If you must run the same operation on other images, you can save the script and use it again.

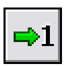
14. Select **File»Save Script As**, and name the script `threshold.scr`.

    If you find another image that you must threshold similarly, run this script on the image using the following steps:

    a. Load the image.

    b. Select **File»Open Script**, select `threshold.scr`, and click **Open**.

    c. Click the **Run Once** button in the script window.



Try experimenting with different options and images. For example, you can perform a particle analysis to find the area that each object in this image occupies. If you need help with any specific image processing operation, click the **How To** tab or the **Controls** tab in the Context Help window.

Acquiring Images in Vision Assistant

Vision Assistant offers three types of image acquisitions: snap, grab, and sequence. A *snap* acquires and displays a single image. A *grab* acquires and displays a continuous set of images, which is useful, for example, when you need to focus the camera. A *sequence* acquires images according to settings that you specify and sends the images to the Image Browser.

Using Vision Assistant, you can acquire images with various National Instruments Smart Cameras, digital and analog frame grabbers, DCAM-compliant IEEE 1394 cameras, and Gigabit Ethernet (GigE) Vision cameras. For information about driver software, refer to the *NI Vision Acquisition Software Release Notes*.

Configure your image acquisition devices in National Instruments Measurement & Automation Explorer (MAX). For information about configuring image acquisition devices in MAX, refer to the *NI Vision Acquisition Software Release Notes*.

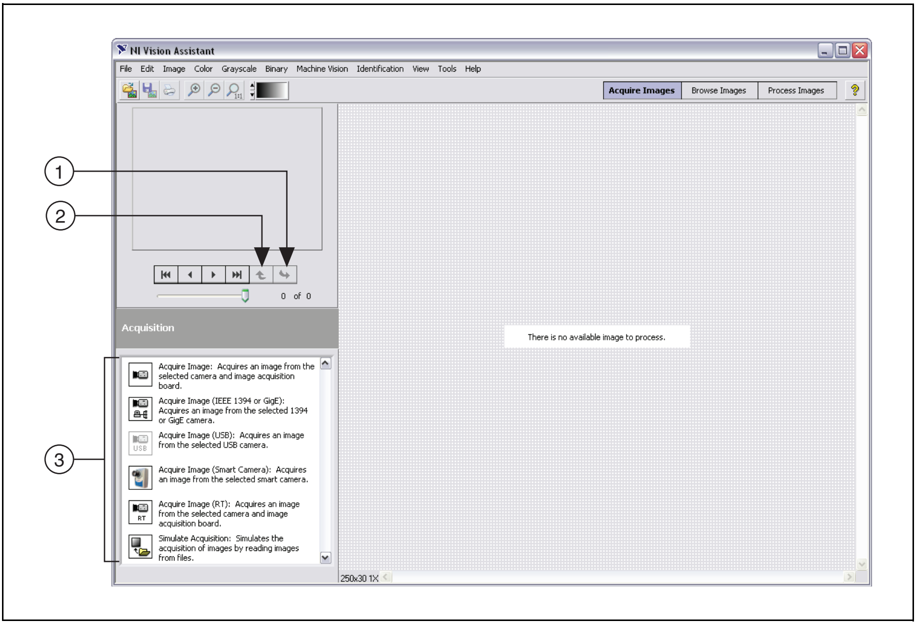
If you do *not* have an image acquisition device and the corresponding driver software, you can use the Simulate Acquisition step to simulate a live acquisition by displaying a sequence of images. You can interact with the simulation module as you would with a live acquisition. For example, you can stop the sequence at any frame, capture the image, and send the image to the Image Browser for processing.

Opening the Acquisition Window

Complete the following steps to acquire images.

1. Launch Vision Assistant if it is not already open.
2. Click **Acquire Image** in the Welcome screen to view the Acquisition functions, as shown in Figure 2-5.

If you already have Vision Assistant running, click **Acquire Images** in the toolbar. Vision Assistant displays the Acquisition functions, as shown in Figure 2-5.



1	Make Image Active	2	Store Acquired Image in Browser	3	Acquisition Functions

Figure 2-5. Acquiring Images in Vision Assistant

3. Click **Acquire Image**. The Setup window displays the NI Vision devices and channels installed on the computer. For example, Figure 2-6 shows that the NI PCI-1410 is installed.

Note The hardware devices listed in the Setup window vary according to the devices installed.

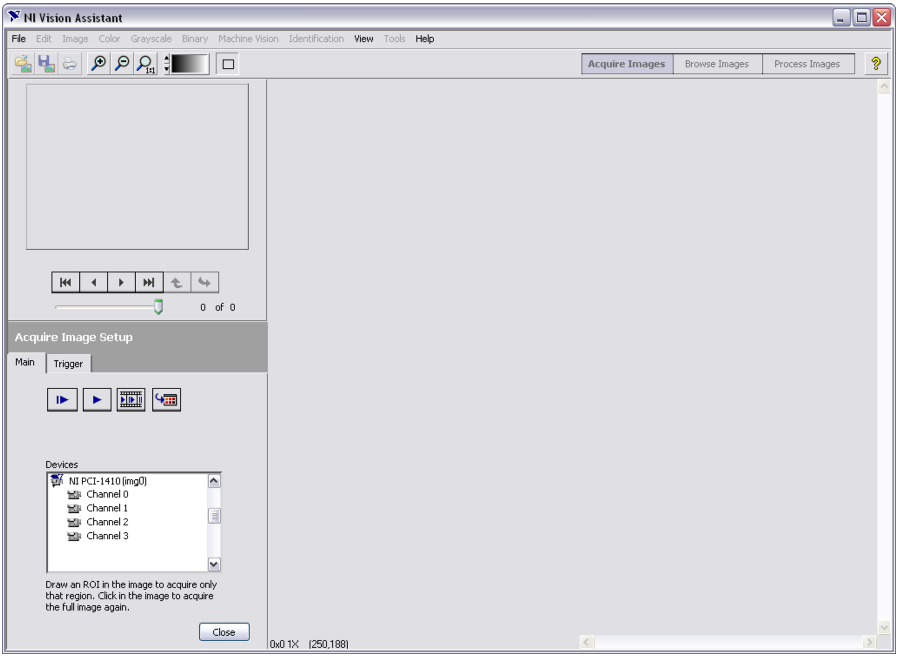


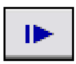
Figure 2-6. Acquire Image Setup Window

4. Click **Close** to close the Acquire Image Setup window.

Snapping an Image

Complete the following steps to acquire and display a single image.

1. Select **File»Acquire Image**.
2. Click **Acquire Image** in the Acquisition function list.
3. Select the appropriate device and channel or port.
4. Click the **Acquire Single Image** button to acquire a single image with the image acquisition device and display it.



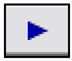
5. Click the **Store Acquired Image in Browser** button to send the image to the Image Browser.

6. Click **Close** to exit the Setup window.
7. Process the image as you would any other image in Vision Assistant. Refer to the other chapters of this tutorial for examples of processing images in Vision Assistant.

Grabbing an Image

Complete the following steps to acquire and display a continuous set of images.

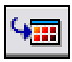
1. Select **File»Acquire Image**.
2. Click **Acquire Image** in the Acquisition function list.
3. Select the appropriate device and channel or port.
4. Click the **Acquire Continuous Images** button to acquire and display images in continuous mode at the maximum rate.



5. Click the **Acquire Continuous Images** button again to stop the acquisition and display the last acquired image.

> **Tip** You can acquire a region of interest (ROI) within the full-sized image. If you draw an ROI on an image while grabbing it, the image reduces to the ROI. You can refine the acquired area again by selecting another region of interest, or you can return to the full-sized image by clicking the image.

6. Click the **Store Acquired Image in Browser** button to send the image to the Image Browser.



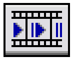
7. Click **Close** to exit the Setup window.
8. Process the image as you would any other image in Vision Assistant. Refer to the other chapters of this tutorial for examples of processing images in Vision Assistant.

Acquiring a Sequence of Images

Complete the following steps to acquire a sequence of images and send the images to the Image Browser.

1. Click **File»Acquire Image**.
2. Click **Acquire Image** in the Acquisition function list.
3. Select the appropriate device and channel or port.

4. Click the **Sequence Acquisition** button.



5. Set the properties on the Sequence Acquisition Wizard.
   - **Number of Frames**—Number of frames you want to acquire.
   - **Skip Count**—Number of frames you want to skip between acquisitions.
   - **Line**—Physical trigger line.
   - **Action**—Triggering action. Valid values include **Disabled**, **Trigger start of acquisition**, and **Trigger each image**.
   - **Timeout**—Time, in milliseconds, within which the trigger must occur.
   - **Polarity**—Determines if the acquisition is triggered on the rising edge or the falling edge.
6. Click **Next**, **Next**, and **Finish** to complete the acquisition.

   If you set the triggering action property to **Disabled**, click **Next** to begin acquiring a sequence of images.

