

IMAQ[™]

NI Vision Builder for Automated Inspection Tutorial

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About This Manual

This manual is for manufacturing test engineers who need to acquire images of parts, process and analyze the images, make measurements, and make pass/fail decisions about the parts. This tutorial is well suited for people who have little experience with machine vision. The tutorial contains many techniques for using NI Vision Builder for Automated Inspection (Vision Builder AI) to solve visual inspection tasks including inspection, gauging, part presence, guidance, and counting.

Follow the instructions in this tutorial to familiarize yourself with the Vision Builder AI Configuration interface and solve common inspection tasks.

Conventions

The following conventions appear in this manual:

<>

Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DIO<3..0>.

»

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 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.

Related Documentation

The following documents contain information that you might find helpful as you read this manual:

- *NI Vision Builder for Automated Inspection: Configuration Help*, available by selecting **Help»Online Help** from the Vision Builder AI Configuration interface
- *NI Vision Builder for Automated Inspection: Inspection Help*, available by selecting **Help»Online Help** from the Vision Builder AI Inspection interface

Getting Started in Vision Builder AI

This chapter introduces the Vision Builder AI environment, teaches you how to create a short *inspection*, and shows you how to run an inspection.

Figures 1-1 and 1-2 show the general instructions for creating a Vision Builder AI inspection. Figure 1-1 describes the general steps for designing a Vision Builder AI inspection. The *Add Inspection Steps* module of Figure 1-1 is expanded in Figure 1-2.

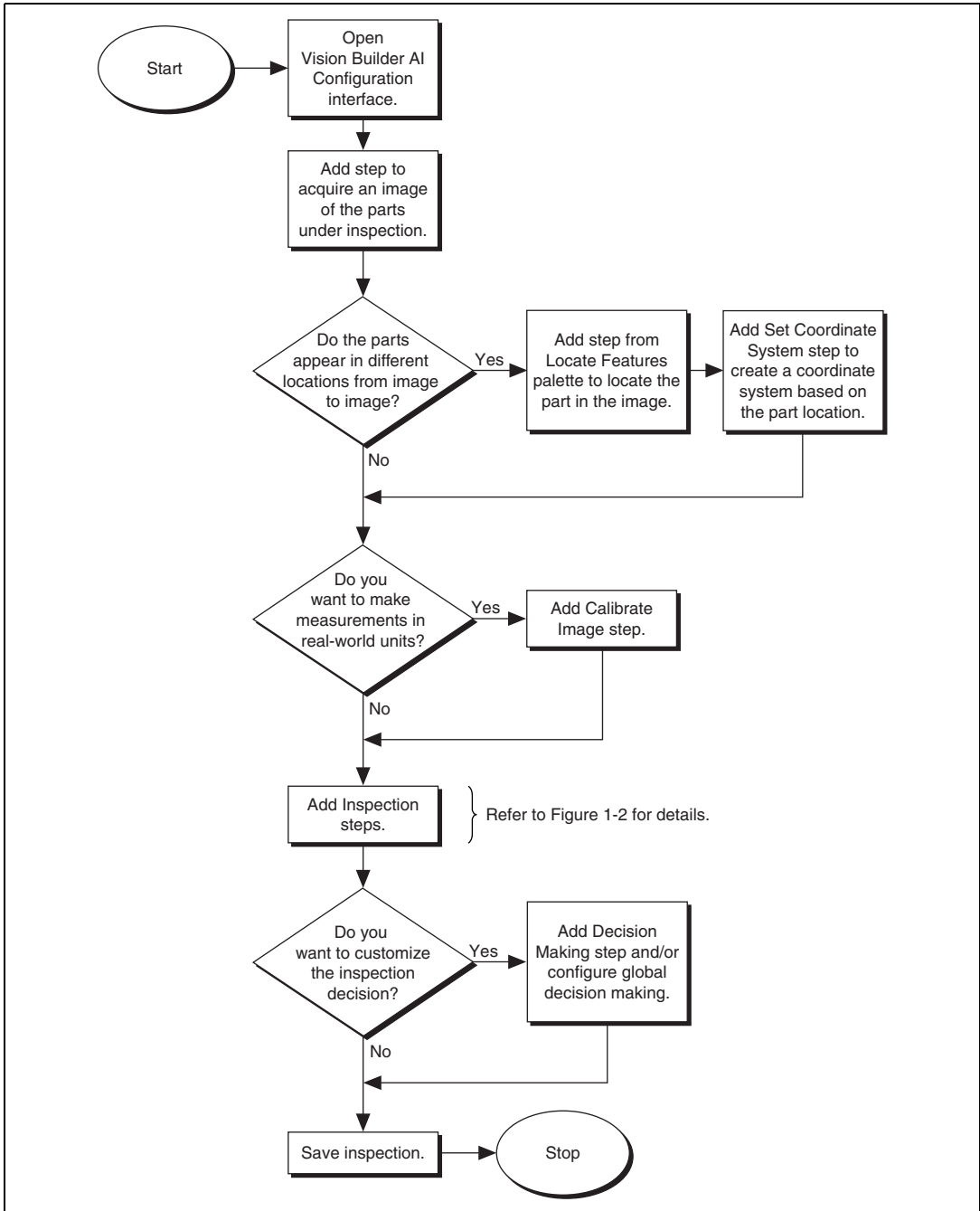


Figure 1-1. General Instructions for Creating a Vision Builder AI Inspection

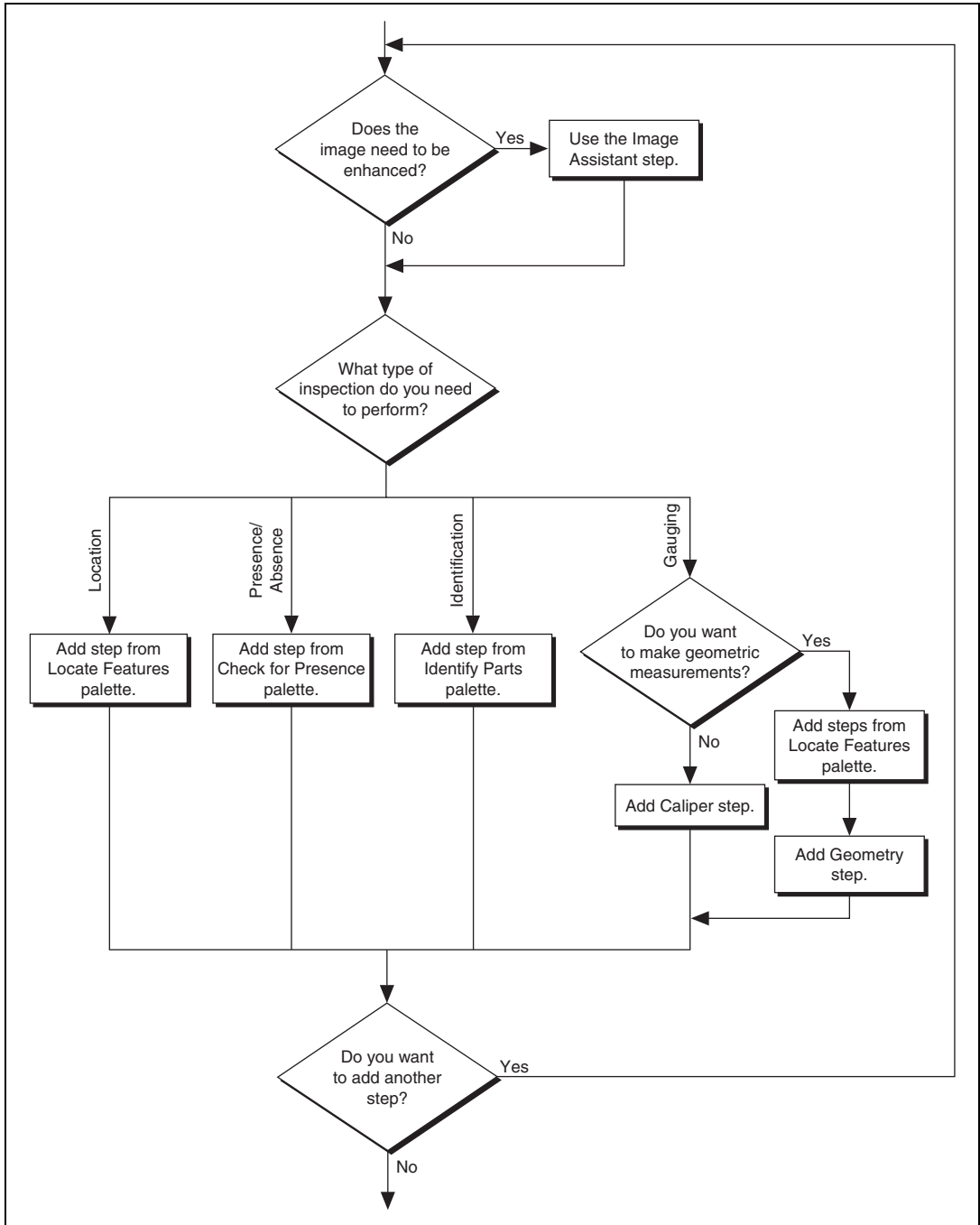


Figure 1-2. Adding Inspection Steps to a Vision Builder AI Inspection

Follow the instructions in this chapter to open Vision Builder AI and configure, test, save, and run an inspection.

