IMAQ™

IMAQ Vision Builder Tutorial

Worldwide Technical Support and Product Information

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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 **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** 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 on 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. This font 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, and code excerpts.

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1

System Requirements and Installation

This chapter lists system requirements and installation instructions and introduces the IMAQ Vision Builder environment.

System Requirements

To run IMAQ Vision Builder, you must have the following minimum system requirements:

- Personal computer using at least a 133 MHz Pentium or higher microprocessor (233 MHz Pentium MMX or higher microprocessor recommended)

- Microsoft Windows 2000/NT/Me/9x. If you are using Windows NT 4.0, you must have Service Pack 3 or higher installed on your computer to run IMAQ Vision Builder.

- 800 × 600 resolution (or higher) video adapter, 65,536 colors (16-bit) or higher

- National Instruments image acquisition (IMAQ) hardware and NI-IMAQ 2.5 or higher for Windows 2000/NT/Me/9x (if you are acquiring images)

- Minimum of 32 MB RAM (64 MB recommended)

- Minimum of 40 MB of free hard disk space

Note You need Microsoft Excel 97 or higher installed on your computer to complete a few steps in the second tutorial.

Installing IMAQ Vision Builder

✏️ **Note**   To install IMAQ Vision Builder on a Windows NT or Windows 2000 system, you must be logged in with Administrator privileges.

1. Insert the IMAQ Vision Builder CD into your CD-ROM drive.

    If the CD startup screen does not appear, use Windows Explorer to run the SETUP.EXE program in the \Setup directory on the CD.

2. Follow the setup instructions you see on your screen.

By default, the IMAQ Vision Builder installation program creates a new folder, \Program Files\National Instruments\IMAQ Vision Builder 6, that contains the following items:

*   program folder—IMAQ Vision Builder.exe, the online help file, function libraries, and other related program files
*   readme.txt—Late-breaking information about IMAQ Vision Builder
*   examples folder—Images and scripts that you need to complete the example tutorials in this manual
*   manuals folder—Portable Document Format (PDF) versions of the *IMAQ Vision Concepts Manual*, *IMAQ Vision Builder Release Notes,* and this manual. You must have Adobe Acrobat Reader installed to access these documents.
*   solutions folder—Example images and scripts

Launching and Exiting IMAQ Vision Builder

To launch IMAQ Vision Builder in Windows, point to **Start»Programs»National Instruments IMAQ Vision Builder 6**.

To quit IMAQ Vision Builder, follow these steps:

1. Close any open parameter windows.
2. Save your script and images if you want to keep them.
3. Select **File»Exit**.

IMAQ Vision Builder Environment

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

The algorithm is recorded in a Builder file. Builder files are ASCII text files that list the processing functions and relevant parameters for an algorithm that you prototype in IMAQ Vision Builder. Using the LabVIEW VI creation wizard, you can create a LabVIEW VI that performs the prototype that you created in IMAQ Vision Builder.

Note You must have LabVIEW 6.0 or higher and IMAQ Vision 6 for LabVIEW or higher installed on your machine to use this feature.

For more information on LabVIEW VI creation, see *Creating a LabVIEW VI* in Chapter 3, *Using Blob Analysis to Analyze the Structure of a Metal*.

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

Features

IMAQ Vision Builder 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 image collections (batch processing). You can modify and save scripts. See Figure 2-4, *Thresholded Image*, to view a script in the Script window.

- Image Browser—Contains all of the images currently loaded in IMAQ Vision Builder. Through the Image Browser, you can select an image to process by double-clicking on it. See Figure 2-1, *Image Browser*, to view images loaded into the Image Browser.

- Acquisition window—Displays the Interfaces window (IMAQ image acquisition boards and channels available) and the property pages for the IMAQ image acquisition board. See Figure 2-5, *Acquiring Images in IMAQ Vision Builder*, to view all the elements of the Acquisition window.

- Processing window—Updates the image as you change parameters. Because this view immediately reflects the changes you have made in the parameters window, you can continue modifying parameters until you get the desired result. See Figure 2-2, *Processing an Image*, to view an image loaded into the Processing window.

- Parameter window—Displays parameters that you can set for an image processing function. Each IMAQ Vision function available through the menus has a parameter window in which you set the parameters for that function. See Figure 2-3, *Thresholding an Image*, to view an example of the threshold Parameter window.

- Reference window—Displays the original version of the image (image source) as you manipulate it in the processing window. See Figure 2-2, *Processing an Image*, to view an image in the Reference window.

- Tools palette—Displays a collection of tools for selecting regions of interest (ROIs), zooming in and out, and changing the Image palette. See Figure 2-4, *Thresholded Image*, to view the Tools palette.

- Solution Wizard—Displays a list of industries and corresponding quality-assurance tasks that those industries perform. Based on the task the user selects, the wizard loads an IMAQ Vision-based solution to the task.

- Performance Meter—Estimates how long your script will take to complete in IMAQ Vision on a given image.

- LabVIEW VI Creation—Creates the LabVIEW and IMAQ Vision VI corresponding to the algorithm you prototype in IMAQ Vision Builder. 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.

Image Analysis Functions

IMAQ Vision Builder offers several image analysis functions, including the following:

- Histogram—Counts the total number of pixels in each grayscale value and graphs the result

- Line Profile—Returns the grayscale values of the pixels along a line that you draw with the **Line Tool** from the Tools palette and graphs the result

- 3D View—Displays an image using an isometric view. Each pixel from the image source is represented as a column of pixels in the 3D view. The pixel value corresponds to the altitude.

Color Image Processing Functions

IMAQ Vision Builder includes a comprehensive set of functions for processing and analyzing color images, including the following:

- Color Operators—Applies an arithmetic operation between two images or between an image and a constant

- Color Plane Extraction—Extracts the Red, Green, or Blue plane or the Hue, Saturation, or Luminance plane of a color image

- Color Threshold—Applies a threshold to the three planes of an RGB or HSL image

- Color Location—Locates colors in an image

- Color Matching—Compares the color content of one or multiple regions in an image to a reference color set

- Color Pattern Matching—Searches for a color template in an image

Grayscale Image Processing and Analysis Functions

IMAQ Vision Builder also includes functions for grayscale image processing and analysis:

- Filtering—Functions for smoothing, edge detection, and convolution

- Lookup Tables—Applies predefined lookup table transformations to the image to modify the dynamic intensity of regions in the image with poor contrast

- Operators—Performs basic arithmetic and logical operations on images

- Grayscale Morphology—Modifies the shape of objects in grayscale images using erosion, dilation, opening, and closing functions

- Threshold—Isolates pixels that interest you and sets the remaining pixels as background pixels

- Quantify—Measures the intensity statistics of one or multiple regions in an image

- Centroid—Computes the energy center of a grayscale image or area of interest

Binary Processing and Analysis Functions

IMAQ Vision Builder contains functions for binary processing and analysis:

- Binary Morphology—Performs morphology transformations that modify the shape of objects in binary images
- Invert Binary Image—Reverses the dynamic of an image that contains two different grayscale populations
- Particle Filtering—Filters objects based on shape measurements
- Particle Analysis—Computes more than 40 measurements on objects in an image, including the area and perimeter of the objects
- Circle Detection—Separates overlapping circular objects and classifies them according to their radii

Machine Vision Functions

IMAQ Vision Builder features several machine vision functions, such as the following:

- Edge Detection—Finds edges along a line that you draw with the **Line Tool** from the Tools palette
- Find Straight Edge—Finds points within the edge of an object and then finds a line describing the edge
- Find Circular Edge—Locates the intersection points between a set of search lines within a circular area (annulus), and then finds the best fit circle
- Clamp—Finds edges within a rectangular ROI drawn in the image and measures the distance between the first and last edge
- Pattern Matching—Locates regions of a grayscale image that match a predetermined template. Pattern Matching can find template matches regardless of poor lighting, blur, noise, shifting of the template, and rotation of the template
- Caliper—Computes measurements—such as distances, areas, and angles—based on results returned from other machine vision and image processing functions

Calibration Functions

IMAQ Vision Builder features several calibration functions, including the following:

- Simple Calibration—Sets a simple calibration for an image. This function sets the horizontal and vertical scaling factor, as well as the origin and orientation of the coordinate system for the image.

- Grid Calibration—Learns a calibration based on the image of a grid template acquired with the imaging setup you are calibrating

- Calibration from Image—Applies the calibration information saved in an image file to the current image

- Image Correction—Transforms a distorted image acquired in a calibrated setup into an image where perspective errors and lens distortion are corrected

Getting Help

As you work with IMAQ Vision Builder, you may need to consult other sources if you have questions. The following sources can provide you with more specific information about IMAQ Vision, IMAQ hardware, and imaging.

IMAQ Vision Builder Online Help

IMAQ Vision Builder offers tooltips and online help that you can access in the following ways:

- Access the IMAQ Vision Builder online help by selecting **Online Help** from the **Help** menu. There you can find information not available in this manual, such as function descriptions and directions for performing image processing functions.

- Move the cursor over a button to see tooltips on buttons in the Processing toolbar, Tools palette, Script window, Reference window, Acquisition window, or Image Browser.

- Click the **Help** button in any function parameter window to get information about that function and its parameters.

IMAQ Vision Documentation

If you have purchased IMAQ Vision software from National Instruments, you also have one of the following sets of documentation, depending on the development environment you use.

- IMAQ Vision for LabVIEW

    – *IMAQ Vision for LabVIEW User Manual*—Contains information about how to build a Vision application using IMAQ Vision for LabVIEW.

    – IMAQ Vision for LabVIEW online help (from inside the LabVIEW environment: **Help»IMAQ Vision**)—Contains reference information about IMAQ Vision VIs.

- IMAQ Vision for Measurement Studio

    – *IMAQ Vision for Measurement Studio User Manual: LabWindows/CVI*—Contains information about how to build a vision application using IMAQ Vision for LabWindows/CVI.

    – IMAQ Vision for LabWindows/CVI online help—Contains reference information about IMAQ Vision for LabWindows/CVI.

    – *IMAQ Vision for Measurement Studio User Manual: Visual Basic*—Contains information about how to build a Vision application using the tools for Visual Basic that come with IMAQ Vision for Measurement Studio.

    – IMAQ Vision for Visual Basic online help—Contains reference information about the tools for Visual Basic that come with IMAQ Vision for Measurement Studio.

For detailed information about the concepts and algorithms used by IMAQ Vision Builder, launch the *IMAQ Vision Concepts Manual* from the **Start** menu (**Start»Programs»National Instruments»IMAQ Vision Builder 6»IMAQ Vision Concepts Manual**).

National Instruments Web Site

The National Instruments Web site provides information about IMAQ hardware and software. Visit the site at `ni.com/imaq`.

From the IMAQ site, you can locate information about new IMAQ Vision features, machine vision problems and solutions, using MMX technology on machine vision applications, and selecting the appropriate IMAQ hardware, cameras, lenses, and lighting equipment for your application.

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

IMAQ Vision Builder Scripts

You installed several example scripts when you installed IMAQ Vision Builder. You can run these scripts to learn more about IMAQ Vision Builder scripting capabilities. You also can customize these scripts for your own applications. By default, the scripts are installed at `\Program Files\National Instruments\IMAQ Vision Builder 6\Examples` and at `\Program Files\National Instruments\IMAQ Vision Builder 6\Solutions`.