   Images acquired are automatically sent to the Image Browser.
7. Click **Close** to exit the Setup window.
8. Process the image as you would any other image in Vision Assistant. Refer to the other chapters of this tutorial for examples of processing images in Vision Assistant.

3

Using Particle Analysis to Analyze the Structure of a Metal

This chapter describes particle analysis and provides step-by-step directions for prototyping a particle analysis application in Vision Assistant.

Note You must have Microsoft Excel installed to complete some steps in this tutorial.

What Is Particle Analysis?

Particle analysis consists of a series of processing operations and analysis functions that produce some information about the particles in an image. A particle is a contiguous region of nonzero pixels. You can extract particles from a grayscale image by thresholding the image into background and foreground states. Zero valued pixels are in the background state, and all nonzero valued pixels are in the foreground. In a binary image, the background pixels are zero, and every non-zero pixel is part of a binary object.

You perform a particle analysis to detect connected regions or groupings of pixels in an image and then make selected measurements of those regions. Using particle analysis, you can detect and analyze any two-dimensional shape in an image. With this information, you can detect flaws on silicon wafers, detect soldering defects on electronic boards, or locate objects in motion control applications when there is significant variance in part shape or orientation.

Tutorial

This tutorial demonstrates finding the area of circular particles in a metal. As you perform this analysis, Vision Assistant records all of the processing operations and parameters in a script. You run the script on other images to test the particle analysis algorithm.

To find the total area of circular particles, you perform the following image processing steps:

- Filter the image to sharpen edges and ease the separation of the particles from the background.
- Threshold the image to isolate the appropriate particles.
- Fill holes that appear in the particles after thresholding.
- Remove all objects touching the border so that you remove partial particles.
- Use a particle filter to find all circular particles and remove non-circular particles.
- Perform a particle analysis to find the total area occupied by circular particles.

Loading Images into Vision Assistant

1. If you already have Vision Assistant running, click the **Open Image** button in the toolbar, and proceed to step 4. Otherwise, proceed to step 2.

2. Select **Start»All Programs»National Instruments Vision Assistant**.
3. Click **Open Image** on the Welcome Screen.
4. Navigate to `<Vision Assistant>\Examples\metal`, where `<Vision Assistant>` is the location to which Vision Assistant is installed.
5. Enable the **Select All Files** checkbox.

Tip The **Preview Image** window displays all selected images in a sequence. To view the images at a different rate, adjust the slide to the right of the **Preview Image** window.

6. Click **Open**. Vision Assistant loads the image files, which represent microscopic views of pieces of metal. The first image, `Metal1.jpg`, loads in the Processing window.

Preparing an Image for Particle Analysis

Before you can separate circular particles from non-circular particles, you must prepare the image. To isolate particles of interest, verify that individual particles are separated by a gap and that the borders of those particles are distinct.

Examining the Image

Examine the image in the Processing window. The image is slightly blurred, and the edges of particles are not distinct. Although you can see these problems from just looking at the image, you may need to use a line profile in similar cases. A line profile returns the grayscale values along a line that you draw with the **Line Tool**.

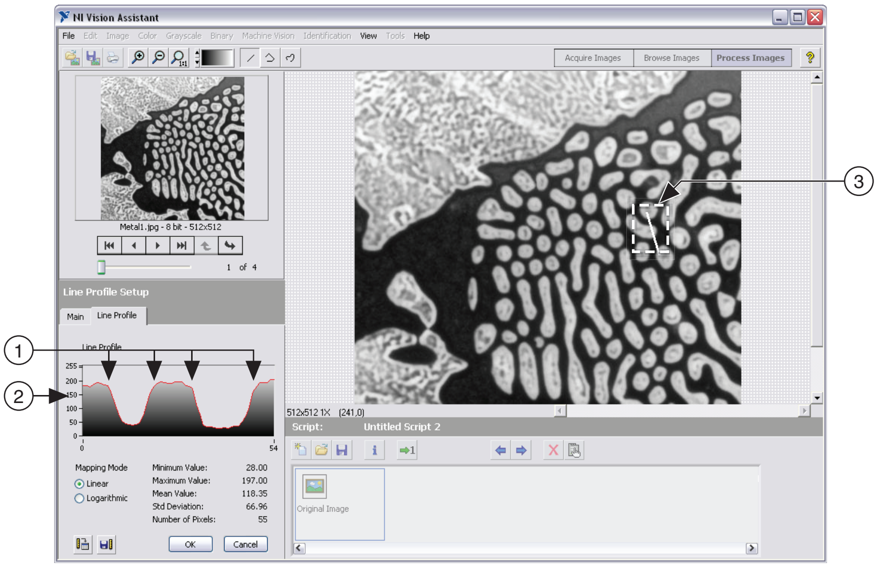
Complete the following steps to examine edges using a line profile.

1. If the Script window already contains a script, click the **New Script** button to open a new script. Otherwise, proceed to step 2.

2. Click **Line Profile** in the **Image** tab of the Processing Functions palette, or select **Image»Line Profile** to open the Setup window. Notice that the **Line Tool** is automatically selected in the toolbar and is active.

3. Draw a short segment across a particle, as shown in Figure 3-1.

Tip ROIs are context sensitive, and you can easily adjust their location in the image or the position of their center points. You can also adjust the position of the ROI in the image by using the arrow keys on the keyboard.



1	Edges of Particles	3	Segment Drawn with Line Tool
2	Graph or Profile Showing Fluctuation in Pixel Values		

Figure 3-1. Using a Line Profile to Examine Edges

In Figure 3-1, the areas labeled **1** represent the edges of the particles. Notice that the edges of the particles have a slope. The more shallow the slope, the greater variation you have in detecting the exact location of the edge. As you change the threshold level in images with shallow-sloped particle edges, you might inadvertently change the shape or size of the particle. In the *Filtering the Image* section of this chapter, you use the Convolution-Highlight Details filter under **Filters** in the **Grayscale** tab of the Processing Functions palette to define the edges of the particles and increase the slope.

The area labeled **2** in Figure 3-1 is a fluctuation in pixel values, which might be caused by brighter and darker pixels in the center of the particles or it might also be edges of a hole in the particle. Later, you will threshold the image to make all of the pixels in the particles the same pixel value and then perform a morphological operation on the image to fill any holes left in the particles.

4. Click **Cancel**. You do not need to add the Line Profile step to the script because it was for investigational purposes only.

Filtering the Image

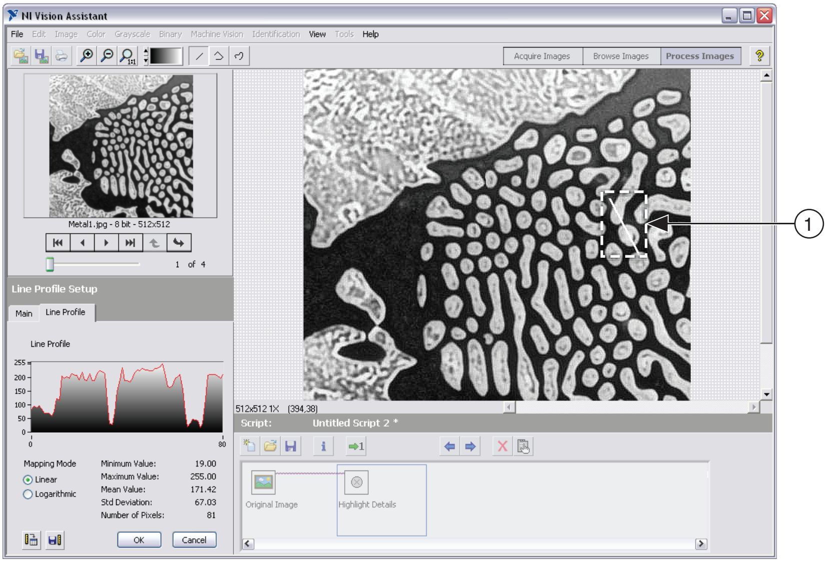
Filters can smooth, sharpen, transform, and remove noise from an image so that you can extract the information you need. To sharpen edges, including the edges of any holes inside a particle, and create contrast between the particles and the background, complete the following steps:

1. Click **Filters** in the **Grayscale** tab of the Processing Functions palette, or select **Grayscale» Filters**.
2. Enter `Highlight Details` in the **Step Name** control.
3. Select **Convolution-Highlight Details** from the Filters list. This function detects sharp transitions and highlights edge pixels according to a *kernel* to make gaps more prominent. A kernel is a structure that represents a pixel and its relationship to its neighbors. For more information about kernels, refer to Chapter 5, *Image Processing*, of the *NI Vision Concepts Manual*.
4. Click **OK** to add this step to the script.

Examining the Results of the Filtering

To confirm that the filter sharpened edges and separated particles, perform another line profile using the following steps:

1. Click **Line Profile** in the **Image** tab of the Processing Functions palette, or select **Image» Line Profile**.
2. Click and drag to draw a short segment across a particle to examine the line profile of the particle and its border, as shown in Figure 3-2. The line profile indicates more defined edges.
3. Click **Cancel**.