Opening the Vision Builder AI Configuration Interface

Vision Builder AI has two modes of operation: configuration and inspection. Use the Configuration interface to configure and test your inspection. Use the Inspection interface to deploy the software and perform online or offline visual inspection.

Follow these instructions to open the Vision Builder AI Configuration interface:

1. Go to the **Start** menu and select **Programs»National Instruments Vision Builder AI 1.0**. The **Welcome** screen appears.
2. Click the **Configure Inspection** button.

Elements of the Configuration Interface

Figure 1-3 shows the Vision Builder AI Configuration interface. The Configuration interface contains four areas: main window, inspection diagram window, inspection steps palette, and embedded help window.

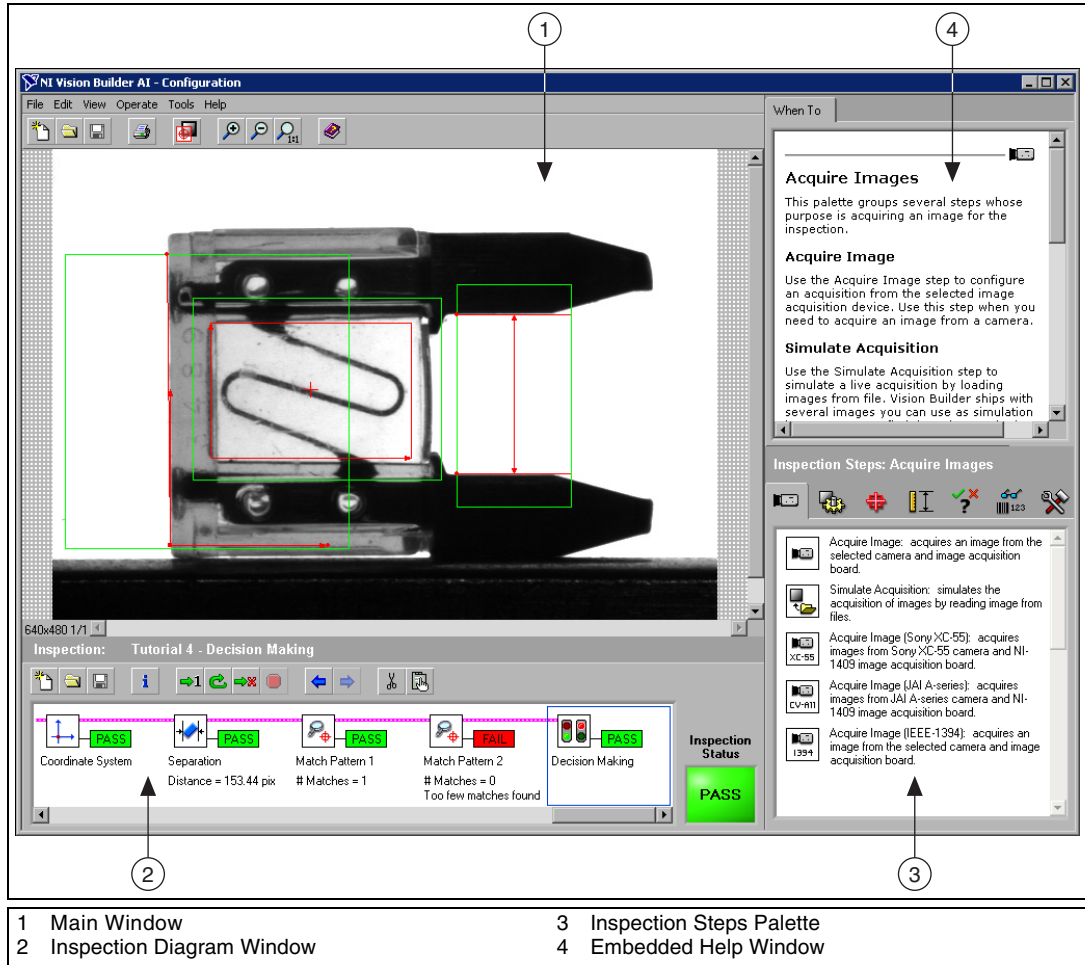


Figure 1-3. Vision Builder AI Configuration Interface

- **Main window**—Displays the image being processed, the **Decision Making** property page, the **Serial I/O** property page, and the **Configure Inputs/Outputs** property page.
- **Inspection diagram window**—Displays the sequence of Vision Builder AI *steps* that comprise the inspection.
- **Inspection steps palette**—Lists and describes the steps you use to create your inspection. When you click on most steps, this palette transforms into the property page for the step.

- **Embedded help window**—Contains context-sensitive help about when to use a step, how to configure a step, the function of the user-interface controls, and frequently asked questions.

Configuring an Inspection

On startup, Vision Builder AI loads a blank inspection in the inspection diagram window. To build an inspection, you need to add and configure steps to the inspection.

This section teaches you how to create a simple inspection that checks for the presence of a label on a National Instruments *FieldPoint* device.

Acquiring an Image

In the inspection steps palette, the **Acquire Images** tab contains four image acquisition steps—**Acquire Image**, **Acquire Image (Sony XC-55)**, **Acquire Image (JAI A-series)**, and **Acquire Image (IEEE 1394)**—and one step that simulates image acquisition by loading images from file—**Simulate Acquisition**.

For simplicity, the exercises in this tutorial incorporate the **Simulate Acquisition** step. However, in your real-world inspection, use one of the four image acquisition steps to acquire images of the object under inspection.

Follow these instructions to configure a **Simulate Acquisition** step that simulates acquiring images of FieldPoint devices.

1. In the inspection steps palette, select the **Acquire Images** tab.
2. Click the **Simulate Acquisition** step. The property page for the step appears.
3. In the **Step Name** control, enter `Acquire Image`.
4. Click the **Browse** button. The **Select an Image File** dialog box appears.
5. Navigate to `<Vision Builder AI 1.0>\DemoImg\Tutorial 1`.
6. Select the first image, `Image 01.jpg`, and click **Open**.
7. Make sure the **Cycle Through Folder Images** control is enabled. When this control is enabled, Vision Builder AI loads a different simulation image from the folder each time the step is run, which simulates a live acquisition of multiple parts.



Browse

- Click **OK**. Vision Builder AI adds the **Simulate Acquisition** step to the inspection.

Checking for the Presence of a Feature Using Match Pattern

Follow these instructions to configure a **Match Pattern** step to check for the presence of the FieldPoint device label.

- In the inspection steps palette, select the **Check for Presence** tab.
- Click the **Match Pattern** step. A dialog box appears.
- Draw a *region of interest* around the area of the image containing the label, as shown in Figure 1-4. This region becomes the *pattern matching template*.

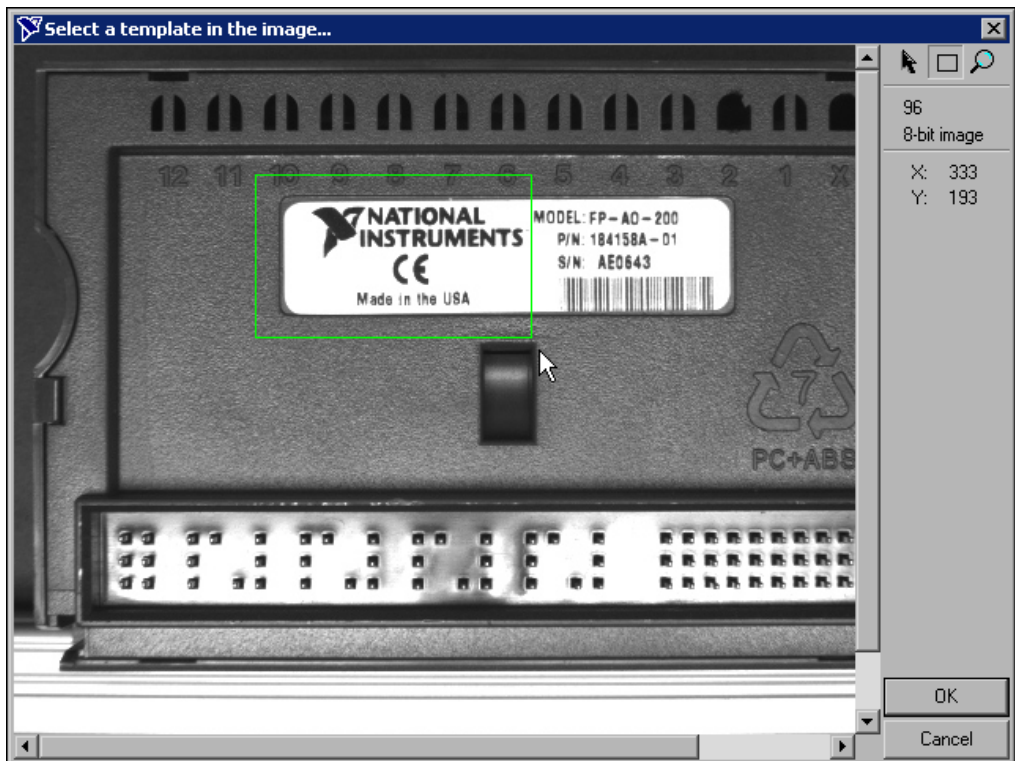


Figure 1-4. Creating a Template Pattern

- Click **OK** to accept the template.

Notice that Vision Builder AI locates the specified template in the green region of interest. The location of the match is overlaid on the inspection image with a red rectangle.