2

Introduction to Image Processing with IMAQ Vision Builder

This chapter describes how you can use IMAQ Vision Builder to create and test your own image processing algorithms. It explains how to get started in IMAQ Vision Builder. For detailed information about digital images, see Chapter 1, *Digital Images*, in the *IMAQ Vision Concepts Manual*.

Getting Started in IMAQ Vision Builder

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 IMAQ Vision Builder works and what you can accomplish with IMAQ Vision Builder is by using it.

In this short example, you load images into IMAQ Vision Builder and perform one image processing function—a *threshold*. Thresholding isolates objects so that you can keep those that interest you and remove 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.

Follow these steps to get started in IMAQ Vision Builder:

1. Launch IMAQ Vision Builder from the **Start** menu (**Start»Programs»National Instruments IMAQ Vision Builder 6**).

2. To load images, select the **Open Image** button from the Welcome Screen.

3. Navigate to `Program Files\National Instruments\IMAQ Vision Builder 6\Examples\Metal` and check the **Select All Files** option. IMAQ Vision Builder previews the images in the Preview Image window and displays information about the file type and image depth.

4. Click **OK**.

IMAQ Vision Builder loads those image files 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.
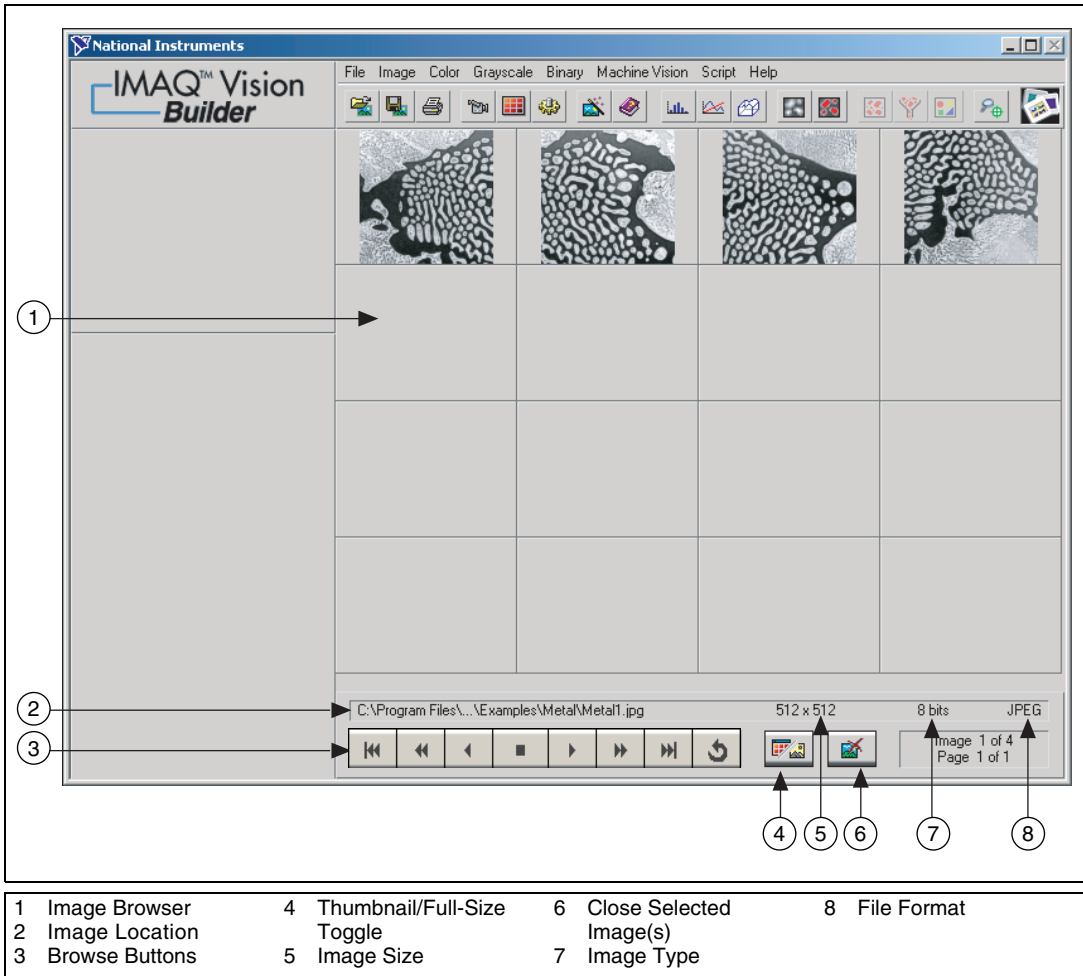

1	Image Browser	4	Thumbnail/Full-Size	6	Close Selected	8	File Format
2	Image Location		Toggle		Image(s)		
3	Browse Buttons	5	Image Size	7	Image Type		

Figure 2-1. Image Browser

You can view new 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.

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

6. To enter processing mode, double-click the image `Metal1.jpg`. IMAQ Vision Builder loads the image into the processing window, as shown in Figure 2-2.
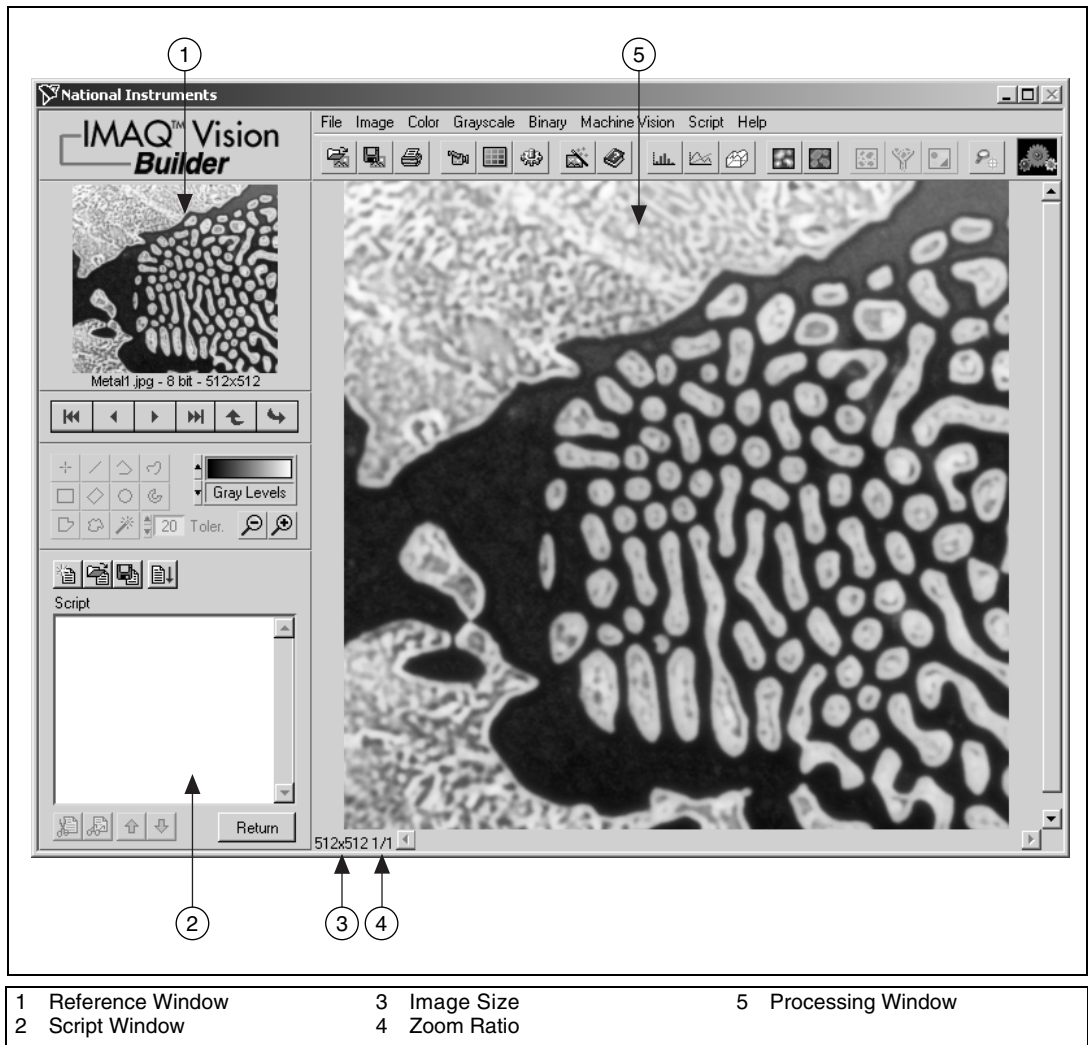

| 1 | Reference Window | 3 | Image Size | 5 | Processing Window |
| 2 | Script Window | 4 | Zoom Ratio | | |

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.

7. Select **Grayscale»Threshold**. The Threshold parameter window appears in the lower right corner of the IMAQ Vision Builder window, as shown in Figure 2-3.

| 1 | Tools Palette | 2 | Threshold Parameter Window |
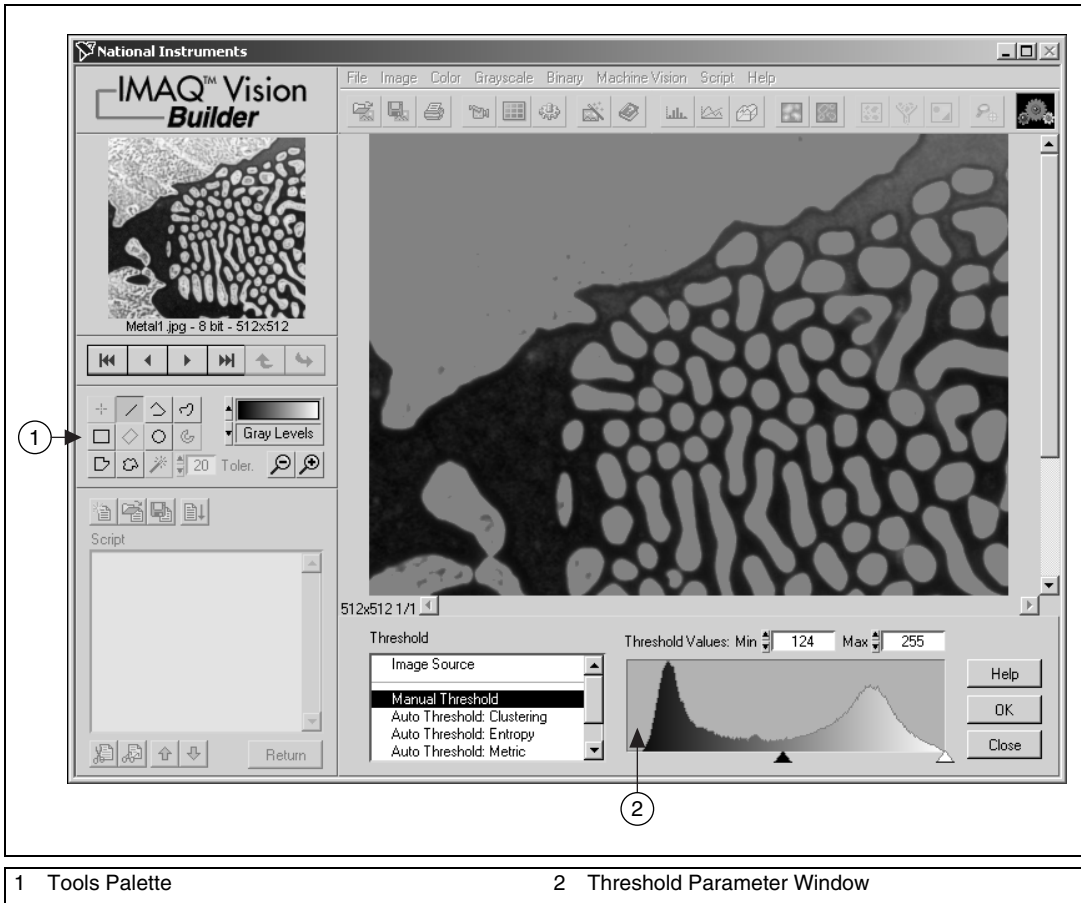
Figure 2-3. Thresholding an Image

The Threshold parameter window displays a histogram. A histogram counts the total number of pixels at each grayscale value and graphs it. From the graph, you can tell whether the image contains distinct regions of a certain grayscale value, and you can select pixel regions of the image. For example, if the background of an image is black and you want to remove it, you can select a range with values close to 255 (white).