1 Segment Drawn with Line Tool

Figure 3-2. Using a Line Profile to Examine Particle Edges

Separating Particles from the Background with Thresholding

Thresholding isolates pixels that interest you and sets the remaining pixels as background pixels. Thresholding also converts the image from grayscale to binary.

Complete the following steps to select a range of brighter pixels for analysis.

1. Click **Threshold** in the **Grayscale** tab of the Processing Functions palette, or select **Grayscale»Threshold**.

   The Threshold Setup window displays a histogram. A histogram counts the total number of pixels in each grayscale value and graphs it. From the graph, you can tell if the image contains distinct regions of a certain grayscale value. You also can select pixel regions of the image.

2. To threshold this image, set the **Minimum** value to `130`.

   Notice that the particles of interest (circular and non-circular) are highlighted in red. When you apply the threshold, everything highlighted is set to 1, and all other pixels are set to 0.

Tip Rather than enter a number in the **Minimum** field, you can select the value using the pointer on the histogram. Adjust the pointer until all of the objects you want to select are red.

3. Click the **Main** tab.
4. Enter `Threshold Image` in the **Step Name** control.
5. Click **OK** to apply the threshold and add this step to the script. Figure 3-3 shows the thresholded image. The pixels that you selected for processing appear red. Unselected pixels appear black.

   The image is now a binary image, which is an image composed of pixels with values of 0 and 1. This image is displayed using a binary palette, which displays the pixel intensities of an image with unique colors. All pixels with a value of 0 appear black and pixels set to 1 appear red. The red pixels are now referred to as particles.

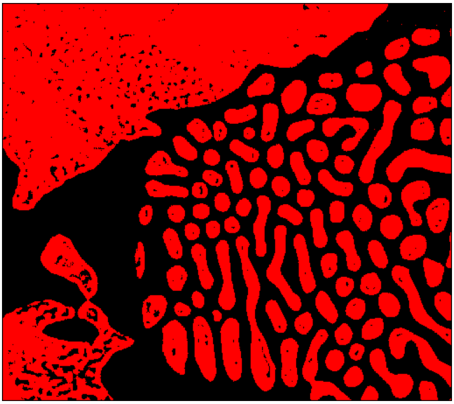


Figure 3-3. Separating Particles from the Background with Thresholding

Modifying Particles with Morphological Functions

Morphological functions affect the shape of particles on an individual basis. Morphological operations prepare particles in the image for quantitative analysis such as finding the area, perimeter, or orientation.

Use the following steps to apply two morphological functions to the image. The first function fills holes in the particles and the second removes objects that touch the border of the image.

1. Click **Adv. Morphology** in the **Binary** tab of the Processing Functions palette, or select **Binary»Adv. Morphology**.
2. Enter `Fill Holes` in the **Step Name** control.
3. Select **Fill holes** from the list.
4. Click **OK** to add this step to the script.
5. Click **Adv. Morphology** in the **Binary** tab of the Processing Functions palette, or select **Binary»Adv. Morphology**.
6. Enter `Remove Border Objects` in the **Step Name** control.

7. Select **Remove border objects** to remove any objects that touch the border of the image. Refer to Figure 3-4 to see what the image looks like after applying morphological functions to the image.
8. Click **OK** to add this step to the script.

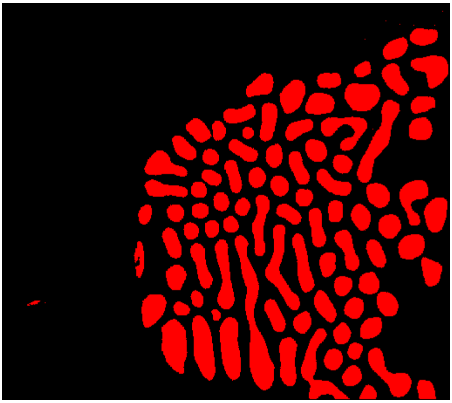


Figure 3-4. Modifying Particles with Morphological Functions

Isolating Circular Particles

Complete the following steps to define a particle filter that isolates and keeps the circular particles and removes the non-circular particles from the image.

1. Click **Particle Filter** in the **Binary** tab of the Processing Functions palette, or select **Binary»Particle Filter**.
2. Enter `Filter Round Particles` in the **Step Name** control.
3. Select **Heywood Circularity Factor** from the list of particle filters. This function calculates the ratio of the perimeter of the particle to the perimeter of the circle with the same area. The more circular the particle, the closer the ratio to 1.
4. To find more circular and less oblong particles, enter a **Minimum Value** of `0` and a **Maximum Value** of `1.06` for the parameter range.
5. Select the **Keep** option to keep circular particles and remove particles that do not fit in the range.

6. Click **OK** to add this step to the script. The image now contains only circular particles, as shown in Figure 3-5.

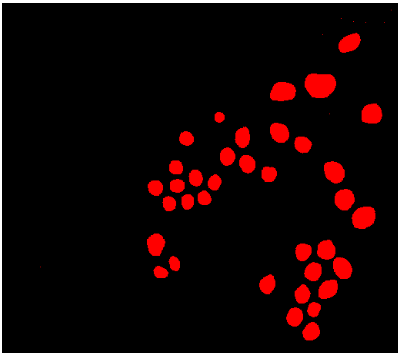


Figure 3-5. Isolating Circular Particles

Analyzing Circular Particles

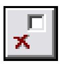
Now that you have isolated circular particles, complete the following steps to find the area occupied by them.

1. Click **Particle Analysis** on the **Binary** tab of the Processing Functions palette, or select **Binary»Particle Analysis**. A results table displays all of the measurement results.

   Vision Assistant assigns numerical labels to each particle. The first row of the results table lists the numerical label associated with each particle.
2. Enter `Particle Analysis` in the **Step Name** control.
3. Enable the **Show Labels** checkbox to view the labels.

> **Tip** When you click a particle, the measurement results for that particle are highlighted in blue. When you click the results for a particle, the particle is surrounded by a green rectangle in the Processing window.

4. To show only the area measurement, click **Select Measurements**.
5. Click the **Deselect All Pixel Measurements** button to deselect all of the measurements. The real-world measurements are grayed out because the image is not calibrated.



6. Select the **pixels** control beside the **Area** measurement.

7. Click **OK** to close the Select Measurements dialog box.

   You now have all of the information you need to analyze the structure of the metal. Remember to include the analysis as part of the LabVIEW, LabWindows/CVI, or Visual Basic solution. You can also use Microsoft Excel to analyze the data Vision Assistant generates.

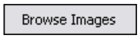
   To send the data to Microsoft Excel, click the **Send Data to Excel** button in the Particle Analysis results window.

8. Click **OK** to record the particle analysis and add the step to the script.

Testing the Particle Analysis Script

The script that you created as you processed this image is a custom algorithm. To test this algorithm, run it on another image in the collection using the following steps:

1. Click **Browse Images**.



2. Double-click the third image, `Metal3.jpg`.

Tip Rather than returning to the Image Browser, you can navigate through the images in the Image Browser from the Reference window. Click the **Next Image** and **Previous Image** buttons until you see the image you want to process and then click the **Make Image Active** button to move that image into the Processing window.

3. Click the **Run Once** button.

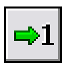
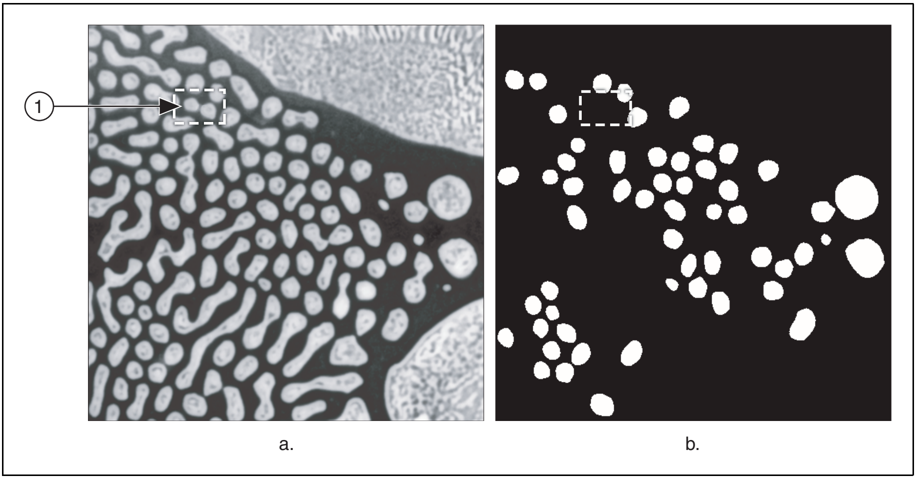


   Figure 3-6a shows the original image, `Metal3.jpg`. Figure 3-6b shows the image after the particle analysis processing. Notice that two circular particles are removed from the image during processing because they are touching each other. You need to adjust the Threshold step to separate the particles.