5. In the **Main** tab, enter `Locate Label` in the **Step Name** control.
6. Redraw or decrease the default green region of interest so that it surrounds only the portion of the device that contains the learned template, as shown in Figure 1-5.

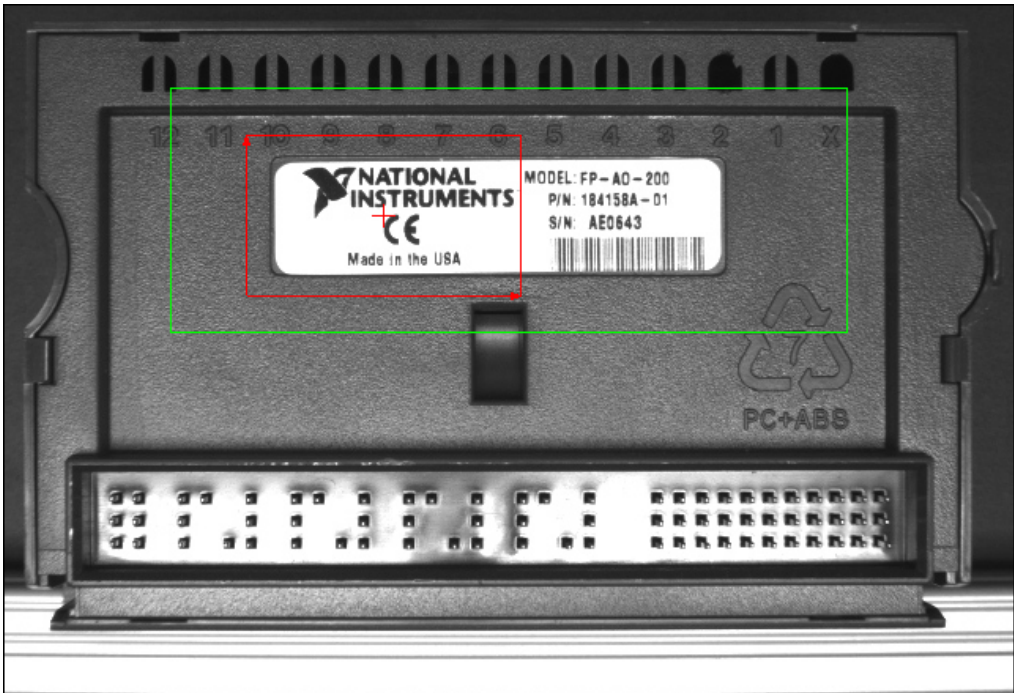


Figure 1-5. Limiting the Search Region

This region of interest represents the area of the image in which Vision Builder AI searches for instances of the template.

7. In the **Settings** tab, set **Number of Matches to Find** to **1**.
Notice the **Minimum Score** control. By default, all instances of the template must have a *match score* of 800 or higher to be considered a valid match. **Minimum Score** can vary between 0 and 1,000. A score of 1,000 indicates a perfect match.
8. In the **Limits** tab, enable the **Minimum Number of Matches** control, and set the value to **1**.

Notice the **Matches** table contains two matches—a match that meets the requirements you set and the next best possible match. This feature helps you choose a **Minimum Score** high enough to discriminate correct parts from defective ones but not so high that the visual inspection cannot tolerate normal process variations.

Testing an Inspection Step

You can test a step before or after adding it to the inspection. Follow these instructions to test the **Locate Label** step to make sure the current step configuration returns the results you expect.



Run Once

1. Click the **Run Once** button located in the inspection diagram window.
Vision Builder AI loads the next image, `Image 02.jpg`, from the `Tutorial 1` folder and performs the **Locate Label** step on the image.



Note The name of the active image is displayed in the **Simulate Acquisition** module of the inspection diagram.

Notice that the **Step Status** is **PASS**.

2. Test the other images in the `Tutorial 1` folder. Table 1-1 lists the test images, **Step Status** to expect for each image, and an explanation of the status.

Table 1-1. Expected Results for the FieldPoint Label Inspection

Image Name	Inspection Status	Explanation
Image 03.jpg	PASS	The label is present.
Image 04.jpg	PASS	The label is present.
Image 05.jpg	FAIL	The label is missing.
Image 06.jpg	FAIL	The label is upside down.



Note If `Image 02.jpg`, `Image 03.jpg`, or `Image 04.jpg` do not pass inspection, slightly reduce the value of the **Minimum Score** control located in the **Settings** tab.

3. Click **OK** to add the step to the inspection.

Saving an Inspection

Follow these instructions to save the example inspection:

1. Select **File»Save As**. An **Inspection Properties** dialog box appears.
2. In the **Inspection Name** control, enter `Lesson 1`.
3. In the **Description** field, enter the following:

```
This inspection checks for the proper application of  
a label on a FieldPoint module using pattern  
matching.
```
4. Click **OK** to save the inspection and its description.

Running an Inspection in the Inspection Interface

As mentioned in the [Opening the Vision Builder AI Configuration Interface](#) section, you deploy and run an inspection from the Vision Builder AI Inspection interface. Figure 1-6 shows the Inspection interface, which has three main areas: the results panel, inspection statistics panel, and display window.

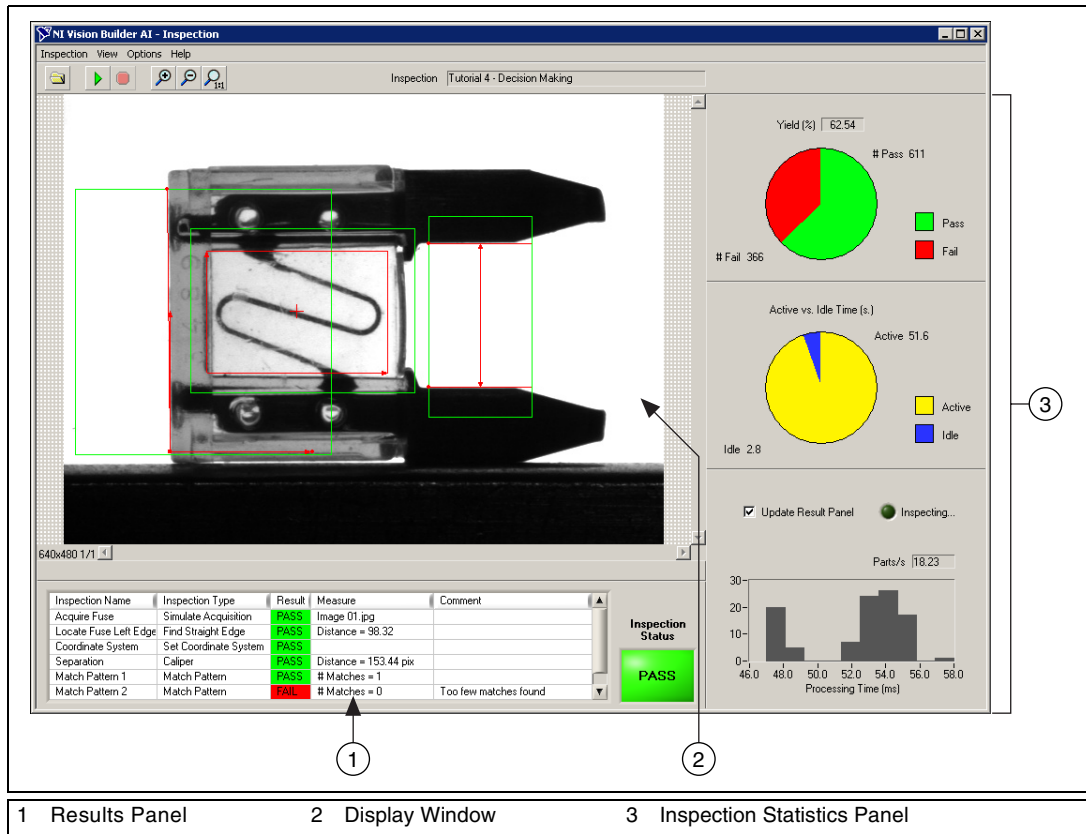


Figure 1-6. Vision Builder AI Inspection Interface

- **Results panel**—Lists the steps in the inspection by name. For each inspection step, Vision Builder displays the step type, result (PASS or FAIL), measurement made, and a comment explaining the reason of a FAIL. The inspection status shows the result of the complete inspection.
- **Display window**—Displays the part under inspection.
- **Inspection statistics panel**—Contains three indicators that display the yield (ratio between PASS and FAIL), active versus idle time, and processing time of the inspection.

Follow these instructions to run the inspection from the Inspection interface:



Start Inspection

1. Select **File»Switch to Inspection Interface** to launch the Inspection interface. The steps of **Lesson 1** appear in the results panel.
2. Click the **Start Inspection** button. Vision Builder AI begins running the inspection on the simulation images and updating the three areas of the Inspection interface with the most recent inspection data.

By default, Vision Builder AI displays all the inspection images in the display window. You can change the display settings in the **View** menu to view only images that fail or to have no display. You also can change the magnification of the displayed images in the **Options** menu.

By default, Vision Builder AI updates the results panel while the inspection runs. If you do not want to update the results panel during an inspection, disable the **Update Result Panel** control.

Notice the performance data displayed in the inspection statistics panel. This data can help you determine how efficiently your inspection is running. Based on this data, you can make adjustments to improve the inspection speed.



Stop Inspection

3. Click the **Stop Inspection** button to stop the inspection.
4. Select **File»Switch to Configuration Interface** to return to the Configuration interface.