The Processing window displays a preview of the threshold operation 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.

8. From the Threshold parameter window, specify settings that work best for your application. To threshold this image, set the **Min** value to 130 and **Max** value to 255 to select all of the objects.

Tip   You may need to manipulate the parameters several times to find the values that work best. Rather than entering numbers in the **Min** and **Max** fields, you can select the range using the pointers on the histogram. Adjust the pointers until all of the objects you want to select are red. The black pointer marks the minimum value, and the white pointer marks the maximum value.

9. 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.
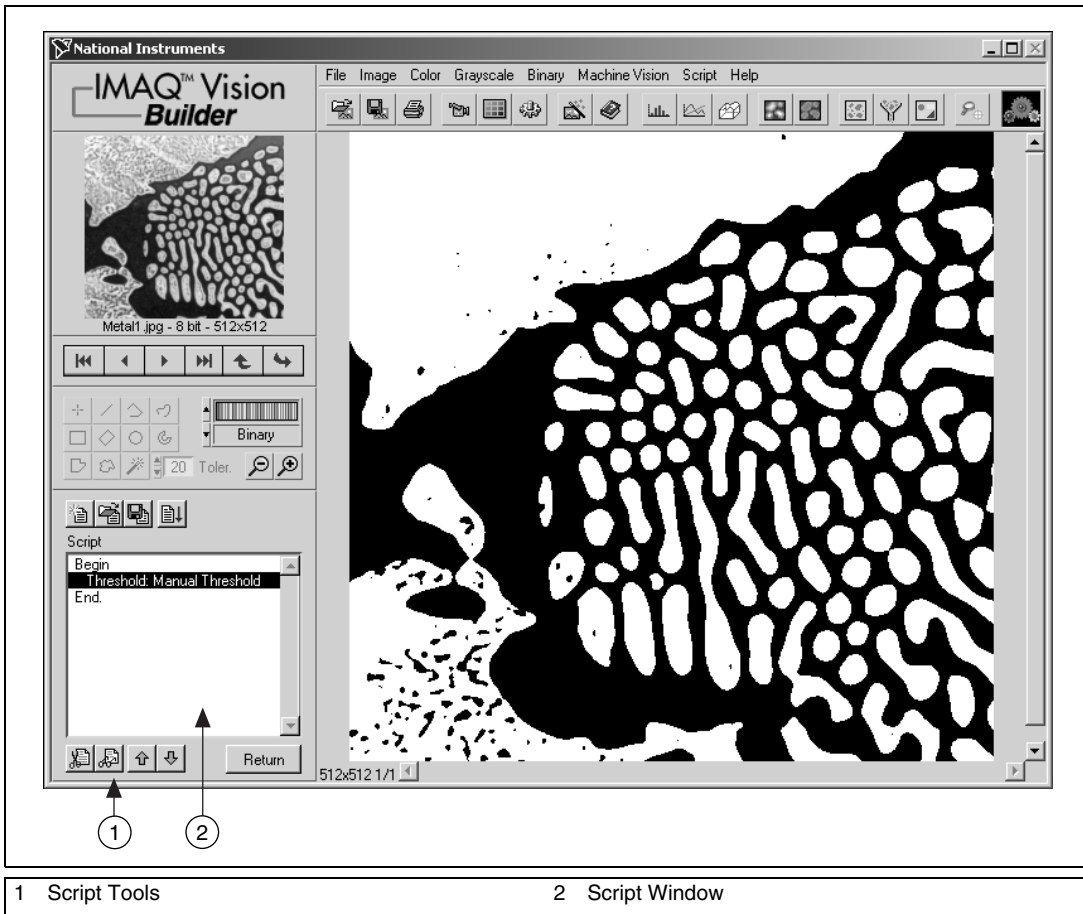

| 1 | Script Tools | 2 | Script Window |

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 need to run the same operation on other images, you can save the script and use it again.

10. Select **Script»Save Script** and name the script `threshold.scr`.

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

    a. Load the image.

    b. Select **Script»Open Script** to open `threshold.scr`.

    c. Click the **Run Script** 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 **Help** button in the parameter window.

11. Select **File»Exit** to close IMAQ Vision Builder.

Acquiring Images in IMAQ Vision Builder

IMAQ Vision Builder 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 sequence, which is useful, for example, when you need to focus your camera. A *sequence* acquires images according to settings that you specify and sends the images to the Image Browser.

If you have National Instruments IMAQ image acquisition boards and NI-IMAQ 2.5 or later installed on your computer, you can acquire live images in IMAQ Vision Builder. For more information on setting up your boards and channels in Measurement & Automation Explorer (MAX), see the MAX online help.

If you do *not* have IMAQ image acquisition boards and NI-IMAQ 2.5 or later installed on your computer, IMAQ Vision Builder automatically simulates the acquisition process by displaying a sequence of images. 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

If IMAQ Vision Builder is not loaded, launch the application from the **Start** menu (**Start»Programs»National Instruments IMAQ Vision Builder 6**). Click the **Acquire Image** button from the Welcome Screen to view the Acquisition window, as shown in Figure 2-5.

If you already have IMAQ Vision Builder running, click the **Acquire Image** button in the toolbar. IMAQ Vision Builder displays the Acquisition window, as shown in Figure 2-5.

The acquisition plug-in list shows the different modules that you can use to acquire images:

• Simulation module

• Image acquisition board

The Interfaces window displays all IMAQ image acquisition boards and channels available for your computer. Figure 2-5 shows that two IMAQ hardware boards are available—the IMAQ PCI-1408 and the IMAQ PCI-1424.

 Note The hardware boards listed in your Interfaces window will vary according to the boards plugged into your computer.

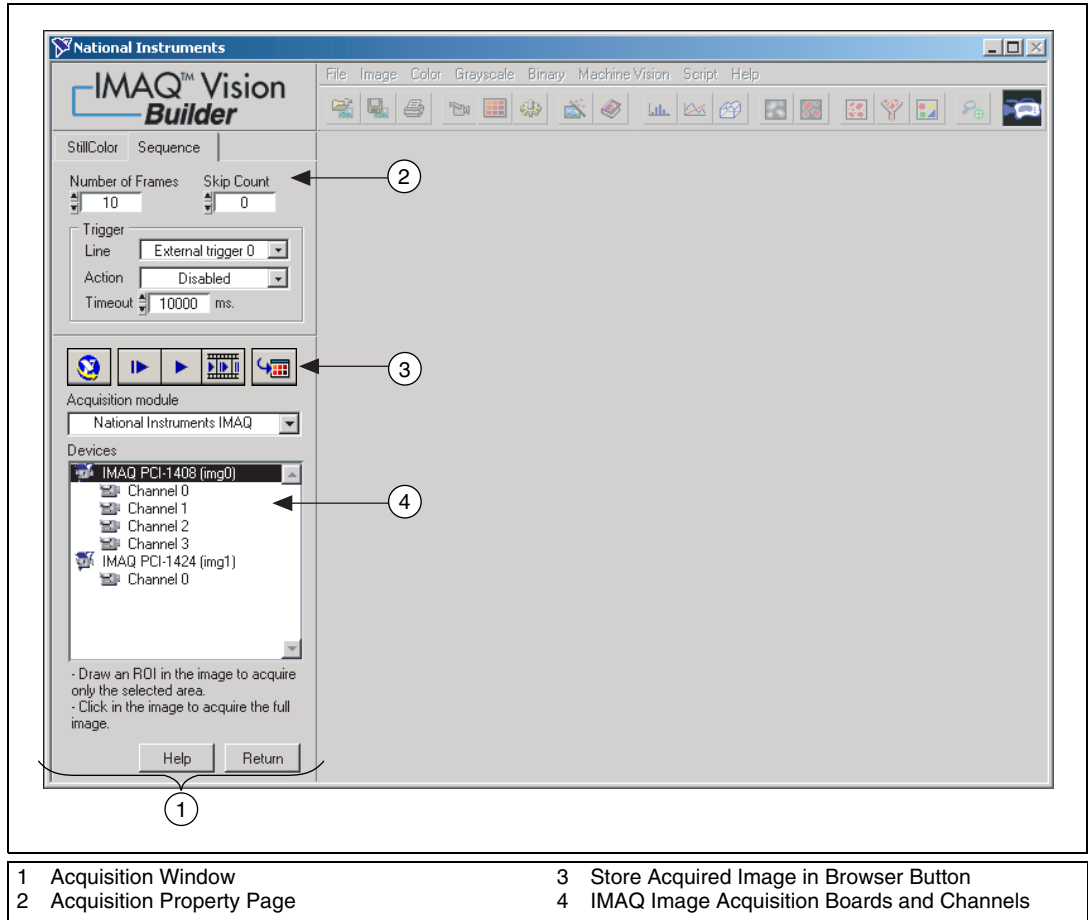| 1	Acquisition Window	3	Store Acquired Image in Browser Button
2	Acquisition Property Page	4	IMAQ Image Acquisition Boards and Channels

Figure 2-5. Acquiring Images in IMAQ Vision Builder

The property pages above the Interfaces window list properties available for the selected board. In Figure 2-5, the IMAQ PCI-1408 is selected. Because the PCI-1408 can acquire a sequence of images, you can set the following properties for a Sequence acquisition. For information about the properties of other IMAQ boards, see your hardware manual and the MAX online help.

•   **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
    - **Disabled**—Disables triggering
    - **Trigger start of acquisition**
    - **Trigger each image**
- **Timeout**—Time, in milliseconds, within which the trigger must occur

Note   A *trigger* is any signal that causes or starts some form of data capture.

To set any other property of your image acquisition board or your camera, select the board or channel in the list, then click the MAX button to display the corresponding MAX property window.

See the MAX online help for more information on the MAX property windows.

Note   Your computer must have a National Instruments IMAQ image acquisition board and NI-IMAQ 2.5 or higher installed before you can acquire live images in IMAQ Vision Builder.

Snapping an Image (Single Acquisition)

1. Make sure the Acquisition window is open.

2. Click the **Acquire Single Image** button to acquire a single image with the IMAQ board and display it. This operation is also known as a *snap*.

Note   If your computer does *not* have an IMAQ board, IMAQ Vision Builder simulates the live acquisition process. You can interact with the simulation module as you would with a live acquisition.

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

4. Click **Return** to return to the Image Browser.

5. Process the image as you would any other image in IMAQ Vision Builder. See Chapter 3, *Using Blob Analysis to Analyze the Structure of a Metal*, and Chapter 4, *Using Gauging for Part Inspection* for examples of processing images in IMAQ Vision Builder.