1	Overlapping Circular Particles

Figure 3-6. Comparing the Original Image to the Processed Image

4. Click **OK** to close the Particle Analysis Setup window.
5. Double-click the Threshold step in the script window to open the Threshold Setup window. Figure 3-7 shows `Metal3.jpg` at the thresholding step of the script.

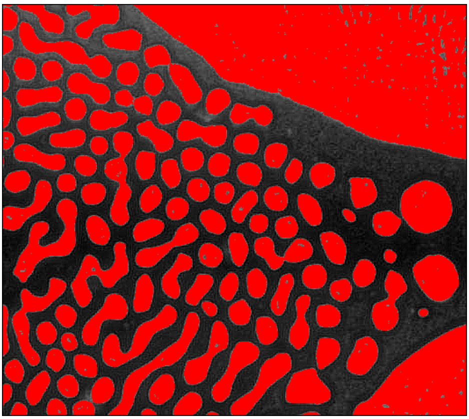
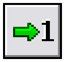


Figure 3-7. Testing the Particle Analysis Script

6. Adjust the minimum threshold value until the particles are clearly separated. A minimum value of 150 works well.
7. Click **OK**.

8. Click **Run Once** to rerun the script. Notice that only the circular particles now appear in the final processed image.



9. Click **OK** to close the Particle Analysis Setup window.

Saving the Particle Analysis Script

Now that you have written a particle analysis algorithm and tested it on another image, you can save the script to use on similar images. You can also perform batch processing with this script.

1. Select **File»Save Script As**.
2. Save the script as `particle analysis.scr`.

Refer to the *NI Vision Assistant Help* for more information about the Vision Assistant batch processing functionality.

Estimating Processing Time

Vision Assistant can estimate the time, in milliseconds, that NI Vision takes to process the active image with the open script. The Performance Meter gives both an estimate of the total time NI Vision takes to process the image and an estimate of the time each function within the script requires. Complete the following steps to estimate how many milliseconds NI Vision uses to process `Metal3.jpg` with `particle analysis.scr`.

1. Select **Tools»Performance Meter**. The Performance Meter estimates the total time NI Vision takes to run the script.
2. Click **Details** to view an itemized list of the time NI Vision takes to perform each function in the script.
3. Click **OK** to close the Performance Meter.

Creating a LabVIEW VI

Vision Assistant features a wizard that creates a LabVIEW VI that implements the different steps of the script.

> **Note** You must have LabVIEW 7.1 or later and the NI Vision 8.6 Development Module or later installed to use the Vision Assistant LabVIEW VI Creation Wizard.

Complete the following steps to create a LabVIEW VI.

1. Select **Tools»Create LabVIEW VI**.

> **Note** If several versions of LabVIEW and NI Vision are installed on the computer, the wizard searches the machine and displays a list of the available LabVIEW and NI Vision versions you can use to create the VI.

2. Select the version of LabVIEW in which you want to create a VI.
3. Click the Browse button and select the location to which you want to save the VI.

4. Enter a **File name**, and click **OK**.
5. Click **Next**.
6. Select **Current Script** to create a VI from the script you created in this chapter.
7. Click **Next**.
8. Select **Image File** as the image source to create a VI that opens an image from the hard disk.
9. Click **Finish** to create the VI.

Note If you have LabVIEW open, you cannot create a VI for a different version of LabVIEW. For example, if you have LabVIEW 8.0.1 open and you select LabVIEW 8.2 in the LabVIEW VI Creation Wizard, the wizard returns an error when you click **Finish**.

Creating a C Program

Vision Assistant features a wizard that creates C code that implements the different steps of the script.

Note You must have the NI Vision 8.6 Development Module or later installed to use the Vision Assistant C Code Creation Wizard.

Complete the following steps to create a C program.

1. In Vision Assistant, select **Tools»Create C Code**.
2. Enter the name of the implementation file that will contain the image processing function that implements the Vision Assistant steps.
3. Select the **Create Main Function** option if you want the wizard to generate a main function to test the image processing function.
   a. Enter the name for the new C file in the **Main File Name** control.
   b. In the **Image Source** drop-down menu, select **Image File** as the source of the image that is used by the main function.
4. Browse to the folder to which you want to save the generated files.

Tip If you have LabWindows/CVI installed, and you want to use it to compile and test the C code, select the **Add Files to LabWindows/CVI Project** option.

5. Click **OK** to create the C program.

4

Using Gauging for Part Inspection

This chapter describes gauging and provides step-by-step directions for prototyping a part inspection application in Vision Assistant.

What Is Gauging?

Components such as connectors, switches, and relays are small and manufactured in high quantity. While human inspection of these components is tedious and time consuming, vision systems can quickly and consistently measure certain features on a component and generate a report with the results. From the results, you can determine if a part meets its specifications.

Gauging consists of making critical distance measurements—such as lengths, diameters, angles, and counts—to determine if the product is manufactured correctly. Gauging inspection is used often in mechanical assembly verification, electronic packaging inspection, container inspection, glass vial inspection, and electronic connector inspection.

Tutorial

In this tutorial, you analyze images of pipe brackets to determine if the brackets meet their physical specifications. A pipe bracket is a metal piece of hardware used to secure long, slender parts, such as a tube of bundled wires.

The goal is to measure angles and distances between features on the brackets and determine if those measurements fall within a tolerance range. Figure 4-1 illustrates the measurements and the acceptable values for them.

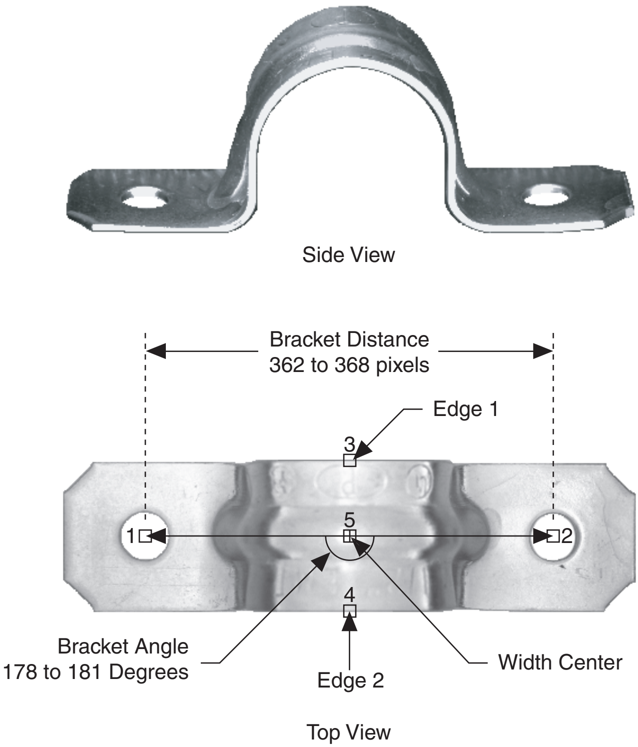


Figure 4-1. Bracket Specifications

Width Center is the center of the bracket and becomes the vertex of Bracket Angle. Bracket Angle measures the angle of the arms of the bracket and determines if the bracket arms are aligned properly. Bracket Distance measures the length in pixels between two manufactured holes in the bracket. Bracket Distance also determines if the bracket arch is the appropriate height and curvature.

As you perform this analysis, Vision Assistant records all of the processing operations and parameters in a script that you can run on other bracket images to determine which are good and which are defective.

Loading Images into Vision Assistant

1. If Vision Assistant is already running, click the **Open Image** button in the toolbar, and go to step 4. Otherwise, go to step 2.

2. Select **Start»All Programs»National Instruments Vision Assistant**.
3. Click **Open Image** on the Welcome Screen.
4. Navigate to <Vision Assistant>\Examples\bracket, where <Vision Assistant> is the location to which Vision Assistant is installed.
5. Enable the **Select All Files** checkbox.

Tip The Preview Image window displays all selected images in a sequence. To view the images at a different rate, adjust the slide to the right of the Preview Image window.

6. Click **Open** to load the image files into Vision Assistant. The first image, Bracket1.jpg, loads in the Processing window.

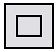
Finding Measurement Points Using Pattern Matching

Before you can compute measurements, you must locate features on which you can base the measurements. In this example, you use pattern matching to find manufactured holes in a bracket. These holes serve as measurement points from which you can determine if the bracket arch is the appropriate height and curvature.

1. If the Script window already contains a script, click **New Script** to open a new script.

2. Select **Pattern Matching** in the **Machine Vision** Processing Functions tab, or select **Machine Vision»Pattern Matching**.
3. Click **New Template**. The NI Vision Template Editor opens.

4. With the **Rectangle Tool**, click and drag to draw a square ROI around the left hole in the image, as shown in Figure 4-2. The ROI becomes the template pattern.