Checking for the Presence of a Part

This chapter introduces the **Measure Intensity** and **Set Coordinate System** steps. Follow the instructions in this chapter to create an inspection that checks for the presence of a spray bottle cap regardless of the bottle position in the inspection images.



Note Launch Vision Builder AI if it is not open. Refer to the *Opening the Vision Builder AI Configuration Interface* section of Chapter 1, *Getting Started in Vision Builder AI*, for more information.

Creating a New Inspection

Select **File»New**. Vision Builder AI loads a new, blank inspection into the inspection diagram window.

Simulating Image Acquisition

Follow these instructions to configure a **Simulate Acquisition** step that simulates acquiring images of spray bottles.

1. In the inspection steps palette, select the **Acquire Images** tab.
2. Click the **Simulate Acquisition** step. The property page for the step appears.
3. In the **Step Name** control, enter `Acquire Spray Bottle`.
4. Click the **Browse** button. The **Select an Image File** dialog box appears.
5. Navigate to `<Vision Builder AI 1.0>\DemoImg\Tutorial 2`.
6. Select the first image, `Image 01.jpg`, and click **Open**.
7. Make sure the **Cycle Through Folder Images** control is enabled so that Vision Builder AI loads a different simulation image from the folder each time the step is run.
8. Click **OK** to add this step to the inspection.



Browse

Defining a Feature on Which to Base a Coordinate System

In a machine vision inspection, you typically limit your inspection and processing to a region of interest rather than the entire image for the following reasons:

- To improve your inspection results by avoiding extraneous objects
- To increase inspection speed

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 fixtured and always appears at the same location and orientation in the images you need to process, defining a region of interest is straightforward. However, if the object under inspection appears shifted or rotated within the images, the regions of interest need to shift and rotate with the object under inspection.

For the regions of interest to move in relation to the object, you need to set a *coordinate system* relative to a significant and original feature of the object under inspection. Choose a feature that is always in the *field of view* of the camera despite the different locations that the objects may appear in from image to image. Also make sure the feature is not affected by major defects that could drastically modify the visual appearance of the feature.

Follow these instructions to configure a **Match Pattern** step that locates a bottle feature on which you can base a coordinate system.

1. In the inspection steps palette, select the **Locate Features** tab.
2. Click the **Match Pattern** step. A dialog box appears.

3. Draw a region of interest around the base of the sprayer, as shown in Figure 2-1. This region becomes the pattern matching template.

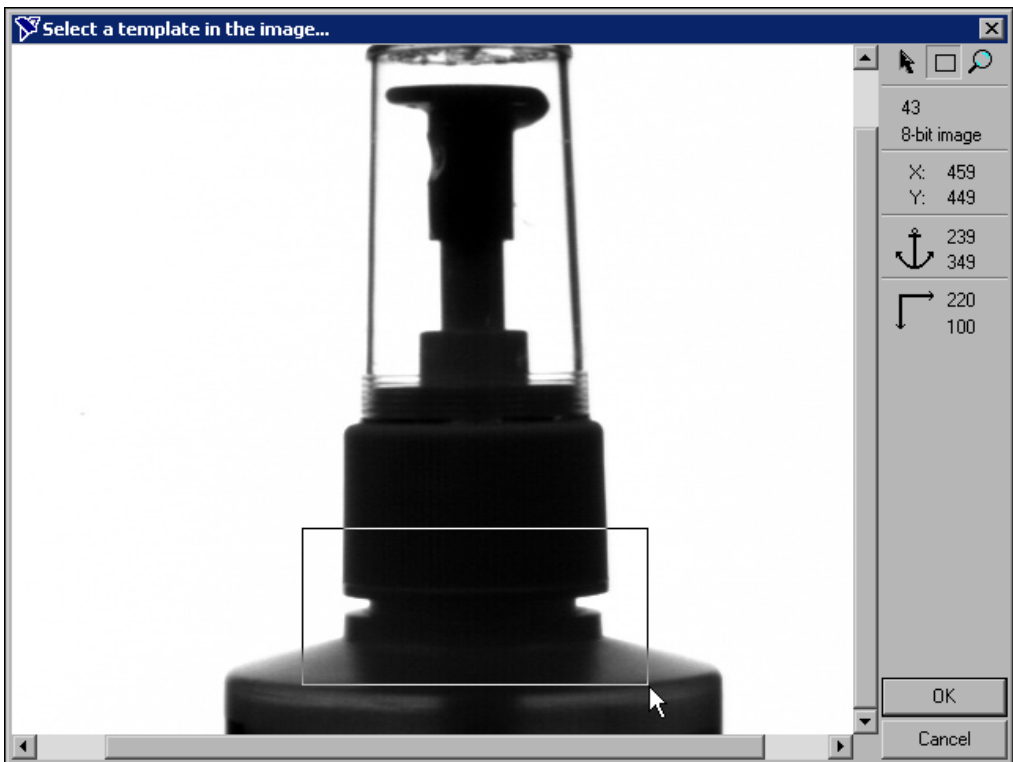


Figure 2-1. Creating a Template Pattern

4. Click **OK** to accept the template.
5. In the **Main** tab, enter `Locate Sprayer Base` in the **Step Name** control.

The green region of interest specifies the area of the image in which Vision Builder AI tries to locate the template. Assuming that the bottles are fixtured in such a way that they can move only horizontally within the field of view, you can limit the region of interest so that it surrounds only the area of the image that may contain a template match during inspection.

6. Redraw or decrease the default green region of interest so that it surrounds only the lower portion of the image, as shown in Figure 2-2.

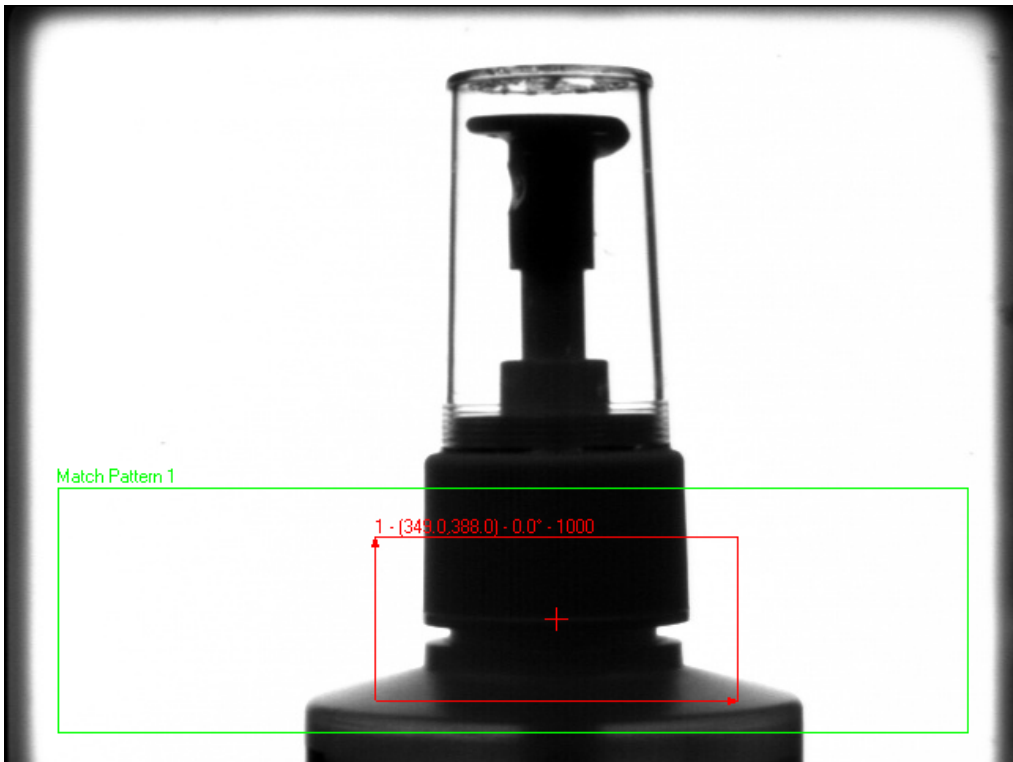


Figure 2-2. Limiting the Search Region

7. In the **Template** tab, drag the red pointer in the template image to the left edge of the sprayer base, as shown in Figure 2-3. This changes the *focal point* of the template. Vision Builder AI uses the focal point later as the origin of a coordinate system.

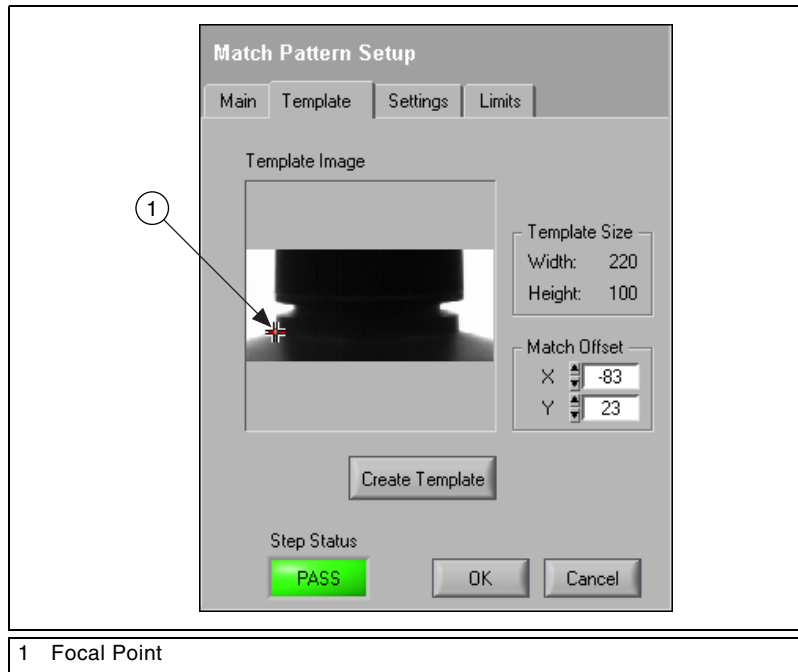


Figure 2-3. Adjusting the Focal Point of the Template

8. In the **Settings** tab, set **Number of Matches to Find** to **1**.
9. In the **Limits** tab, enable the **Minimum Number of Matches** control, and set the value to **1**.
10. Click **OK** to add the step to the inspection.