Grabbing an Image (Continuous Acquisition)

1. Make sure the Acquisition window is open.

2. Click the **Acquire Continuous Images** button to acquire and display images in continuous mode at the maximum rate. This operation is also known as a *grab*.

3. 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 within the full-sized image. Draw a region of interest in your image while grabbing it, and the image reduces to that area. You can refine the acquired area again by selecting another region of interest or return to the full-sized image by clicking on the image.

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

5. Click **Return** to return to the Image Browser.

6. Process the image as you would any other image in IMAQ Vision Builder. See Chapter 3, *Using Blob Analysis to Analyze the Structure of a Metal*, and Chapter 4, *Using Gauging for Part Inspection*, for examples of processing images in IMAQ Vision Builder.

Acquiring a Sequence of Images

1. Make sure the Acquisition window is open.

2. Set the properties for the Sequence property page.

3. Click the **Sequence Acquisition** button to acquire a sequence of live images. A panel describing the status of the Sequence acquisition appears.

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

    Images acquired are automatically sent to the Image Browser.

Note   If your computer does *not* have an IMAQ board, IMAQ Vision Builder simulates the live acquisition process. You can interact with the simulation module as you would with a live acquisition.

4. Click **Return** to return to the Image Browser.

5. Process the image as you would any other image in IMAQ Vision Builder. See Chapter 3, *Using Blob Analysis to Analyze the Structure of a Metal*, and Chapter 4, *Using Gauging for Part Inspection*, for examples of processing images in IMAQ Vision Builder.

3

Using Blob Analysis to Analyze the Structure of a Metal

This chapter describes blob analysis and provides step-by-step directions for prototyping a blob analysis application in IMAQ Vision Builder.

What Is Blob Analysis?

Blob analysis consists of a series of processing operations and analysis functions to produce some information about the blobs in an image. A blob (*b*inary *l*arge *ob*ject) is defined as a connected region or grouping of pixels in an image in which all pixels have the same intensity level. In a binary image, the background pixels are zero, and every non-zero pixel is part of a binary object.

You perform a blob analysis to find statistical information—such as the size of the blobs or the number, location, and presence of blob regions. 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

In this tutorial, you find the area of circular particles in a metal. As you perform this analysis, IMAQ Vision Builder records all of the processing operations and parameters in a script. You will run that script on other images to test your blob analysis algorithm.

To find the total area of circular particles, you will 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 pixels that interest you (the 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 blobs and remove non-circular blobs.

- Perform a particle analysis to find the total area occupied by circular blobs.

Loading Images into IMAQ Vision Builder

1. If IMAQ Vision Builder is not loaded, launch the application from the **Start** menu (**Start»Programs»National Instruments IMAQ Vision Builder 6**). Click the **Open Image** button from the Welcome Screen.

    If you already have IMAQ Vision Builder running, press the **Open Image** button in the toolbar.

2. Navigate to Program Files\National Instruments\IMAQ Vision Builder 6\Examples\Metal and check the **Select All Files** option. IMAQ Vision Builder previews the images in the **Preview Image** window and displays information about the file format, size, and pixel depth.

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.

3. Click **OK**.

    IMAQ Vision Builder loads the image files, which represent microscopic views of pieces of metal, into the Image Browser. From this collection of images in the Image Browser, you can select the image that you want to process.

4. Double-click the first image, Metal1.jpg. The image is loaded into the processing window.

Preparing an Image for Blob Analysis

Before you can separate circular particles from non-circular particles, you need to prepare the image. To isolate particles of interest, verify that individual particles are distinct from other particles (that is, there is a gap between particles) and that the borders of those particles are distinct.

Examining the Image

Examine the image in the processing window. The image is slightly blurred. Also, the edges of particles are not distinct. Although you can see these problems from just looking at this image, you may need to use a *line profile* in other cases. A line profile returns the grayscale values along a line that you draw with the **Line Tool** from the Tools palette. Follow these steps to examine edges using a line profile:

1. Select **Image»Line Profile**. The parameter window appears and the **Line Tool** from the Tools palette is automatically selected and active.

2. 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.

| 1 | Edges of Particles | 3 | Segment Drawn with Line Tool |
| 2 | Fluctuation in Pixel Values | | |
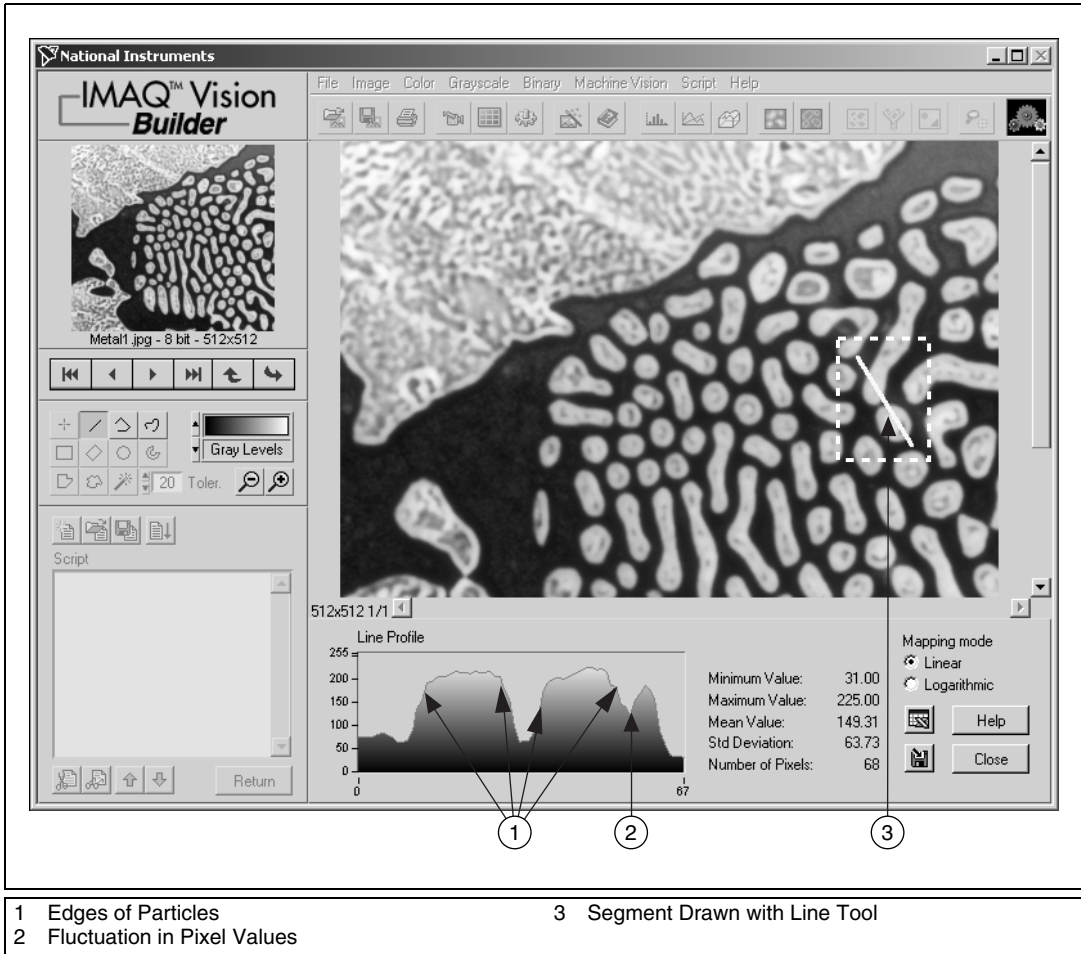
Figure 3-1. Using a Line Profile to Examine Edges

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

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

3.   Click **Close**.

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, follow these steps:

1.   Select **Grayscale»Filters**.

2.   Select **Convolution-Highlight Details** from the Filters list. This function looks for 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, see Chapter 5, *Image Processing*, in the *IMAQ Vision Concepts Manual*.

3.   Click **Apply** to add this step to the script.

4.   Click **Close**.

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.   Select **Image»Line Profile**.

2.   Click and drag to draw a short segment across a particle to examine the line profile of a particle and its border, as shown in Figure 3-2. The line profile indicates more defined edges.

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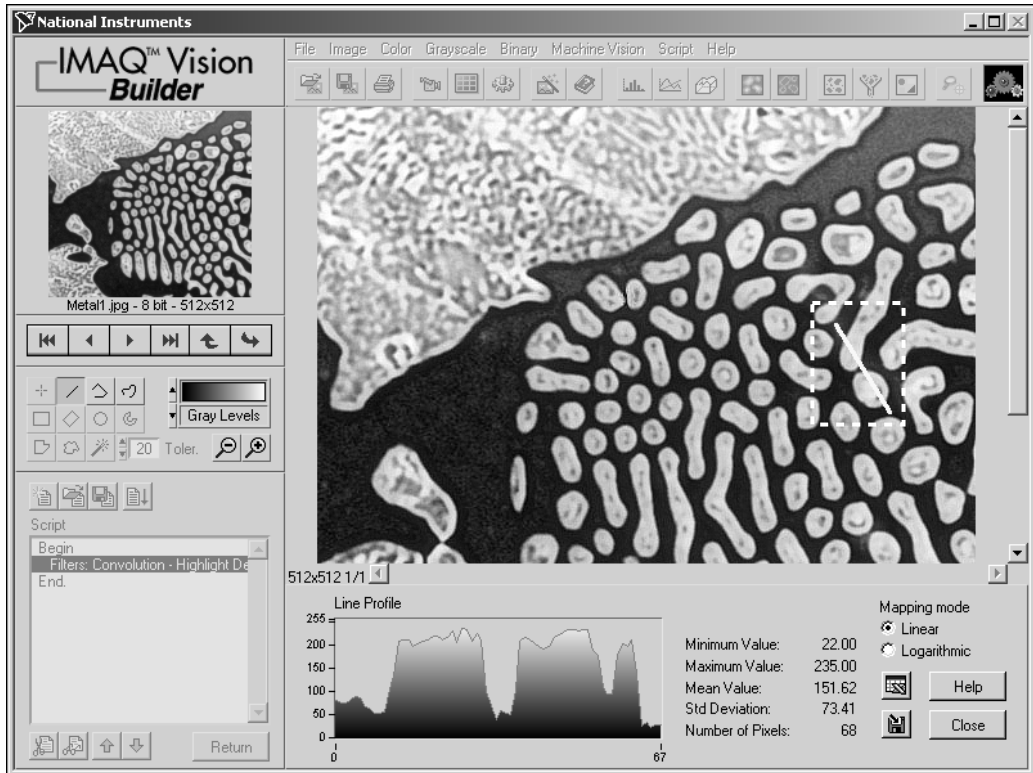
Figure 3-2. Using a Line Profile to Examine Particle Edges

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.

The Threshold parameter 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 whether the image contains distinct regions of a certain grayscale value, and you can select pixel regions of the image.

Follow these steps to select a range of brighter pixels to analyze:

1. Select **Grayscale»Threshold**.

2. Select **Manual Threshold** from the Threshold list.

3. Select a range of **130** to **255**.

    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**   You can adjust the pointers until all of the particles of interest are red. The black pointer marks the minimum value, and the white pointer marks the maximum value.