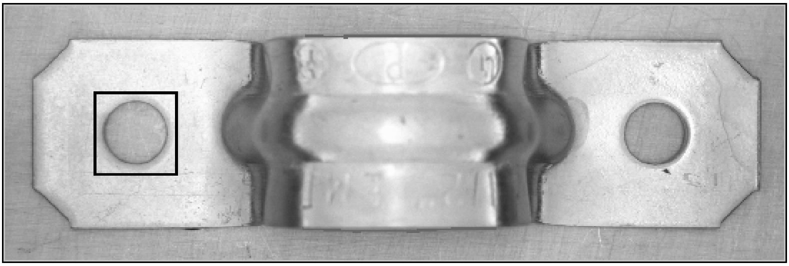


Figure 4-2. Selecting a Template Pattern

5. Click **Next**.
6. Click **Finish**. Learning the template takes a few seconds. After Vision Assistant learns the template, the **Save Template as** dialog box opens.
7. Navigate to <Vision Assistant>\Examples\bracket.
8. Save the template as `template.png`. The Pattern Matching Setup window displays the template image and its path.
9. Click the **Settings** tab.
10. Set **Number of Matches to Find** to `1`.
11. Set the **Minimum Score** to `600` to ensure that Vision Assistant finds matches similar, but not identical, to the template.
12. Enable the **Subpixel Accuracy** checkbox.
13. Make sure **Search for Rotated Patterns** is not selected to set the search mode to shift invariant. Use shift-invariant matching when you do not expect the matches you locate to be rotated in their images. If you expect the matches to be rotated, use rotation-invariant matching.

14. With the **Rectangle Tool**, draw an ROI around the left side of the bracket, as shown in Figure 4-3. Be sure that the region you draw is larger than the template image and big enough to encompass all possible locations of the template in the other images you analyze.

    Drawing an ROI in which you expect to locate a template match is a significant step in pattern matching. It reduces the risk of finding a mismatch. It also allows you to specify the order in which you want to locate multiple instances of a template in an image and speeds up the matching process.

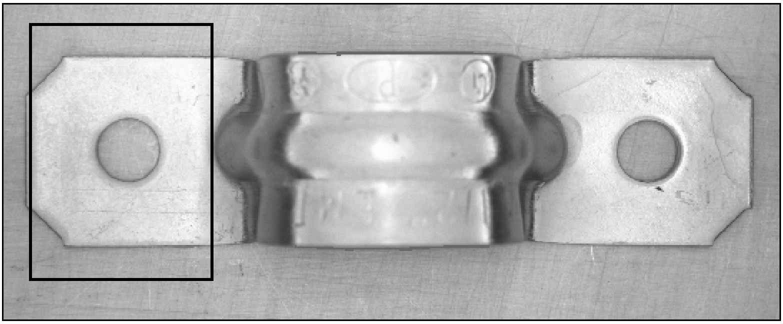


Figure 4-3. Selecting the First Search Area

    When you draw the ROI, Vision Assistant automatically locates the template in the region and displays the score and location of the match. Notice that the score for the match is 1000. The score for this match is perfect because you made the template from the same region of the image.

15. Click **OK** to save this step to the script.
16. Select **Pattern Matching** in the **Machine Vision** tab of the Inspection steps, or select **Machine Vision»Pattern Matching**.
17. Click **Load from File** and open the template you just saved.
18. Click the **Settings** tab.
19. Set **Number of Matches to Find** to `1`.
20. Set the **Minimum Score** to `600` to ensure that Vision Assistant finds matches that are similar, but not identical, to the template.
21. Enable the **Sub-pixel Accuracy** checkbox.

22. With the **Rectangle Tool**, draw an ROI around the right side of the bracket, as shown in Figure 4-4. Vision Assistant automatically locates the template in the region bound by the rectangle and displays the score and location of the match.

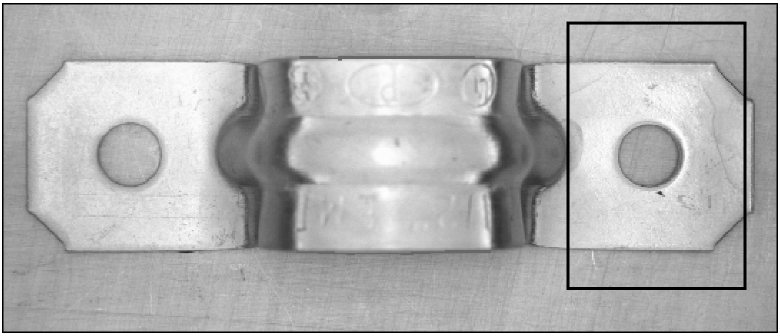


Figure 4-4. Selecting the Second Search Area

The score of the second match is not a perfect 1000, but it is high enough for you to consider it a match to the template.

23. Click **OK** to add this step to the script.

Finding Edges in the Image

Before you can compute measurements to determine if a bracket meets specifications, you must detect edges on which you can base the measurements. The Edge Detector function finds edges along a line that you draw with the Line Tool from the Tools palette.

1. Select **Edge Detector** in the **Machine Vision** tab of the Inspection steps, or select **Machine Vision»Edge Detector**.
2. Select the **Advanced Edge Tool** from the **Edge Detector** drop-down listbox. The Advanced Edge Tool is effective on images with poor contrast between the background and objects.
3. Select **First & Last Edge** from the **Look For** drop-down listbox so that Vision Assistant finds and labels only the first and last edges along the line you draw.
4. Set the **Min Edge Strength** to `40`. The detection process returns only the first and last edge whose contrast is greater than 40.
5. Click and drag to draw a vertical line across the middle of the bracket to find the edges that you can use to calculate Width Center, as shown in Figure 4-5. Vision Assistant labels the edges 1 and 2.

Tip To draw a straight line, press and hold the <Shift> key as you draw the line.

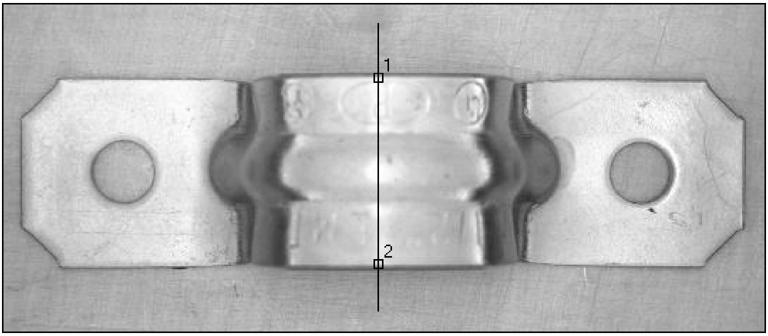


Figure 4-5. Finding the Edges for Bracket Distance

Look at the edge strength profile. The sharp transitions in the line profile indicate edges. Notice that the number of edges found is displayed under the edge strength profile.

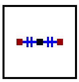
6. Click **OK** to add this step to the script.

Taking the Measurements

Now that you have found the bracket holes and the necessary edges, you can calculate the center of the bracket width, distance between the bracket holes, and angle of the bracket arms with the Caliper function. The Caliper function is a tool that uses points on the image to calculate measurements—such as distances, angles, the center of a segment, or the area—depending on the number of points you have selected on the image. These points are results of earlier processing steps, such as edge detections and pattern matching.

Complete the following steps to make the measurements.

1. Select **Caliper** in the **Machine Vision** tab, or select **Machine Vision»Caliper**.
2. Select **Mid Point** in the **Geometric Feature** listbox.



3. Click points **3** and **4** in the image to obtain the Width Center measurement, which specifies the center of the bracket width.

   When you select a point in the image, Vision Assistant places a check mark next to the corresponding point in the Caliper Setup window.

Tip If you have trouble finding the points, click the **Zoom In** tool in the Tools palette to magnify the image. Magnification factors are displayed in the lower left corner of the Processing window. 1/1 specifies 100% magnification (default). 2/1 specifies a slightly magnified view, and 1/2 specifies a slightly demagnified view.

Tip Instead of selecting points from the image, you can select points by double-clicking their entries in the **Available Points** listbox.

4. Click **Measure** to compute the center of the bracket width and add the Mid Point measurement to the results table, as shown in Figure 4-6.
5. Click **OK** to add this step to the script.