Setting a Coordinate System

Follow these instructions to configure a **Set Coordinate System** step based on the **Match Pattern** step you configured.

1. In the inspection steps palette, select the **Locate** tab.
2. Click the **Set Coordinate System** step.
3. In the **Main** tab, enter `Coordinate System` in the **Step Name** control.
4. In the **Settings** tab, select **Horizontal and Vertical Motion** from the **Mode** control because the bottles appear shifted but not rotated from one image to another.



Horizontal and
Vertical Motion

Notice the **Origin** list. **Match 1**, the match location of the previous **Locate Sprayer Base** step, is the default origin of the coordinate system because it is the only location point created by previous steps in the inspection.

5. Click **OK** to add this step to the inspection.

Checking for the Cap Using Measure Intensity

You can check for the presence of the cap by measuring the *pixel intensities* in the regions you expect the cap to be located. Follow these instructions to configure a **Measure Intensity** step that checks for the presence of a spray bottle cap.

1. In the inspection steps palette, select the **Check for Presence** tab.
2. Click the **Measure Intensity** step. The property page for the step appears.
3. In the **Main** tab, enter `Check Cap Presence` in the **Step Name** control.
4. Enable the **Reposition Region of Interest** control.

Enabling this control allows you to link the regions of interest specified in this step to a previously defined coordinate system so that Vision Builder AI 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. **Coordinate System** is the default reference coordinate system because it is the only **Set Coordinate System** step in the current inspection.

Notice that the **Measure Intensity** 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, ellipse, annulus, polygon, and freehand region.



Rectangle Tool

5. Using the default **Rectangle Tool**, hold down <Ctrl>, and draw three regions of interest that enclose edges of the cap, as shown in Figure 2-4.

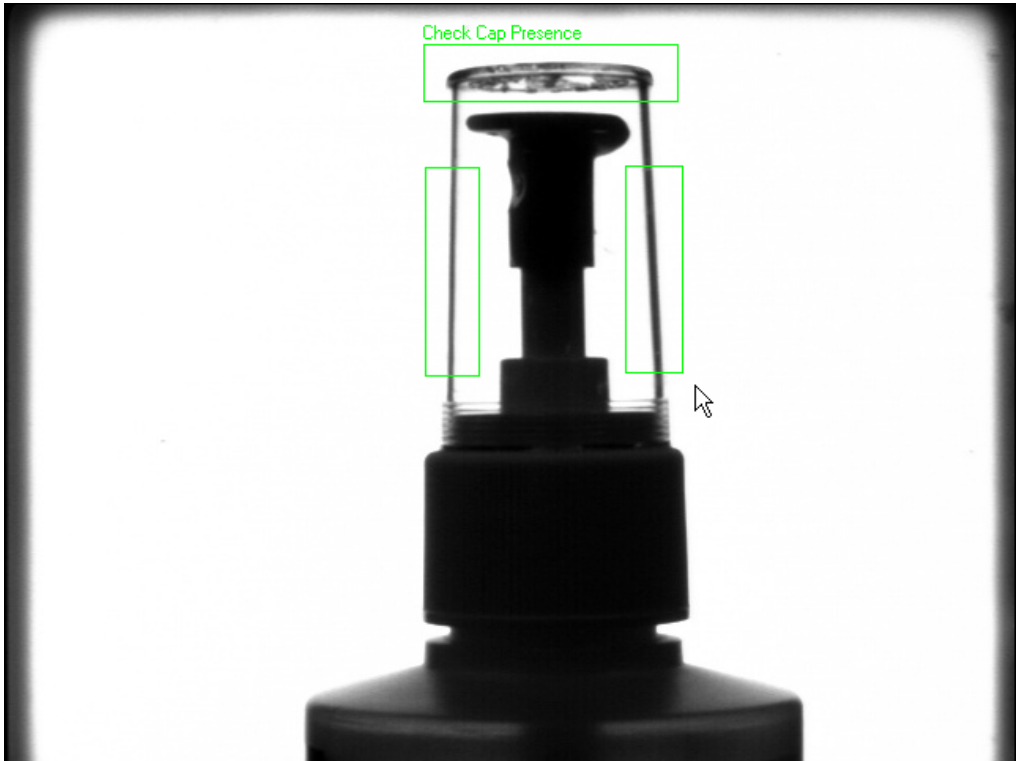


Figure 2-4. Defining Regions in Which to Measure Intensity

6. Select the **Limits** tab.

At the bottom of the tabbed page, Vision Builder AI returns the intensity statistics of the pixels inside the regions of interest. Pixel intensities can range from 0–255, where 0 equals black and 255 equals white.

The **Minimum Intensity** value at the bottom of the page returns the lowest pixel value inside the regions of interest. The backlit edges of the plastic cap appear in silhouette as dark pixels (which have low pixel intensities) on a bright background (which has high pixel intensities).

Therefore, when the cap is present, the minimum intensity for the regions is low. When the cap is not present, the minimum intensity for the regions is high because the regions contain only bright background pixels.

7. Enable the **Minimum Intensity** control. Set the **Maximum** value to 50.00.



Run Once

8. Click the **Run Once** button located in the inspection diagram window.

Vision Builder AI loads the next image, `Image 02.jpg`, from the `Spray Bottle` folder.

Notice that the bottle appears closer to the left edge of the image.

Vision Builder AI repositions the regions of interest based on the new location of the bottle. The **Step Status** for the image is **PASS** because the presence of the cap inside the regions of interest causes the **Minimum Intensity** value to fall within the limits you set.

9. Test the other images in the `Tutorial 2` folder. The following table lists the test images, inspection status to expect for each image, and an explanation of the status.

Table 2-1. Expected Results for the FieldPoint Label Inspection

Image Name	Inspection Status	Explanation
Image 03.jpg	PASS	The cap is present.
Image 04.jpg	PASS	The cap is present.
Image 05.jpg	FAIL	The cap is missing.

10. Click **OK** to add the step to the inspection.

Saving the Inspection

Save the example inspection with the following name and description.

- **Inspection Name**—Lesson 2
- **Description**—This inspection checks for the presence of a cap on a spray bottle using an intensity measurement and a coordinate system that is based on pattern matching.

Refer to the *Saving an Inspection* section of Chapter 1, *Getting Started in Vision Builder AI*, for more information.

Inspecting Objects for Correct Measurements

This chapter introduces the **Calibrate Image**, **Detect Objects**, and **Geometry** steps. Follow the instructions in this chapter to create an inspection that measures the distance between holes in a gasket to verify that the gasket conforms to manufacturing specifications.



Note Launch Vision Builder AI if it is not open. Refer to the *Opening the Vision Builder AI Configuration Interface* section of Chapter 1, *Getting Started in Vision Builder AI*, for more information.

Creating a New Inspection

Select **File»New**. Vision Builder AI loads a new, blank inspection into the inspection diagram window.

Simulating Image Acquisition

Follow these instructions to configure a **Simulate Acquisition** step that simulates acquiring images of gaskets.

1. In the inspection steps palette, select the **Acquire Images** tab.
2. Click the **Simulate Acquisition** step. The property page for the step appears.
3. In the **Step Name** control, enter `Acquire Gasket`.
4. Click the **Browse** button. The **Select an Image File** dialog box appears.
5. Navigate to `<Vision Builder AI 1.0>\DemoImg\Tutorial 3`.
6. Select the first image, `Image 01.jpg`, and click **Open**.
7. Make sure the **Cycle Through Folder Images** control is enabled so that Vision Builder AI loads a different simulation image from the folder each time the step is run.
8. Click **OK** to add the step to the inspection.



Browse

Calibrating Images

By default, Vision Builder AI returns measurements in pixel units. If you want the inspection to return measurements in real-world units, you need to map pixel units to real-world units through a process called *spatial calibration*.

Follow these instructions to configure a **Calibrate Image** step that defines the type of calibration, the calibration parameters, and the real-world unit in which you want to express measurements.

1. In the inspection steps palette, select the **Enhance Images** tab.
2. Click the **Calibrate Image** step. The calibration wizard appears.

For this example, assume that the camera that acquired the inspection images is perpendicular to the image plane and lens distortion is negligible. Based on these assumptions, you can use **Simple Calibration** to calibrate your images. **Simple Calibration** transforms a pixel coordinate to a real-world coordinate through scaling in the x (horizontal) and y (vertical) directions.

3. Double-click **Simple Calibration** to open the **Simple Calibration Setup** dialog box. **Step 1 of 3** appears.
4. Make sure **Pixel Type** is set to **Square** because the camera that acquired the images for this exercise has square pixels.
5. Click **Next**.
6. In **Step 2 of 3**, carefully click the 0 mm and 50 mm markings on the ruler in the image, as shown in Figure 3-1.