4. 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 blobs or particles.
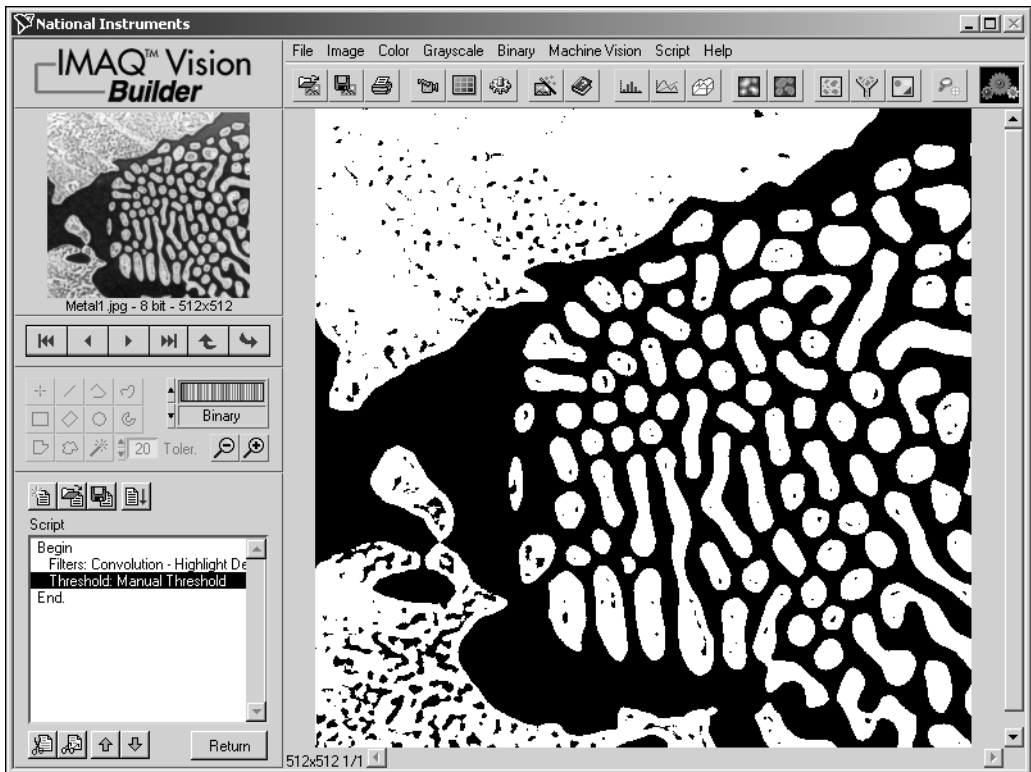
Figure 3-3. Separating Particles from the Background with Thresholding

Modifying Blobs with Morphological Functions

Morphological functions affect the shape of blobs. Each blob or region in the binary image is affected on an individual basis. Morphological operations prepare blobs 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. Select **Binary»Adv. Morphology**.

2. Select **Fill holes** from the Morphology-Advanced function list.

3. Click **Apply** to add this step to the script.

4. Select **Remove border objects** to remove any objects that touch the border of the image, as shown in Figure 3-4.

5. Click **Apply** and **Close** to add this step to the script and close the Advanced Morphology window.
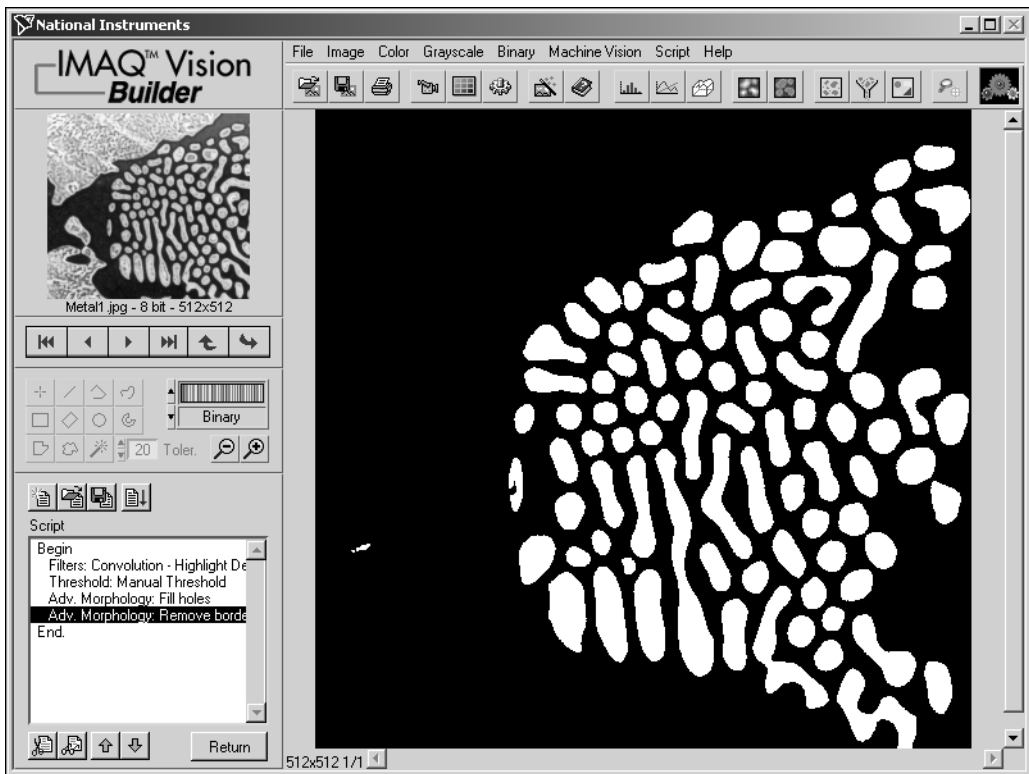
Figure 3-4. Modifying Blobs with Morphological Functions

Isolating Circular Blobs

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

1. Select **Binary»Particle Filter**.

2. Select **Heywood circularity factor** from the list of particle filters. This function calculates the ratio of the perimeter of the blob to the perimeter of the circle with the same area. The more circular the blob, the closer the ratio to 1.

3. To find more circular and less oblong blobs, enter a minimum value of **0** and a maximum value of **1.06** for the parameter range.

4. Select the **Keep Objects** option to keep circular blobs (and remove blobs that do not fit in this range).

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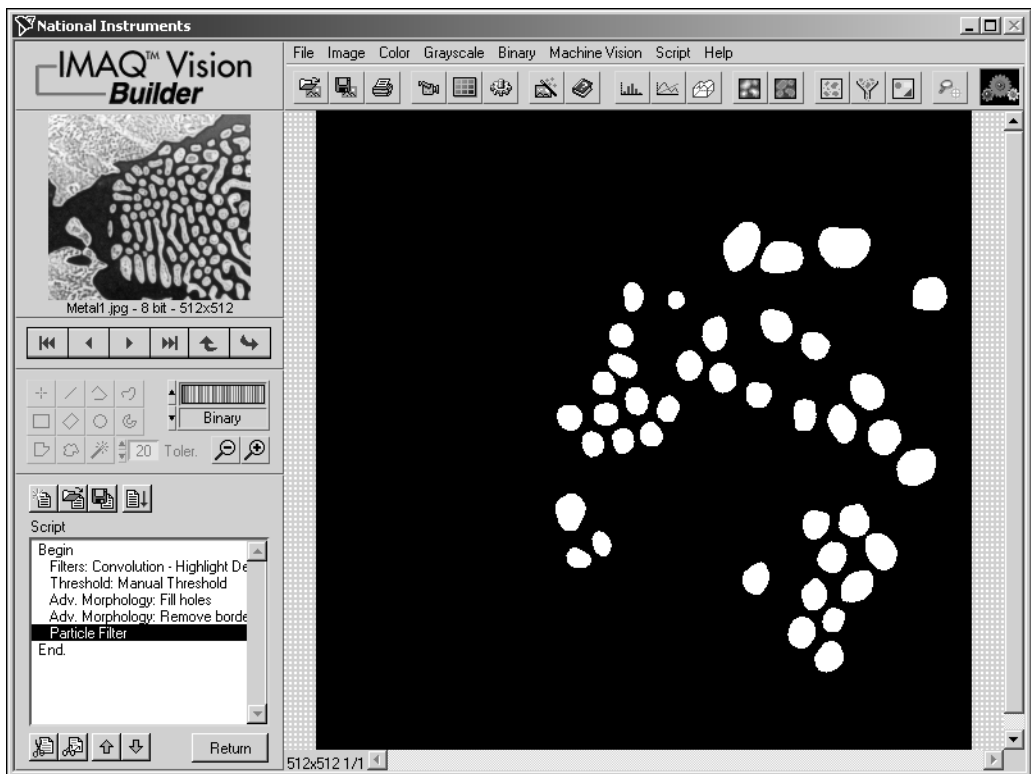
Figure 3-5. Isolating Circular Blobs

Analyzing Circular Blobs

Now that you have isolated circular blobs, follow these steps to find the area occupied by them:

1. Select **Binary»Particle Analysis**. A results table is displayed with all of the measurement results.

   IMAQ Vision Builder assign numerical labels to each blob. The first row of the results table lists the numerical label associated with each blob.

2. Click the **Show/Hide Labels** button to view the labels.

Tip   When you click on a blob, the measurement results for that blob are highlighted in blue. When you click on the results for a blob, the blob is highlighted in green in the processing view.

3. To show only the area measurement, click the **Choose Measurements** button.

4. Click **None** to deselect all of the measurements.

5. Click **Area (unit)**.

6. Click **OK**.

7. Click **Apply** to record the particle analysis in the script.

8. Click **Close**.

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

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

Testing the Blob 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 the **Image Browser** button in the Standard toolbar.

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 Script** button.

Figure 3-6a shows the original image, Metal3.jpg. Figure 3-6b shows the image after the blob analysis processing. Notice that two circular blobs are removed from the image during processing because they are touching each other. Adjust the thresholding step to separate particles from each other.

a.	b.