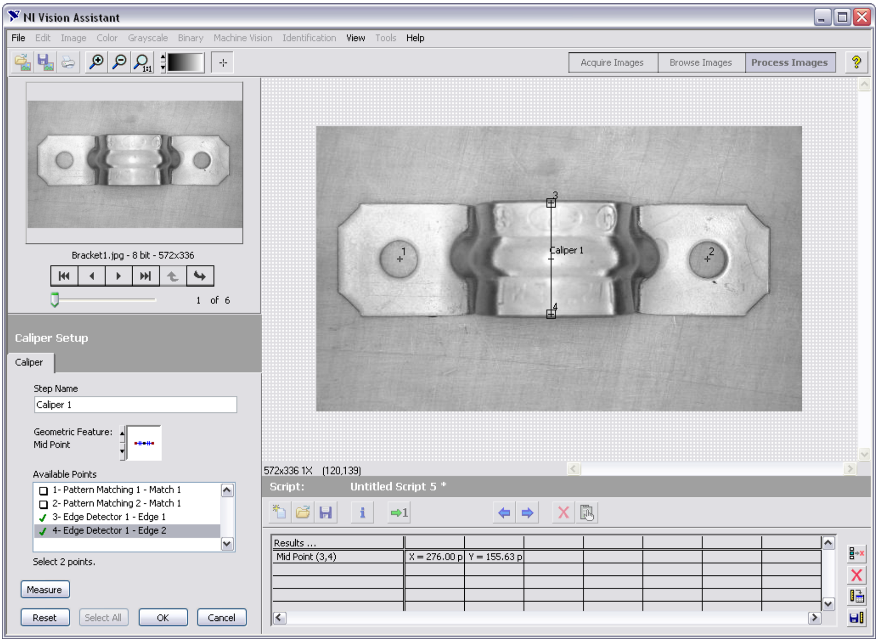
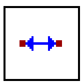


Figure 4-6. Using the Caliper Function to Find Width Center

6. Select **Caliper** in the **Machine Vision** tab, or select **Machine Vision»Caliper** again. The center of the bracket width appears as point 5.
7. Select Distance in the **Geometric Feature** listbox.



8. Click points **1** and **2** in the image to find the Bracket Distance, which measures the length between the manufactured holes in the bracket and determines if the bracket arch is the appropriate height.

9. Click **Measure** to compute the distance between the bracket holes. The distance measurement is added to the results table, as shown in Figure 4-7.

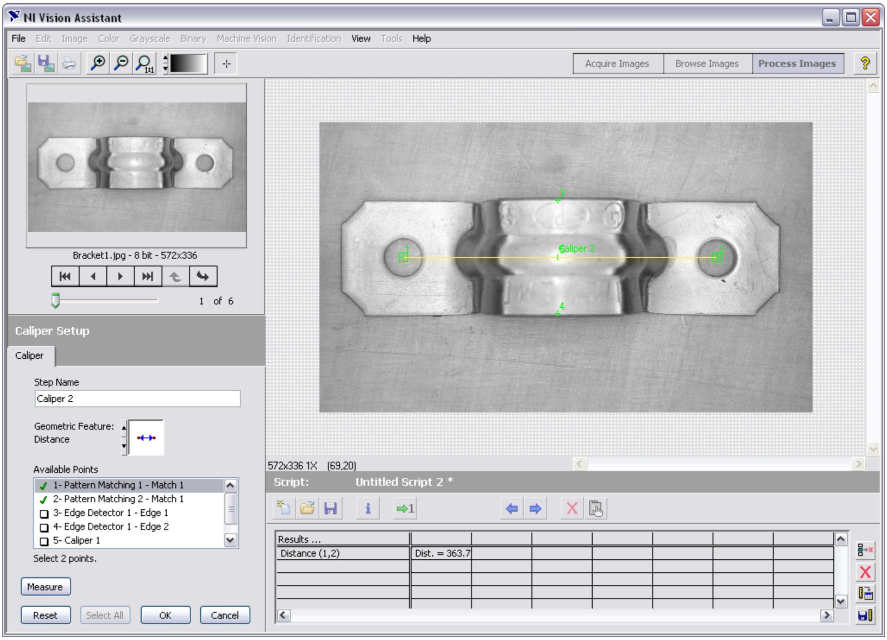
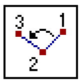


Figure 4-7. Using the Caliper Function to Find Bracket Distance

10. Select **Angle Defined by 3 Points** in the **Geometric Feature** listbox. Click points **1**, **5**, and **2**, in this order, to find the next measurement—Bracket Angle—which measures the angle of the bracket arms with respect to a vertex at point 5, as shown in Figure 4-8.



11. Click **Measure** to compute the angle of the bracket arms and add the measurement to the results table.

Figure 4-8 shows the image with Bracket Distance and Bracket Angle selected on the image and displayed in the results table.

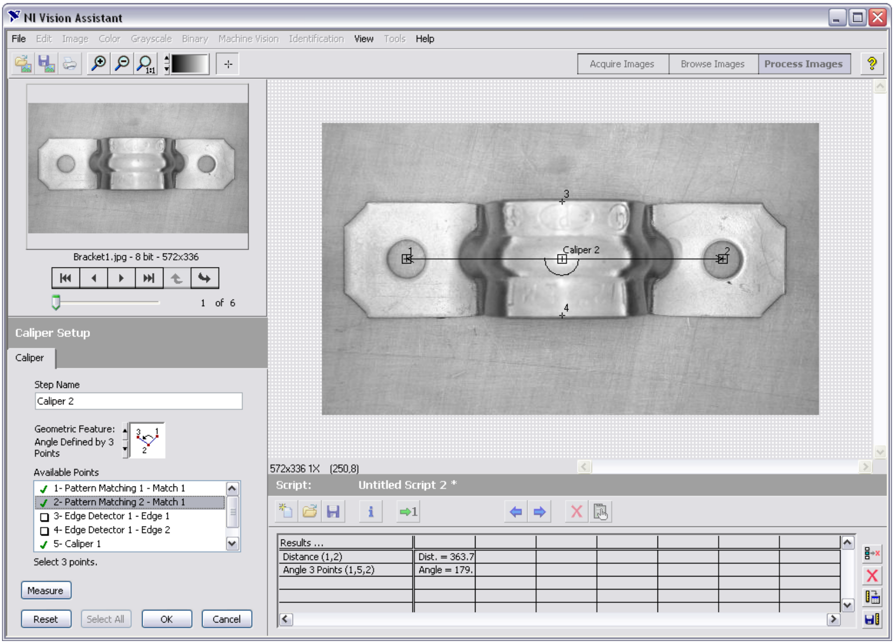


Figure 4-8. Using the Caliper Tool to Collect Measurements

12. Click **OK** to add these caliper measurements to the script and close the caliper window.
13. Select **File»Save Script As**, and save the script as `bracket.scr`.

Analyzing the Results

Batch processing involves running a script on a collection of images. You can use batch processing to analyze multiple images and save the resulting analysis information in a tab-delimited text file. Complete the following steps to run `bracket.scr` on all the images in the Image Browser.

1. Select **Tools»Batch Processing**.
2. Select the Image Source **Browser** to process all images in the Image Browser.
3. Select **Caliper 2** from the Script Steps list. Caliper 2 is the step that returns Bracket Distance and Bracket Angle.
4. Select the **Save Results** Analysis Mode. This enables the Save Options control.
5. Click **Setup**. A dialog box opens.
6. Select **One file for all results** to log the results for every image to the same file.

7. Click the **Folder Path** button. Navigate to the directory in which you want to save the results file, and click **Current Folder**.

8. Enter `bracket_results.txt` in the **File Prefix** control. Because you are logging all the results to one file, the **File Prefix** is the name of the individual results file. If you were logging the results for each image to a separate file, **File Prefix** would be the prefix associated with the index for each results file.
9. Click **OK**.
10. Click **Run** to run the script on all the images in the Image Browser and log the results.
11. Click **OK** to close the Batch Processing finished notification.
12. Navigate to the directory path specified in step 7, and open `bracket_results.txt`.
13. Compare the **Bracket Distance** and **Bracket Angle** measurements in the results file to the values in Table 4-1.

    Table 4-1 shows the acceptable ranges for the bracket measurements and the actual values you might see for each bracket image. Notice that `Bracket1`, `Bracket2`, and `Bracket3` are the only ones that meet the specifications. The **bold** values for the other brackets indicate which measurements caused them to fail.

Note The results may vary slightly based on the template you chose for the pattern matching step and the position of the line you drew for the edge detection step.

Table 4-1. Bracket Measurement Results

Bracket Number	Bracket Distance (acceptable range: 362 to 368 pixels)	Bracket Angle (acceptable range: 178° to 181°)
Bracket 1	363.27	179.56
Bracket 2	363.05	180.26
Bracket 3	363.27	180.13
Bracket 4	**347.98**	179.06
Bracket 5	**337.45**	178.56
Bracket 6	**358.33**	**175.54**

Refer to the *NI Vision Assistant Help* for more information about the Vision Assistant batch processing functionality.

5

Using a Coordinate System for Part Inspection

This chapter describes how to set up a coordinate system and provides step-by-step directions for prototyping an inspection that checks for the presence of a part in Vision Assistant.

What Is a Coordinate System?

In a typical machine vision inspection, you limit your inspection and processing to a region of interest rather than the entire image. To limit the inspection area, the parts of the object you are interested in must always appear inside the region of interest you define.