Tip You may need to scroll down to see the ruler at the bottom of the image.

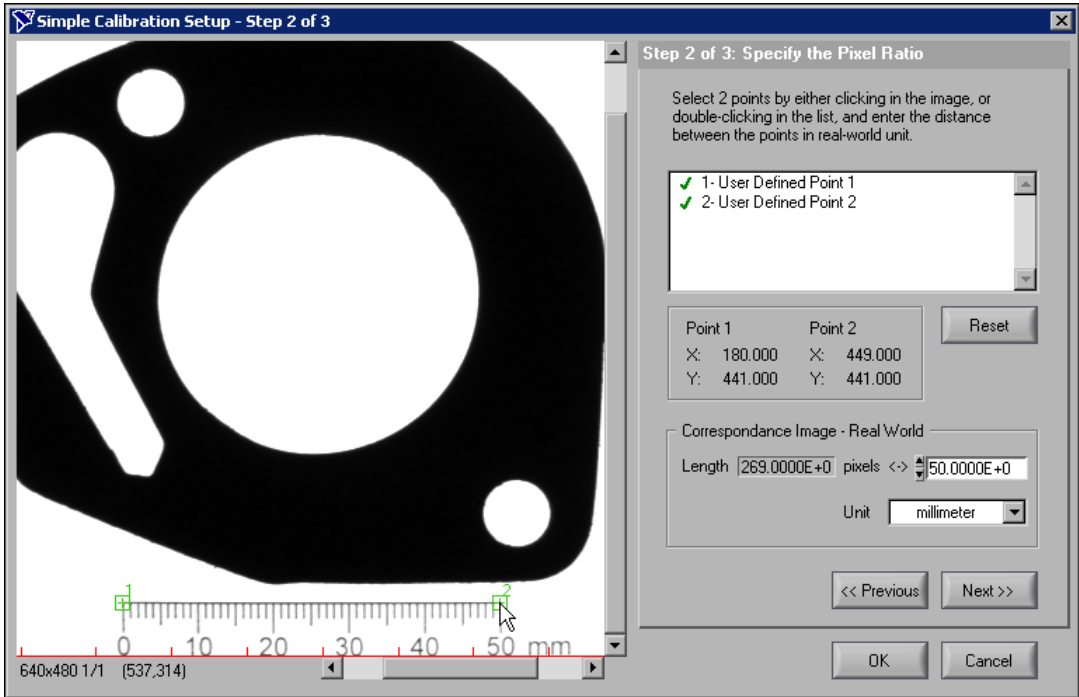


Figure 3-1. Specifying the Pixel Ratio

7. In the **Correspondence Image - Real World** control, enter 50 for the value, and select **millimeter** for the **Unit**.
8. Click **Next**.

In **Step 3 of 3**, you can define the origin and angle of the calibration axis anywhere in the image. By default, the bottom, left pixel in the image is the calibration axis origin, and the horizontal axis of the image is the calibration axis angle. Use the default calibration axis settings for this exercise.



Tip In some applications, you may want to measure between a fixed reference feature on the part and other features in the image. Setting the origin of the calibration axis to the location of the reference feature simplifies making measurements because the starting point for the measurements becomes 0.

9. Click **OK** to exit the calibration wizard.

10. In the **Main** tab of the **Calibrate Image** property page, enter Calibrate Gasket in the **Step Name** control.
11. Click **OK** to add the step to the inspection.

Locating Features to Measure

Follow these instructions to configure a **Detect Object** step that finds small holes in the gasket.

1. In the inspection steps palette, select the **Locate Features** tab.
2. Click the **Detect Objects** step. The property page for the step appears.
3. In the **Step Name** control, enter Detect Small Holes.
4. Using the default **Rectangle Tool**, draw a region of interest around the entire gasket, as shown in Figure 3-2.



Rectangle Tool

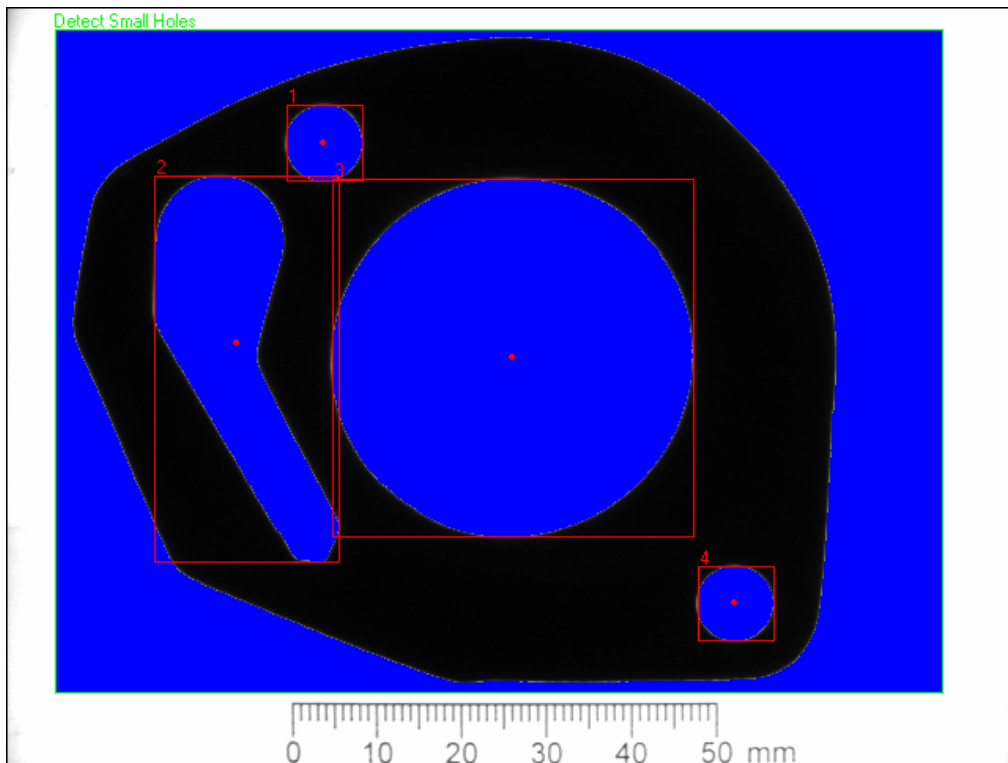


Figure 3-2. Defining the Region of Interest

5. In the **Threshold** tab, select the **Bright Objects** control.
Notice that the blue shading highlights all bright pixels—pixels with high intensity values that fall within the **Threshold Range**—in the region of interest. Vision Builder AI groups contiguous highlighted pixels into *objects*, which are depicted by red bounding rectangles.
6. Click the **Settings** tab.
The step locates four objects, which are listed in Table 3-1.

Table 3-1. Sizes of Gasket Holes

Object Number	Size (pix ²)	Size (mm ²)
1	1,808	62.46
2	13,351	461.26
3	40,816	1,410.15
4	1,782	61.57

Object 1 and **Object 4** are the small holes of interest in this step. Use the **Minimum Object Size** and **Maximum Object Size** controls of the **Detect Objects** step to eliminate objects of no interest based on their size.

7. Enable the **Minimum Object Size** and **Maximum Object Size** controls.

Based on the information in Table 3-1, the small holes have sizes of 62.46 mm² and 61.57 mm².

8. Set **Minimum Object Size** to 50 and **Maximum Object Size** to 70.
9. In the **Limits** tab, enable the **Minimum Number of Objects** and **Maximum Number of Objects** controls. Set their values to 2.
10. Click **OK** to add this step to the inspection.

Follow these instructions to find the large hole in the gasket:

1. Right-click the **Detect Small Holes** step in the inspection diagram window. A shortcut menu appears.
2. Select **Copy**.
3. Right-click the **Detect Small Holes** step again.
4. Select **Paste**. A copy of the **Detect Small Holes** step appears after the original step.



Edit Step

5. Double-click the **Detect Small Holes** copy or click the **Edit Step** button to launch the property page of the step for editing.
6. In the **Step Name** control, enter `Detect Large Hole`.
7. Select the **Settings** tab.

Based on the information in Table 3-1, the large hole has a size of 1410 mm².

8. Set **Minimum Object Size** to 1300 and **Maximum Object Size** to 1450.
9. In the **Limits** tab, enable the **Minimum Number of Objects** and **Maximum Number of Objects** controls. Set their values to 1.
10. Click **OK** to update the inspection.



Note Vision Builder AI returns the centers of mass for the holes as their locations.

Measuring Parts of the Gasket

Follow these instructions to measure the distance from the top small hole to the large hole to inspect whether the distance meets specifications.

1. In the inspection steps palette, select the **Measure Features** tab.
2. Click the **Geometry** step. The property page for the step appears.
3. In the **Step Name** control, enter `Top Distance`.
4. In the **Geometric Feature** control, select the **Distance** measurement.
5. Select points **1** and **3** by clicking the points in the image or selecting the points from the **Available Points** list.
6. In the **Limits** tab, enable the **Minimum Distance** control and set it to 32. Enable the **Maximum Distance** control and set it to 35.
7. Click **OK** to add the step to the inspection.



Distance Measurement

Follow these instructions to measure the distance from the large hole to the bottom small hole to inspect whether the distance meets specifications.