1   Overlapping Circular Blobs
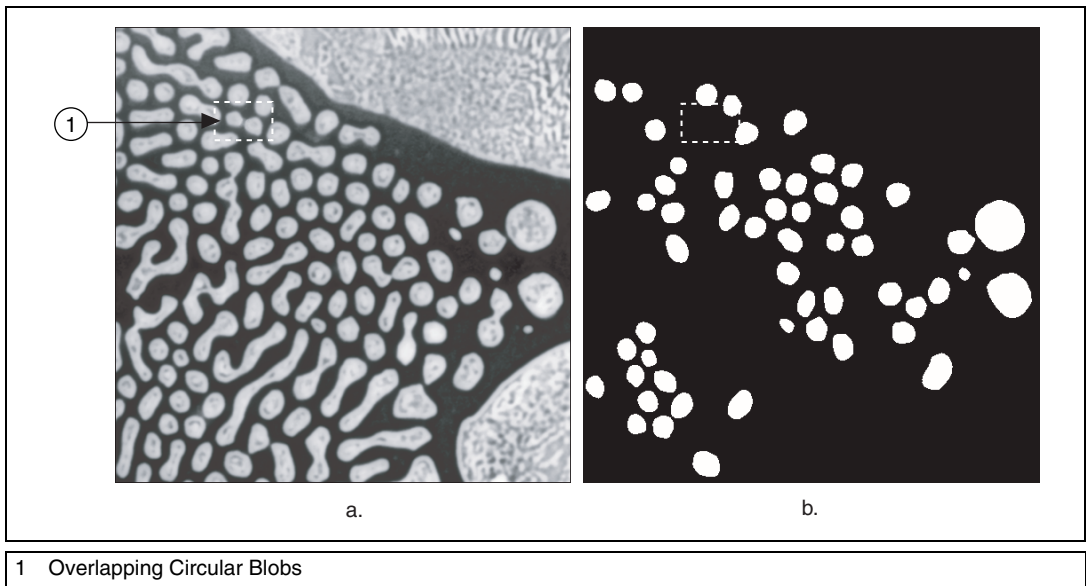
Figure 3-6. Comparing the Original Image to the Processed Image

4.   Click **Done** to close the Particle Analysis window.

5.   Double-click the Threshold step in the script window to open the threshold parameters. Figure 3-7 shows Metal3.jpg at the thresholding step of the script.
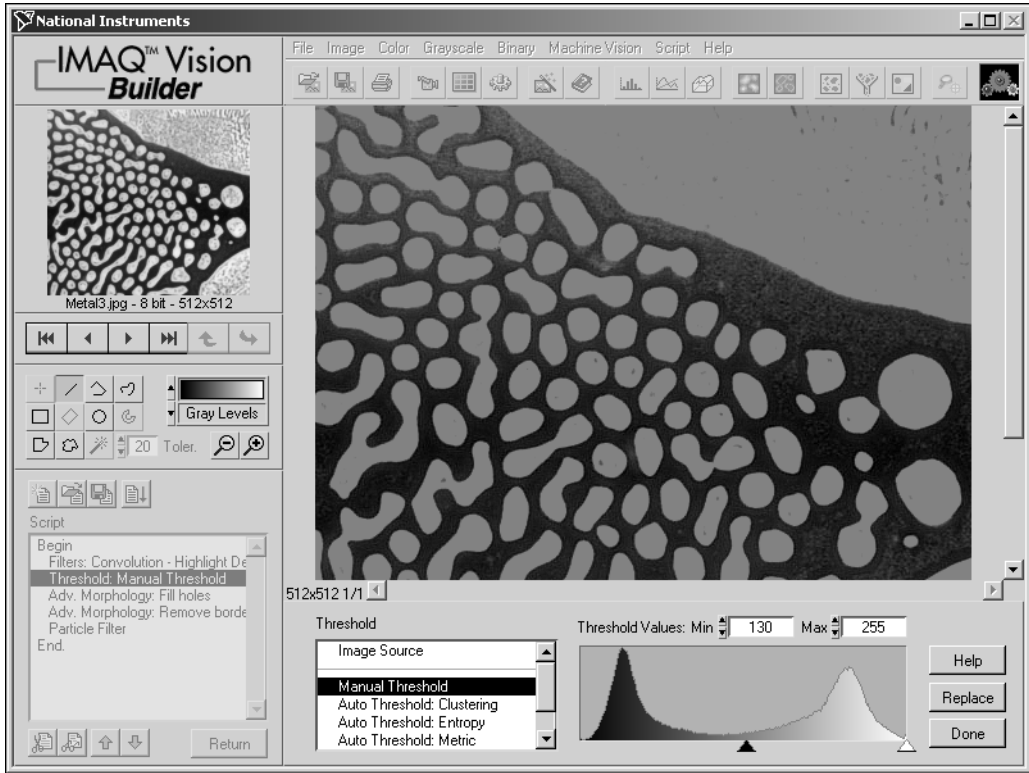
Figure 3-7. Testing the Blob Analysis Script

6. Adjust the minimum threshold value until the blobs are clearly separated. A minimum value of **150** works well.

7. Click **Replace**.

8. Click the **Run Script** button to rerun the script. Notice that only the circular blobs now appear in the final processed image.

9. Click **Done** to close the Particle Analysis window.

Saving the Blob Analysis Script

Now that you have written a blob analysis 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. See the *Analyzing a Collection of Images with Batch Processing* section in Chapter 4, *Using Gauging for Part Inspection*, for an example of batch processing in IMAQ Vision Builder.

1. Select **Script»Save Script**.

2. Save the script as `blob analysis.scr`.

Estimating Processing Time

IMAQ Vision Builder can estimate the time, in milliseconds, that IMAQ Vision will take to process the active image with the open script. The Performance Meter gives both an estimate of the total time IMAQ Vision will take to process the image and an estimate of the time each function within the script will require. Follow these steps to estimate how many milliseconds IMAQ Vision will use to process `Metal3.jpg` with `blob analysis.scr`:

1. Select **Script»Performance Meter**. The Performance Meter gives an estimate of the total time IMAQ Vision will take to run the script.

2. Click **Details** to view an itemized list of the time IMAQ Vision will take to perform each function in the script.

3. Click **OK** to close the Performance Meter.

Creating a LabVIEW VI

IMAQ Vision Builder features a wizard that creates the LabVIEW and IMAQ Vision VI for implementing the different steps of your script. Figure 3-8 shows the VI creation wizard.
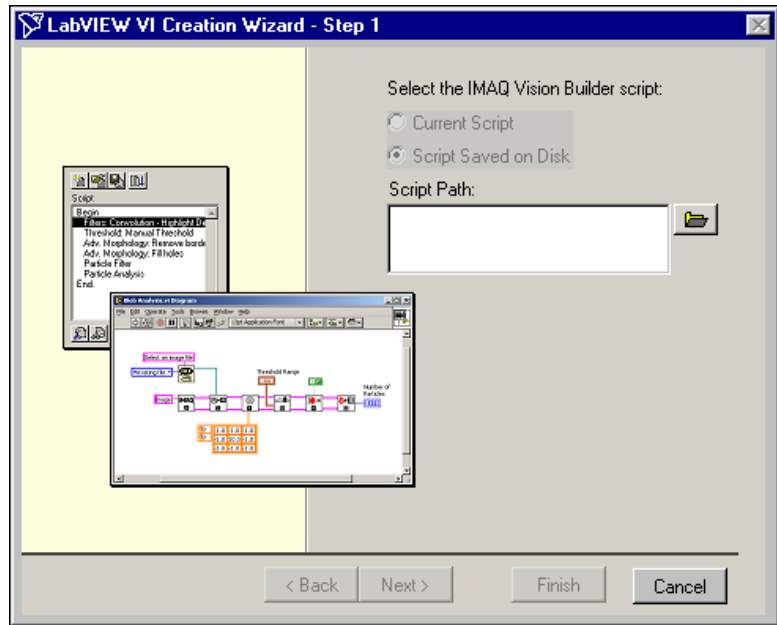
Figure 3-8. LabVIEW VI Creation Wizard

Follow these steps to create your LabVIEW VI:

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

✐ **Note** If several versions of LabVIEW and IMAQ Vision are installed on your computer, the wizard searches your machine and displays a list of the available LabVIEW and IMAQ Vision versions you can use to create the VI. Select the target version of LabVIEW in the list, and click **Next**.

2. Select Current Script to create a VI that performs the algorithm you prototyped.

3. Select the **Image Source** and the **Acquisition Type**, then click **Next**.

4. Select Image File as the Image Source to create a VI to open an image from your hard disk.

5. Check the parameters that you want to appear as controls (inputs) and indicators (outputs) on the front panel of the created VI. Any unchecked parameters are hard-coded as constants in the diagram.

6. Click **Finish** to create the VI.

Note   You must have LabVIEW 6 or higher and IMAQ Vision 6 for LabVIEW or higher to use the LabVIEW VI creation features of IMAQ Vision Builder.

4

Using Gauging for Part Inspection

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

What Is Gauging?

Components such as connectors, switches, and relays are small and manufactured in high quantity. 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 whether 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. If the gauged distance or count does not fall within tolerance limits, the component or part does not meet specifications and should be rejected. Gauging inspection is used often in mechanical assembly verification, electronic packaging inspection, container inspection, glass vile inspection, and electronic connector inspection.

Tutorial

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

Your 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 those measurements.
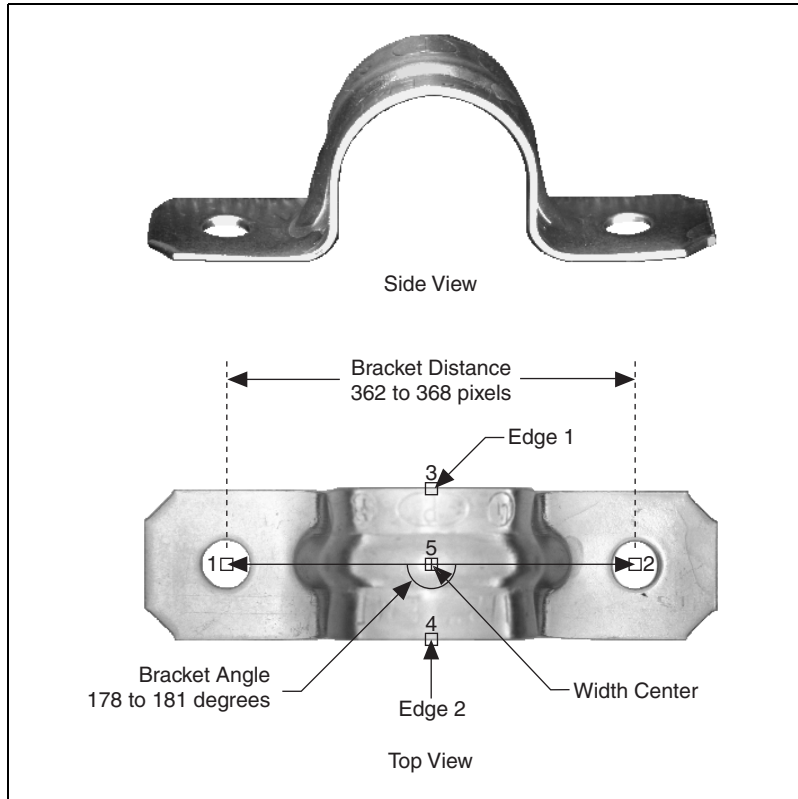
Figure 4-1. Bracket Specifications

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

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

Loading Images into IMAQ Vision Builder

Perform the following steps to load an image:

1. Launch IMAQ Vision Builder from the **Start** menu (**Start»Programs»National Instruments IMAQ Vision Builder 6**).

2. Select **File»Open Image** to load images.

3. Navigate to `Program Files\National Instruments\IMAQ Vision Builder 6\Examples\Bracket` and check the **Select All Files** option. IMAQ Vision Builder previews the images in the Preview Image window and displays information about the file format, size, and type.

💡 **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.

4. Click **OK** to load the image files into IMAQ Vision Builder. From this collection of images in the Image Browser, you can select the image that you want to process.

5. Double click the first image, `Bracket1.jpg`, to load it into the processing window.

Finding Measurement Points Using Pattern Matching

Before you can compute the measurements, you need to 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 whether the bracket's arch is the appropriate height and curvature.

1. Select **Machine Vision»Pattern Matching**. Make sure the Learn Template tab is selected.

2. With the **Rectangle Tool**, click and drag a box around the left hole in the image, as shown in Figure 4-2. The selected area, or region of interest (ROI), will become the template pattern.
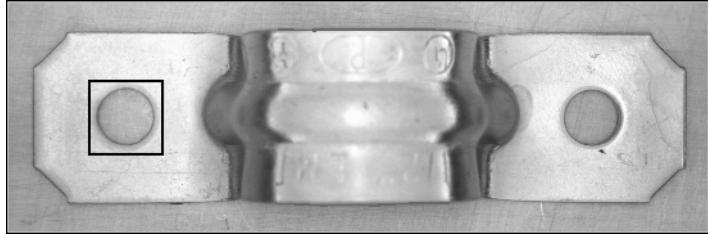
Figure 4-2. Selecting a Template Pattern

3. Click **Create from ROI** to learn the selected area as the template pattern. Learning the template takes a few seconds. After IMAQ Vision Builder learns the template, a save dialog box appears.