If the object under inspection is always at the same location and orientation in the images you need to process, defining a region of interest is simple. However, the object under inspection often appears shifted or rotated within the images you need to process. When this occurs, the region of interest needs to shift and rotate with the parts of the object you are interested in. In order for the region of interest to move in relation to the object, you need to define a coordinate system relative to a feature in the image.

A coordinate system is specified by its origin and the angle its x-axis makes with the horizontal axis of the image. Assign a coordinate system based on how you expect the object to move in the image. If the object is going to only translate in the horizontal or vertical directions, you need only to select a feature whose location can represent the origin of the coordinate system. The angle is 0 by default. If the object is going to translate and rotate, you need to select features that can represent the location of the origin and angle of the coordinate system.

Tutorial

In this tutorial, you analyze images of dental floss holders to determine if the holders contain toothpaste and a wire.

Loading Images into Vision Assistant

1. If Vision Assistant is already running, click the **Open Image** button in the toolbar, and go to step 4. Otherwise, go to step 2.

2. Select **Start»All Programs»National Instruments Vision Assistant**.
3. Click **Open Image** on the Welcome Screen.
4. Navigate to <Vision Assistant>\Examples\dental floss, where <Vision Assistant> is the location to which Vision Assistant is installed.
5. Enable the **Select All Files** checkbox.

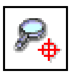
Tip The Preview Image window displays all selected images in a sequence. To view the images at a different rate, adjust the slide to the right of the Preview Image window.

6. Click **Open** to load the image files into Vision Assistant.

Defining a Feature on which to Base a Coordinate System

Complete the following instructions to configure a **Pattern Matching** step that locates a dental floss feature on which you can base a coordinate system. You will choose a feature, the base of the dental floss holder, that is always in the field of view of the camera despite the different locations that the dental floss holders may appear in from image to image.

1. Select **Pattern Matching** in the **Machine Vision** tab of the Processing Functions, or select **Machine Vision»Pattern Matching**.
2. In the Pattern Matching Setup window, click **New Template**. The Select a Template Region dialog box opens.



3. Draw a rectangle around the base of the dental floss, as shown in Figure 5-1. This region becomes the pattern matching template.

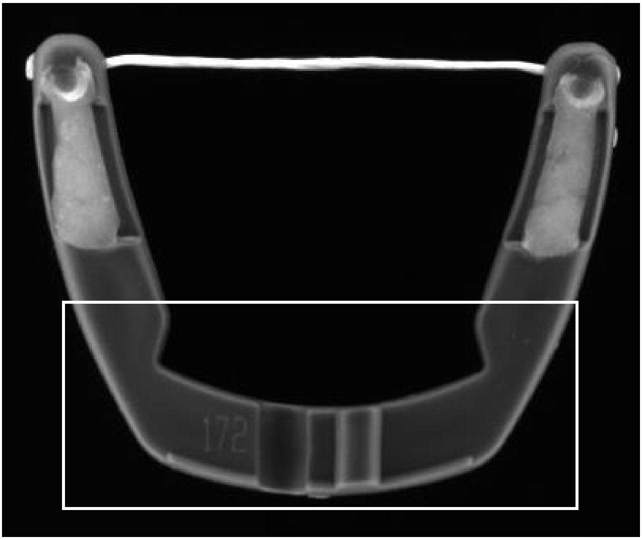


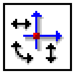
Figure 5-1. Creating a Template Pattern

4. Click **Next**.
5. Click **Finish**. The Save Temple as dialog box opens.
6. Navigate to `<Vision Assistant>\Examples\dental floss`, where `<Vision Assistant>` is the location to which Vision Assistant is installed.
7. Save the template as `template.png`. The Pattern Matching Setup window displays the template image and its path.
8. Click the **Main** tab.
9. Enter `Find Dental Floss Base` in the **Step Name** control.
10. Click the **Settings** tab.
11. Enable the **Subpixel Accuracy** checkbox.
12. Enable the **Search for Rotated Patterns** checkbox.
13. Set the **Angle Range +/–** control to `180`.
14. Click **OK** to save this step to the script.

Defining a Coordinate System

Complete the following instructions to configure a **Set Coordinate System** step based on the **Pattern Matching** step you configured.

1. Select **Set Coordinate System** in the **Image** tab of the Processing Functions, or select **Image»Set Coordinate System**.
2. Enter `Define Coordinate System` in the **Step Name** control.
3. Select **Horizontal, Vertical, and Angular Motion** from the **Mode** control. Because the dental floss holders appear shifted and rotated from one image to another, the changes in the region of interest need to be accounted for. This mode adjusts the region of interest positions along the horizontal and vertical axes, and adjusts for rotational changes.

   Notice the **Origin** and **X-Axis Angle** lists. Match 1, the match location of the previous Find Dental Floss Base step, is the default origin of the coordinate system because it is the only location point created by previous steps in the script.
4. Click **OK** to save this step to the script.

Checking for Presence

Complete the following instructions to configure a Quantify step to check the dental floss holders for the presence of toothpaste and a wire.

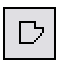
1. Select **Quantify** in the **Grayscale** tab of the Processing Functions, or select **Grayscale»Quantify**.
2. Enter `Measure Area Intensity` in the **Step Name** control.
3. Enable the **Reposition Region of Interest** checkbox.

   Enabling this control allows you to link the regions of interest specified in this step to a previously defined coordinate system so that Vision Assistant can adjust the location and orientation of the region of interest from image to image relative to the specified coordinate system.

   The **Reference Coordinate System** list shows all the previously defined coordinate systems. **Set Coordinate System** is the default reference coordinate system because it is the only Set Coordinate System step in the current script.

Notice that the Quantify step supports a variety of different tools that enable you to draw different shaped regions of interest, such as a point, line, broken line, freehand line, rectangle, oval, polygon, and freehand region. These tools are available in the Vision Assistant toolbar.

4. Click the **Polygon Tool** in the Vision Assistant toolbar.



5. Draw three regions of interest that enclose the wire and the two sections of toothpaste in the dental floss holder, as shown in Figure 5-2. Click and drag repeatedly to select a polygon region. Double-click to complete the polygon.

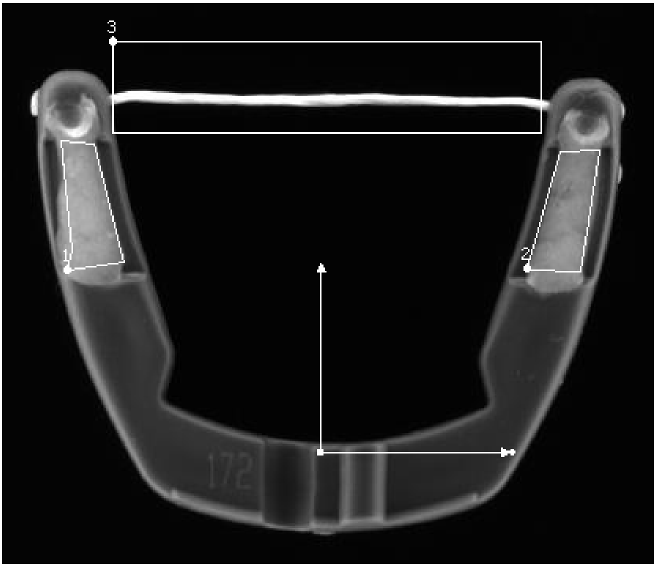
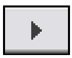


Figure 5-2. Defining Regions in which to Check for Presence

Testing the Dental Floss Script

The script that you created is a custom vision algorithm. You can verify the regions of interest reposition correctly by testing the algorithm on another image. To test this algorithm, complete the following steps:

1. In the Reference window, click the **Next Image** button to view the next image, `Dental Floss 01.jp2`.



2. Click the **Make Image Active** button to move that image into the Processing window. The dental floss base should be found in the new image and the regions of interest for the toothpaste and wire should reposition correctly based on the coordinate system.

3. Repeat steps 1 and 2 to test the script on the other images.
4. Click **OK** to add the Quantify step to the script.

Verifying your algorithm on new images is an important step in creating a robust algorithm because it helps you determine if your regions of interest are positioned correctly and helps you determine acceptable values for the results in the Quantify step.

You may need to adjust some parameters for the algorithm to work properly on other dental floss images. For example, if the base of the dental floss holder is not found in an image, the region of interest will not reposition correctly. If that happens, open the `Find Dental Floss Base` step and adjust the minimum score and, if necessary, adjust the search area.

To determine acceptable values, you can compare the **Mean Value** measurements in the Quantify step results. The **Mean Value** displays the mean value of the pixel intensity in the regions of interest you drew in the Quantify step.

Table 5-1 shows the acceptable values for the dental floss measurements and the actual values you might see for each dental floss image. For Mean Value 1 and Mean Value 2, which are the mean values for the toothpaste regions of interest, an acceptable value is 100 or greater. Mean values less than 100 signify that the toothpaste is missing from the dental floss holder. Notice that Dental Floss 2, Dental Floss 4, and Dental Floss 8 are missing toothpaste.