1. In the inspection steps palette, select the **Measure Features** tab.
2. Click the **Geometry** step. The property page for the step appears.
3. In the **Step Name** control, enter `Bottom Distance`.
4. In the **Geometric Feature** control, select the **Distance** measurement.
5. From the **Available Points** list, select **2** and **3**, which correspond to the bottom small hole and large hole, respectively.

6. In the **Limits** tab, enable the **Minimum Distance** control and set it to 38. Enable the **Maximum Distance** control and set it to 40.
7. Click **OK** to add the step to the inspection.

Testing the Inspection

Test the inspection to make sure it returns the results you expect. The following table lists the test images, the inspection status to expect for each image, and an explanation of the status.

Table 3-2. Expected Results for the Gasket Inspection

Image Name	Inspection Status	Explanation
Image 01.jpg	PASS	All steps passed.
Image 02.jpg	PASS	All steps passed.
Image 03.jpg	PASS	All steps passed.
Image 04.jpg	FAIL	The Top Distance step failed because the distance between the holes is too small.
Image 05.jpg	FAIL	The Detect Small Holes step failed because the bottom hole is missing. The missing hole also caused the Bottom Distance step to fail.

Refer to the [Testing an Inspection Step](#) in Chapter 1, [Getting Started in Vision Builder AI](#), for more information.

Saving the Inspection

Save the example inspection with the following name and description:

- **Inspection Name**—Lesson 3
- **Description**—This inspection locates holes in a gasket and measures the distance between the holes.

Refer to the [Saving an Inspection](#) section of Chapter 1, [Getting Started in Vision Builder AI](#), for more information.

Inspecting for Multiple Correct Instances of an Object

This chapter introduces the **Find Straight Edge, Caliper**, and **Decision Making** steps. Follow the instructions in this chapter to create an inspection that measures the distance between the blade connectors of a fuse and checks the integrity of the fuse conductor regardless of the fuse position or whether the fuse is inverted.



Note Launch Vision Builder AI if it is not open. Refer to the *Opening the Vision Builder AI Configuration Interface* section of Chapter 1, *Getting Started in Vision Builder AI*, for more information.

Creating a New Inspection

Select **File»New**. Vision Builder AI loads a new, blank inspection into the inspection diagram window.

Simulating Image Acquisition

Follow these instructions to configure a **Simulate Acquisition** step that simulates acquiring images of fuses.

1. In the inspection steps palette, select the **Acquire Images** tab.
2. Click the **Simulate Acquisition** step. The property page for the step appears.
3. In the **Step Name** control, enter `Acquire Fuse`.
4. Click the **Browse** button. The **Select an Image File** dialog box appears.
5. Navigate to `<Vision Builder AI 1.0>\DemoImg\Tutorial 4`.
6. Select the first image, `Image 01.jpg`, and click **Open**.



Browse

7. Make sure the **Cycle Through Folder Images** control is enabled so that Vision Builder AI loads a different simulation image from the folder each time the step is run.
8. Click **OK** to add the step to the inspection.

Defining a Feature on Which to Base a Coordinate System

The fuses can appear shifted horizontally and slightly rotated from one inspection image to another. Follow these instructions to configure a **Find Straight Edge** step that finds the left edge of the fuse so that regions of interest in subsequent steps can shift with the fuse.

1. In the inspection steps palette, select the **Locate Features** tab.
2. Click the **Find Straight Edge** step. The property page for the step appears.
3. In the **Step Name** control, enter `Locate Fuse Left Edge`.
4. Draw a region of interest across the left edge of the fuse, as shown in Figure 4-1.

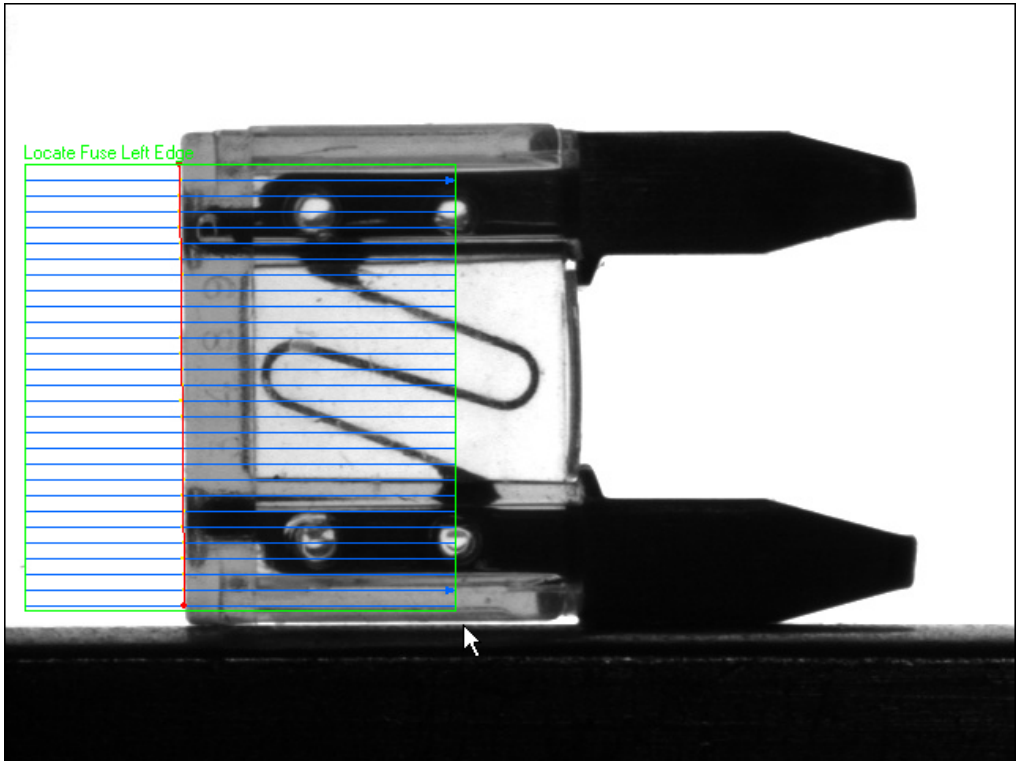


Figure 4-1. Finding a Straight Edge

Notice that the region contains blue search lines. The step searches along the search lines for sharp transitions in pixel intensities, which usually represent object edges. The step fits a straight line through the individual detected edge points of each search line to determine the left edge of the fuse.

5. Click **OK** to add this step to the inspection.

Setting a Coordinate System

Follow these instructions to configure a **Set Coordinate System** step based on the **Find Straight Edge** step you configured.

1. In the inspection steps palette, select the **Locate Features** tab.
2. Click the **Set Coordinate System** step. The property page for the step appears.



Horizontal Motion

3. In the **Main** tab, enter `Coordinate System` in the **Step Name** control.
4. In the **Settings** tab, select **Horizontal Motion** from the **Mode** control.

Notice the **Origin** list. **Point 1**, the first point of the straight line detected by the **Locate Fuse Left Edge** step, is the default origin of the coordinate system. In this exercise, the location of the origin does not affect the measurement you need to make. Therefore, use the default origin.

5. Click **OK** to add this step to the inspection.

Measuring the Separation between Connectors

Follow these instructions to configure a **Caliper** step that measures the distance between the blade connectors of the fuse.

1. In the inspection steps palette, select the **Measure Features** tab.
2. Select the **Caliper** step. The property page for the step appears.
3. In the **Main** tab, enter `Separation` in the **Step Name** control.
4. Enable the **Reposition Region of Interest** control.
5. Draw a region of interest across the blade connectors, as shown in Figure 4-2.

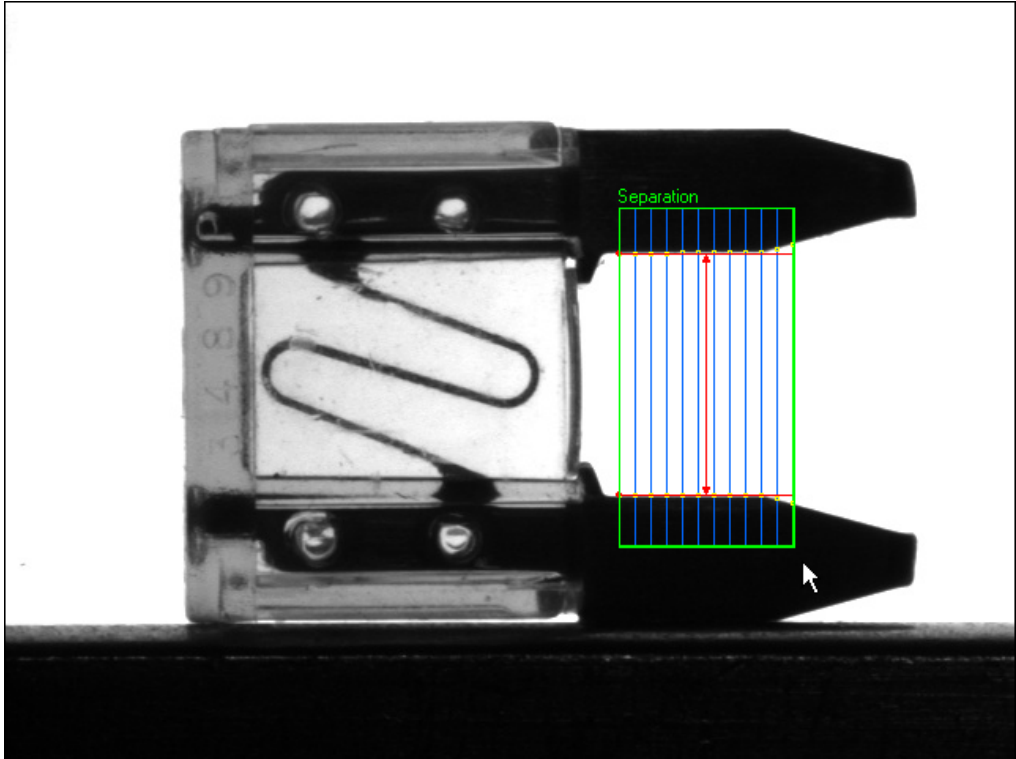


Figure 4-2. Measuring the Distance Between Two Edges



Vertical Min Caliper

6. In the **Settings** tab, select the **Process** named **Vertical Min Caliper** to change the direction and orientation of the caliper search lines.
7. In the **Limits** tab, enable the **Minimum Distance (Pixels)** control and set the value to **150**. Enable the **Maximum Distance (Pixels)** control and set the value to **160**.
8. Click **OK** to add this step to the inspection.