4. Navigate to `Program Files\National Instruments\ IMAQ Vision Builder 6\Examples\Bracket`.

5. Save the template as `template.png`. The Pattern Matching parameter window displays the template image and its path.

6. Select the **Search Template** tab.

7. Set **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 your matches to be rotated, use rotation-invariant matching.

8. Check the **Sub-Pixel Accuracy** checkbox.

9. Set the **Minimum Score** to 600. A minimum score of 600 ensures that IMAQ Vision Builder will find matches similar, but not identical, to the template.

10. Set **Number of Matches** to 1.

11. 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 will analyze.

Drawing a region of interest 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.
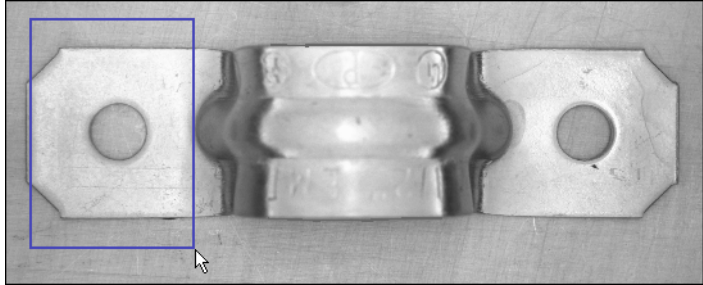
Figure 4-3. Selecting the First Search Area

Once you draw the region of interest, IMAQ Vision Builder 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.

12. Click **Apply** to add this step to the script.

13. With the **Rectangle Tool**, draw a region of interest around the right side of the bracket, as shown in Figure 4-4. IMAQ Vision Builder 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.

14. Click **Apply** to add this step to the script.

15. Click **Close**.

Finding Edges in the Image

Before you can compute measurements to determine whether a bracket meets specifications, you need to 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 **Machine Vision»Edge Detector**.

2. Select the **Advanced Edge Tool**. The Advanced Edge Tool is effective on images with poor contrast between the background and objects.

3. Select **First & Last Edge** so that IMAQ Vision Builder finds and labels only the first and last edges along the line you draw.

4. Set the **Contrast** to 40. The detection process only returns 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. IMAQ Vision Builder labels the edges 1 and 2.

Tip   To draw a straight line, press and hold the `<Shift>` key as you draw the line.
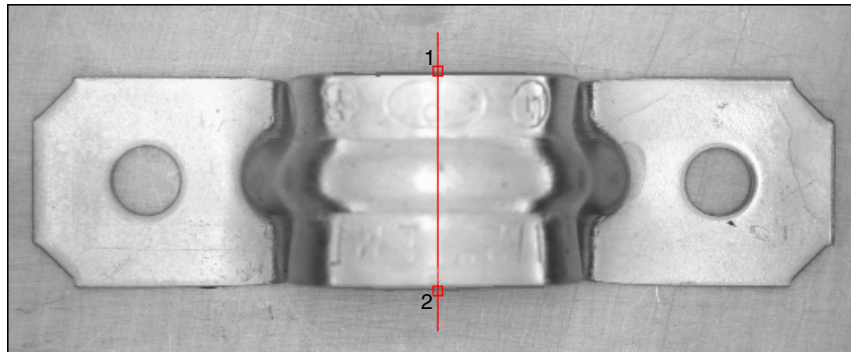
Figure 4-5. Finding the Edges for Bracket Distance

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

6. Click **Apply** to add this edge detection step to the script.

7. Click **Close** to close the Edge Detector window.

Taking the Measurements

Now that you have found the bracket's holes and the necessary edges, you can calculate the center of the bracket's width, distance between the bracket's holes, and angle of the bracket's 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.

Follow these steps to make the measurements:

1. Select **Machine Vision»Caliper**.

2. In the image, click on points **3** and **4** to obtain the first measurement—Width Center—which specifies the center of the bracket's width.

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 clicking on the points in the image, you can double click on the points in the **Points** list box to select them. When you select a point, IMAQ Vision Builder places a check mark next to it.

3. Select **Center** from the **Type of Measure** list.

4.   Click the **Measure** button to compute the center of the bracket's width and add the Width Center measurement to the results table, as shown in Figure 4-6.
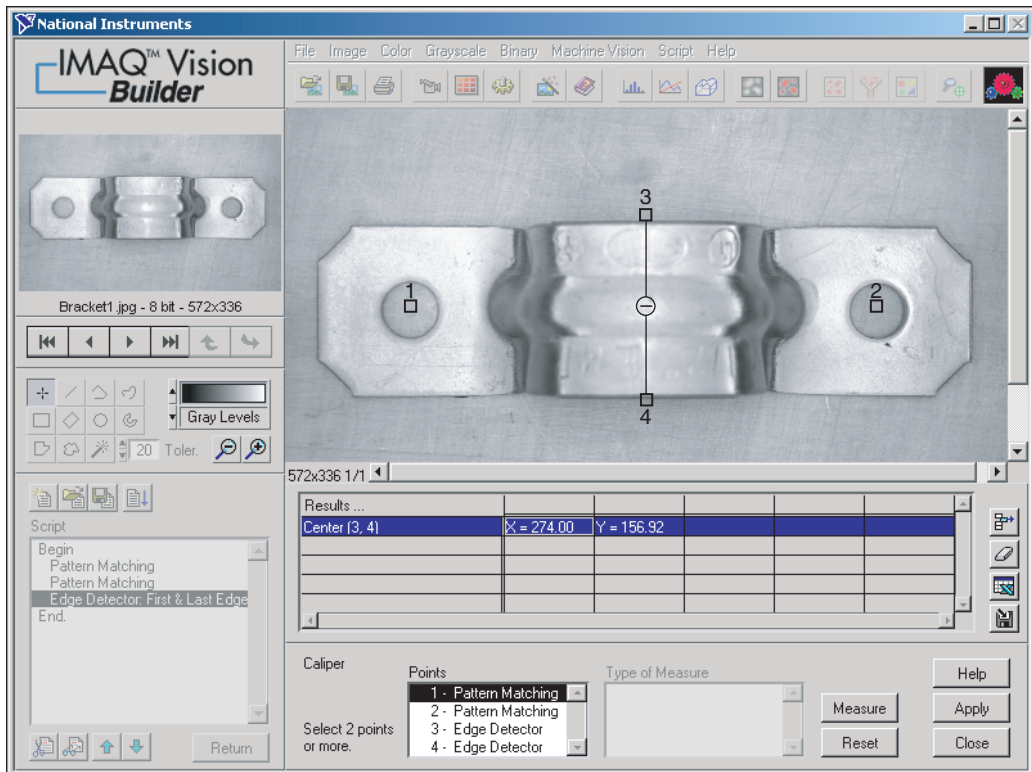
Figure 4-6. Using the Caliper Function to Find Width Center

5.   Click **Apply** to add this step to the script.

6.   Select **Machine Vision»Caliper** again. The center of the bracket's width appears as point 5.

7.   Click on points **1** and **2** in the image to find the second measurement—Bracket Distance—which measures the length between the manufactured holes in the bracket and determines whether the bracket's arch is the appropriate height.

8.   Select **Distance** from the Type of Measure list.

9.   Click the **Measure** button to compute the distance between the bracket's holes and add the measurement to the results table.

10. Click on points **1**, **5**, and **2** (in that order) to find the third measurement—Bracket Angle—which measures the angle of the bracket's arms with respect to a vertex at point 5, as shown in Figure 4-7.

11. Select **Angle** from the Type of Measure list.

12. Click the **Measure** button to compute the angle of the bracket's arms and add the measurement to the results table.

Figure 4-7 shows the image with Bracket Distance and Bracket Angle selected on the image and displayed in the results table.
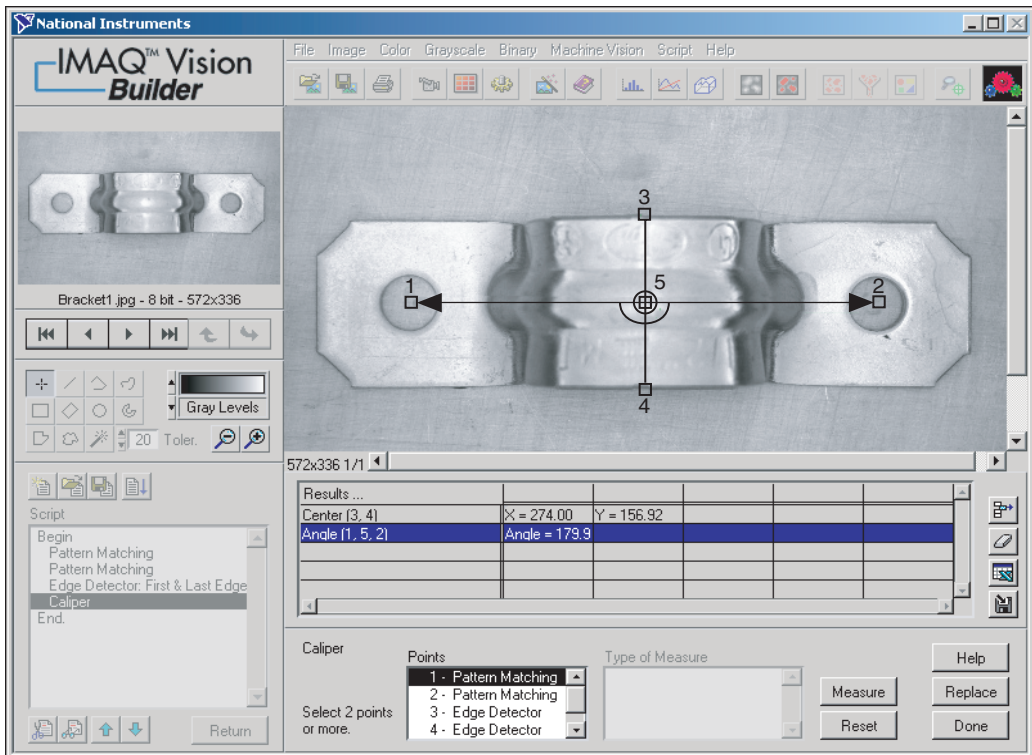
Figure 4-7. Using the Caliper Tool to Collect Measurements

13. Click **Apply** to add these caliper measurements to the script and close the caliper window.

14. Select **Script»Save Script** and save the script as bracket.scr.

Analyzing a Collection of Images with Batch Processing

Perform the following steps to run the script as a batch process on the bracket images and generate a text file containing all of the measurement data:

1. Select **Script»Batch Processing**.

2. Select **Browser** from Image Source to process the images stored in the Image Browser.

   The listbox contains all of the steps in the script. You can select any step in the script and choose options, such as saving that step's results to file, displaying results, or opening the parameter window to adjust the settings on each iteration. For this example, open the caliper parameter window and save the caliper results to a file.

3. Select the last caliper entry in the list box.

4. Check **Open Results Panel** and **Save Results** under Analysis Mode.

5. Click the **Setup** button and set the following options:

   a. Select **One file for all results**.

   b. Press the **Browse** button, navigate to the directory where you want the file saved, and click **Select Cur Dir**.

   c. In the File Name Prefix box, type bracket.txt to give the results files a consistent name.