For Mean Value 3, which is the mean value for the wire region of interest, an acceptable value is greater than 20, but less than 40. A mean value below 20 signifies that the wire is missing from the dental floss holder. Notice that Dental Floss 6 and Dental Floss 8 are missing wires. A mean value above 40 signifies a frayed wire. Dental Floss 7 has a frayed wire.

Note The results may vary slightly based on the position of the regions of interest you drew for the Quantify step.

Table 5-1. Dental Floss Measurement Results

Bracket Number	Mean Value 1 (Left Toothpaste)	Mean Value 2 (Right Toothpaste)	Mean Value 3 (Wire)
Acceptable Values	Greater than 100	Greater than 100	Between 20–40
Dental Floss 0	153.87199	127.29397	29.25323
Dental Floss 1	168.29030	129.75693	29.48656
Dental Floss 2	30.87846	30.95160	28.50083
Dental Floss 3	151.90704	140.33263	29.88302
Dental Floss 4	157.62241	38.14659	27.56245
Dental Floss 5	147.63632	137.76910	28.95566
Dental Floss 6	110.40456	124.61018	3.40535

Table 5-1. Dental Floss Measurement Results (Continued)

Bracket Number	Mean Value 1 (Left Toothpaste)	Mean Value 2 (Right Toothpaste)	Mean Value 3 (Wire)
Dental Floss 7	182.45360	178.04030	60.25054
Dental Floss 8	32.93908	165.94063	3.39985
Dental Floss 9	151.82718	136.74701	30.63069

Saving the Dental Floss Script

Now that you have written an algorithm and tested it on another image, you can save the script to use on similar images. You also can perform batch processing with this script.

1. Select **File»Save Script As**.
2. Save the script as `Dental Floss.scr`.

Analyzing the Results

Batch processing involves running a script on a collection of images. You can use batch processing to analyze multiple images and save the resulting analysis information in a tab-delimited text file. Complete the following steps to run `Dental Floss.scr` on all the images in the Image Browser.

1. Select **Tools»Batch Processing**.
2. Select the Image Source **Browser** to process all images in the Image Browser.
3. Select **Measure Area Intensity** from the Script Steps list. Measure Area Intensity is the step that returns information about the dental floss holders.
4. Select the **Save Results** Analysis Mode. This enables the Save Options control.
5. Click **Setup**. A dialog box opens.
6. Select **One file for all results** to log the results for every image to the same file.
7. Click the **Folder Path** button. Navigate to the directory in which you want to save the results file, and click **Current Folder**.

8. Enter `dental_floss_results.txt` in the **File Prefix** control. Because you are logging all the results to one file, the **File Prefix** is the name of the results file. If you were logging the results for each image to a separate file, **File Prefix** would be the prefix associated with each results file.
9. Click **OK**.
10. Click **Run** to run the script on all the images in the Image Browser and log the results.
11. Click **OK** to close the Batch Processing finished notification.

12. Navigate to the directory path specified in step 7, and open `dental_floss_results.txt`.
13. Compare the **Mean Value** measurements in the results file to the values in Table 5-1.

Refer to the *NI Vision Assistant Help* for more information about the Vision Assistant batch processing functionality.

A

Technical Support and Professional Services

Visit the following sections of the award-winning National Instruments Web site at `ni.com` for technical support and professional services:

- **Support**—Technical support at `ni.com/support` includes the following resources::
  - **Self-Help Technical Resources**—For answers and solutions, visit `ni.com/support` for software drivers and updates, a searchable KnowledgeBase, product manuals, step-by-step troubleshooting wizards, thousands of example programs, tutorials, application notes, instrument drivers, and so on. Registered users also receive access to the NI Discussion Forums at `ni.com/forums`. NI Applications Engineers make sure every question submitted online receives an answer.
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You also can visit the Worldwide Offices section of `ni.com/niglobal` to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

Glossary

A

area	A rectangular portion of an acquisition window or frame that is controlled and defined by software.

B

binary image	An image in which the objects usually have a pixel intensity of 1 (or 255) and the background has a pixel intensity of 0.

C

caliper	(1) A function in Vision Assistant that calculates distances, angles, circular fits, and the center of mass based on positions given by edge detection, particle analysis, centroid, and search functions; (2) A measurement function that finds edge pairs along a specified path in the image. This function performs an edge extraction and then finds edge pairs based on specified criteria such as the distance between the leading and trailing edges, edge contrasts, and so forth.
chroma	The color information in a video signal.
contrast	A constant multiplication factor applied to the luma and chroma components of a color pixel in the color decoding process.
coordinate system	A reference location (origin) and angle in an image that regions of interest can relate to when positional and angular adjustments of the region of interest are necessary. A coordinate system is depicted by two lines representing the orientation and direction of its two axes.

D

definition	The number of values a pixel can take on, which is the number of colors or shades that you can see in the image.
digital image	An image $f(x, y)$ that has been converted into a discrete number of pixels. Both spatial coordinates and brightness are specified.
driver	Software that controls a specific hardware device, such as an NI Vision or DAQ device.

E

edge	Defined by a sharp change (transition) in the pixel intensities in an image or along an array of pixels.
edge detection	Any of several techniques to identify the edges of objects in an image.

F

function	A set of software instructions executed by a single line of code that may have input and/or output parameters and returns a value when executed.

G

gauging	Measurement of an object or distances between objects.
grayscale image	An image with monochrome information.

H

histogram	Indicates the quantitative distribution of the pixels of an image per gray-level value.

I

image	A two-dimensional light intensity function $f(x, y)$ where x and y denote spatial coordinates and the value f at any point (x, y) is proportional to the brightness at that point.
Image Browser	An image that contains thumbnails of images to analyze or process in a vision application.
image file	A file containing pixel data and additional information about the image.
image processing	Encompasses various processes and analysis functions that you can apply to an image.
image source	Original input image.

imaging	Any process of acquiring and displaying images and analyzing image data.
inspection	The process by which parts are tested for simple defects such as missing parts or cracks on part surfaces.
intensity	The sum of the Red, Green, and Blue primary colors divided by three: (*Red* + *Green* + *Blue*)/3.

K

kernel	Structure that represents a pixel and its relationship to its neighbors. The relationship is specified by weighted coefficients of each neighbor.

L

LabVIEW	Laboratory Virtual Instrument Engineering Workbench—Program development environment based on the G programming language. LabVIEW is used commonly for test and measurement applications.
line profile	Represents the gray-level distribution along a line of pixels in an image.
luma	The brightness information in the video picture. The luma signal amplitude varies in proportion to the brightness of the video signal and corresponds exactly to the monochrome picture.
luminance	*See* luma.

M

machine vision	An automated application that performs a set of visual inspection tasks.

N

neighbor	A pixel whose value affects the value of a nearby pixel when an image is processed. The neighbors of a pixel are usually defined by a kernel or a structuring element.

NI-IMAQ	The driver software for National Instruments image acquisition devices.
NI-IMAQdx	The National Instruments driver software for IEEE 1394 and GigE Vision cameras.

P

palette	The gradation of colors used to display an image on screen, usually defined by a color lookup table.
particle	A connected region or grouping of pixels in an image in which all pixels have the same intensity level.
particle analysis	A series of processing operations and analysis functions that produce some information about the particles in an image.
pattern matching	The technique used to locate quickly a grayscale template within a grayscale image.
picture element	An element of a digital image. Also called pixel.
pixel	Picture element—The smallest division that makes up the video scan line. For display on a computer monitor, a pixel's optimum dimension is square (aspect ratio of 1:1, or the width equal to the height).
PNG	Portable Network Graphic—Image file format for storing 8-bit, 16-bit, and color images with lossless compression (extension PNG).

Q

quantitative analysis	Obtaining various measurements of objects in an image.

R

resolution	The number of rows and columns of pixels. An image composed of m rows and n columns has a resolution of $m \times n$.

ROI	Region of interest—(1) An area of the image that is graphically selected from a window displaying the image. This area can be used to focus further processing; (2) A hardware-programmable rectangular portion of the acquisition window.
rotation-invariant matching	A pattern matching technique in which the reference pattern can be located at any orientation in the test image as well as rotated at any degree.

S

shift-invariant matching	A pattern matching technique in which the reference pattern can be located anywhere in the test image but cannot be rotated or scaled.

T

template	Color, shape, or pattern that you are trying to match in an image using the color matching, shape matching, or pattern matching functions. A template can be a region selected from an image, or it can be an entire image.
threshold	Separates objects from the background by assigning all pixels with intensities within a specified range to the object and the rest of the pixels to the background. In the resulting binary image, objects are represented with a pixel intensity of 255 and the background is set to 0.
Tools palette	Collection of tools that enable you to select regions of interest, zoom in and out, and change the image palette.

V

value	The grayscale intensity of a color pixel computed as the average of the maximum and minimum red, green, and blue values of that pixel.
VI	Virtual Instrument—(1) A combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument; (2) A LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program.

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