6. Click **OK** to close the Setup options.

7. Click **Run!** to start the batch process.

   As batch processing runs, a progress window appears on the left side of the IMAQ Vision Builder window. The progress window displays the current process (acquiring an image or processing an image), the number of times the process has been completed, the starting time, and an estimation of the time remaining. If you ever need to stop a batch process, click the **Cancel** button.

Note   Because you checked **Open Results Panel** when setting up the batch processing parameters, you must click the **Done** button after the script runs on each image.

8. When the batch processing completes, click **OK**.

9. Click **Return** to exit the Batch Processing window.

The bracket images have been processed and the caliper results stored in a text file.

Analyzing the Results

As you implement this algorithm in your development environment using the LabVIEW VI creation feature or the Builder file, remember to include your analysis. For this example, you can use Microsoft Excel to quickly analyze the results.

Note To complete this part of the tutorial, you must have Microsoft Excel 97 or higher installed on your computer.

1. Launch Microsoft Excel.
2. Open `bracket.txt` from within Excel to view the results.

The results are labeled and listed in the order in which they appear in the Image Browser. In this case, images are listed from `Bracket1.jpg` to `Bracket6.jpg`.

Table 4-1 lists the acceptable ranges for the bracket measurements and the actual values you might see for the bracket images. 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 you see in Excel may not match the values in Table 4-1 exactly. However, the results you obtain should be close enough to the values in Table 4-1 so that `Bracket1`, `Bracket2`, and `Bracket3` pass inspection, and `Bracket4`, `Bracket5`, and `Bracket6` do not pass.

Table 4-1. Bracket Measurement Results

Bracket Number	Bracket Distance (acceptable range: 362–368 pixels)	Bracket Angle (acceptable range: 178°–181°)
Bracket 1	363.00	179.8
Bracket 2	364.00	180.3
Bracket 3	363.00	179.7
Bracket 4	**349.00**	178.5
Bracket 5	**339.01**	178.4
Bracket 6	**359.03**	**174.8**

A

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`

NI Developer Zone

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

Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`

Worldwide Support

National Instruments has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office Web sites provide up-to-date contact information, support phone numbers, e-mail addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

Glossary

Prefix	Meaning	Value
p-	pico-	10^{-12}
n-	nano-	10^{-9}
μ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}
G-	giga-	10^{9}
t-	tera-	10^{12}

Numbers/Symbols

3D   Three-dimensional.

3D view   Displays the light intensity of an image in a three-dimensional coordinate
                    system, where the spatial coordinates of the image form two dimensions
                    and the light intensity forms the third dimension.

A

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

area threshold   Detects objects based on their size, which can fall within a user-specified
                    range.

arithmetic operators The image operations multiply, divide, add, subtract, and remainder.

B

b	Bit. One binary digit, either 0 or 1.
B	Byte. Eight related bits of data, an eight-bit binary number. Also denotes the amount of memory required to store one byte of data.
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.
binary morphology	Functions that perform morphological operations on a binary image.
binary threshold	Separation of an image into objects of interest (assigned a pixel value of 1) and background (assigned pixel values of 0) based on the intensities of the image pixels.
bit depth	The number of bits (n) used to encode the value of a pixel. For a given n, a pixel can take 2^n different values. For example, if n equals 8-bits, a pixel can take 256 different values ranging from 0 to 255. If n equals 16 bits, a pixel can take 65,536 different values ranging from 0 to 65,535 or -32,768 to 32,767.
blob	Binary large object. A connected region or grouping of pixels in an image in which all pixels have the same intensity level.
blob analysis	A series of processing operations and analysis functions that produce some information about the blobs in an image.
blurring	Reduces the amount of detail in an image. Blurring commonly occurs because the camera is out of focus. You can blur an image intentionally by applying a lowpass frequency filter.
BMP	Bitmap. Image file format commonly used for 8-bit and color images (extension BMP).
border function	Removes objects (or particles) in a binary image that touch the image border.
brightness	(1) A constant added to the red, green, and blue components of a color pixel during the color decoding process. (2) The perception by which white objects are distinguished from gray and light objects from dark objects.

C

caliper   (1) A function in IMAQ Vision Builder 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.

chrominance   *See* chroma.

circle function   Detects circular objects in a binary image.

closing   A dilation followed by an erosion. A closing fills small holes in objects and smooths the boundaries of objects.

color images   Images containing color information, usually encoded in the RGB form.

contrast   A constant multiplication factor applied to the luma and chroma components of a color pixel in the color decoding process.

convolution kernel   2D matrices (or templates) used to represent the filter in the filtering process. The contents of these kernels are a discrete two-dimensional representation of the impulse response of the filter that they represent.

D

default setting   A default parameter value recorded in the driver. In many cases, the default input of a control is a certain value (often 0).

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.

dilation   Increases the size of an object along its boundary and removes tiny holes in the object.

driver   Software that controls a specific hardware device, such as an IMAQ 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 contrast	The difference between the average pixel intensity before and the average pixel intensity after the edge.
edge detection	Any of several techniques to identify the edges of objects in an image.
edge steepness	The number of pixels that corresponds to the slope or transition area of an edge.
erosion	Reduces the size of an object along its boundary and eliminates isolated points in the image.

F

fiducial	A reference pattern on a part that helps a machine vision application find the part's location and orientation in an image.
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.
grayscale morphology	Functions that perform morphological operations on a grayscale image.

H

histogram	Indicates the quantitative distribution of the pixels of an image per gray-level value.
hole filling function	Fills all holes in objects that are present in a binary image.
HSI	Color encoding scheme in Hue, Saturation, and Intensity.

HSL	Color encoding scheme using Hue, Saturation, and Luminance information where each image in the pixel is encoded using 32 bits: 8 bits for hue, 8 bits for saturation, 8 bits for luminance, and 8 unused bits.
HSV	Color encoding scheme in Hue, Saturation, and Value.
hue	Represents the dominant color of a pixel. The hue function is a continuous function that covers all the possible colors generated using the R, G, and B primaries. *See also* RGB.

I

I/O	Input/output. The transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces.
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 border	A user-defined region of pixels surrounding an image. Functions that process pixels based on the value of the pixel neighbors require image borders.
Image Browser	An image that contains thumbnails of images to analyze or process in a vision application.
image definition	*See pixel depth.*
image enhancement	The process of improving the quality of an image that you acquire from a sensor in terms of signal-to-noise ratio, image contrast, edge definition, and so on.
image file	A file containing pixel data and additional information about the image.
image format	Defines how an image is stored in a file. Usually composed of a header followed by the pixel data.
image palette	The gradation of colors used to display an image on screen, usually defined by a color lookup table.
image processing	Encompasses various processes and analysis functions that you can apply to an image.

image source	Original input image.
image visualization	The presentation (display) of an image (image data) to the user.
imaging	Any process of acquiring and displaying images and analyzing image data.
IMAQ	Image Acquisition.
inspection	The process by which parts are tested for simple defects such as missing parts or cracks on part surfaces.
inspection function	Analyzes groups of pixels within an image and returns information about the size, shape, position, and pixel connectivity. Typical applications include quality of parts, analyzing defects, locating objects, and sorting objects.
instrument driver	A set of high-level software functions, such as NI-IMAQ, that control specific plug-in computer boards. Instrument drivers are available in several forms, ranging from a function callable from a programming language to a virtual instrument (VI) in LabVIEW.
intensity	The sum of the Red, Green, and Blue primary colors divided by three. (*Red+Green+Blue*)/3
intensity profile	The gray-level distribution of the pixels along an ROI in an image.
intensity range	Defines the range of gray-level values in an object of an image.
intensity threshold	Characterizes an object based on the range of gray-level values in the object. If the intensity range of the object falls within the user-specified range, it is considered an object. Otherwise it is considered part of the background.

J

JPEG	Joint Photographic Experts Group. Image file format for storing 8-bit and color images with lossy compression (extension JPG).

K

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

L

labeling
The process by which each object in a binary image is assigned a unique value. This process is useful for identifying the number of objects in the image and giving each object a unique identity.

LabVIEW
Laboratory Virtual Instrument Engineering Workbench. Program development environment application based on the programming language G used commonly for test and measurement applications.

line profile
Represents the gray-level distribution along a line of pixels in an image.

logic operators
The image operations AND, NAND, OR, XOR, NOR, XNOR, difference, mask, mean, max, and min.

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

M
(1) Mega, the standard metric prefix for 1 million or 10^6, when used with units of measure such as volts and hertz (2) Mega, the prefix for 1,048,576, or 2^{20}, when used with B to quantify data or computer memory.

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

match score
A number ranging from 0 to 1000 that indicates how closely an acquired image matches the template image. A match score of 1000 indicates a perfect match. A match score of 0 indicates no match.

MB
Megabyte of memory.

MMX
Multimedia Extensions. Intel chip-based technology that allows parallel operations on integers, which results in accelerated processing of 8-bit images.

morphological transformations | Extract and alter the structure of objects in an image. You can use these transformations for expanding (dilating) or reducing (eroding) objects, filling holes, closing inclusions, or smoothing borders. They are used primarily to delineate objects and prepare them for quantitative inspection analysis.

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.

neighborhood operations | Operations on a point in an image that take into consideration the values of the pixels neighboring that point.

NI-IMAQ | Driver software for National Instruments IMAQ hardware.

O

opening | An erosion followed by a dilation. An opening removes small objects and smooths boundaries of objects in the image.

operators | Allow masking, combination, and comparison of images. You can use arithmetic and logic operators in IMAQ Vision.

P

palette | The gradation of colors used to display an image on screen, usually defined by a color lookup table.

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).

pixel aspect ratio	The ratio between the physical horizontal size and the vertical size of the region covered by the pixel. An acquired pixel should optimally be square, thus the optimal value is 1.0, but typically it falls between 0.95 and 1.05, depending on camera quality.
pixel depth	The number of bits used to represent the gray level of a pixel.
PNG	Portable Network Graphic. Image file format for storing 8-bit, 16-bit, and color images with lossless compression (extension PNG).
proper-closing	A finite combination of successive closing and opening operations that you can use to fill small holes and smooth the boundaries of objects.
proper-opening	A finite combination of successive opening and closing operations that you can use to remove small particles and smooth the boundaries of objects.
pts	Points.

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 $m{\times}n$.
RGB	Color encoding scheme using red, green, and blue (RGB) color information where each pixel in the color image is encoded using 32 bits: 8 bits for red, 8 bits for green, 8 bits for blue, and 8 bits for the alpha value (unused).
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 focus further processing. (2) A hardware-programmable rectangular portion of the acquisition window.
ROI tools	Collection of tools from the Lab VIEW Tools palette that enable you to select a region of interest from an image. These tools let you select a point or line; polygon, rectangle, and oval regions; and freehand lines and areas.
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

saturation	The amount of white added to a pure color. Saturation relates to the richness of a color. A saturation of zero corresponds to a pure color with no white added. Pink is a red with low saturation.
scale-invariant matching	A pattern matching technique in which the reference pattern can be any size in the test image.
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.
smoothing filter	Blurs an image by attenuating variations of light intensity in the neighborhood of a pixel.
sub-pixel analysis	Finds the location of the edge coordinates in terms of fractions of a pixel.

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.
threshold interval	Two parameters, the lower threshold gray-level value and the upper threshold gray-level value.
TIFF	Tagged Image File Format. Image format commonly used for encoding 8-bit, 16-bit, and color images (extension TIF).
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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