Inspecting the Fuse Conductor

Follow these instructions to configure **Match Pattern** steps that inspect the integrity of the fuse conductor.

1. In the inspection steps palette, select the **Locate Features** tab.
2. Click the **Match Pattern** step. A dialog box appears.

3. Draw a region of interest around the conductor, as shown in Figure 4-3. This region becomes the pattern matching template.

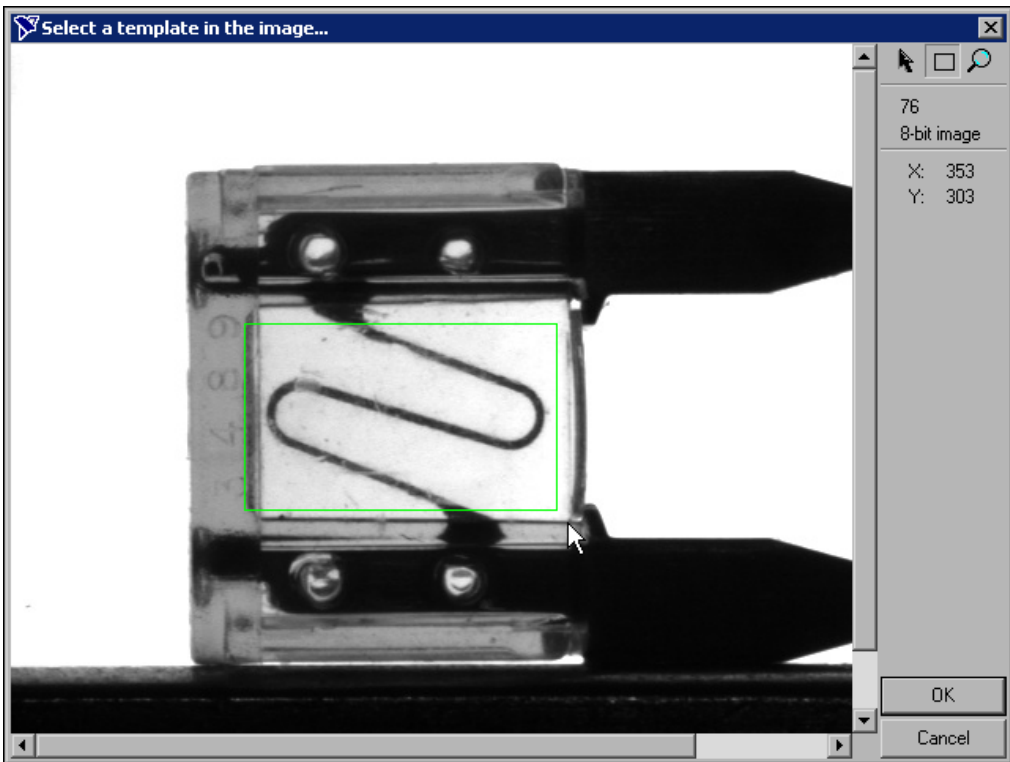


Figure 4-3. Creating a Template Pattern

4. Click **OK** to accept the template.
5. In the **Main** tab, enter `Match Conductor 1` in the **Step Name** control.
6. Make sure the **Reposition Region of Interest** control is enabled.
7. Redraw or decrease the default green region of interest so that it surrounds an area slightly larger than the template, as shown in Figure 4-4.

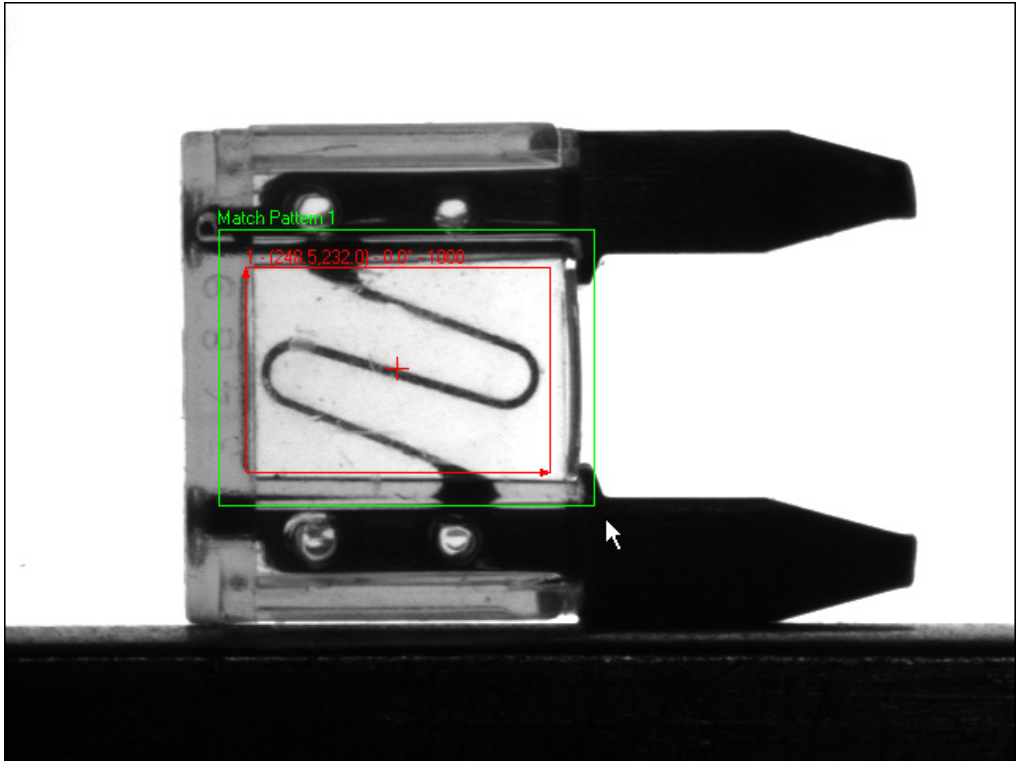


Figure 4-4. Limiting the Search Region

8. In the **Settings** tab, set **Number of Matches to Find** to **1**.
9. Enable the **Search for Rotated Patterns** control.
10. Set the **Angle Range +/- (degrees)** control to **10** to enable the step to locate the best match possible within $\pm 10^\circ$ of the learned template angle.
11. In the **Limits** tab, enable the **Minimum Number of Matches** control and set the value to **1**.
12. Click **OK** to add the step to the inspection.
13. Click the **Run Once** button twice so that `Image_03.jpg` becomes the active image.



Run Once



Note The name of the active image is displayed in the **Simulate Acquisition** module of the inspection diagram.

A fuse may be inverted when Vision Builder AI acquires an image of the fuse. This inversion causes the conductor to look different than the template, shown in Figure 4-5a. To prevent a good but inverted fuse from failing inspection, you need to learn a pattern matching template for the inverted instances of the conductor as well, shown in Figure 4-5b.

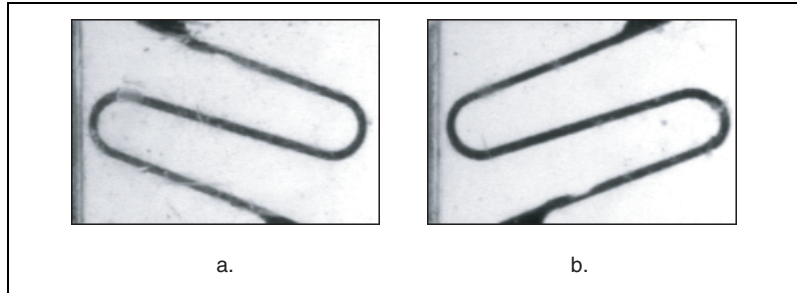


Figure 4-5. Valid Templates for the Conductor



Edit Step

14. Copy and paste the **Match Conductor 1** step.
15. Double-click the copy or click the **Edit Step** button to launch the step property page for editing.
16. In the **Main** tab, enter `Match Conductor 2` in the **Step Name** control.
17. In the **Template** tab, click **Create Template**. A dialog box appears.
18. Draw a region of interest around the conductor, similar to the region you drew in step 3.
19. Click **OK** to learn the inverted template.
20. Click **OK** to update the inspection.

Making Logical PASS/FAIL Decisions

Test the inspection using all of the images in the `Tutorial 4` folder. Notice that all of the images fail inspection. The images fail inspection because the **Match Conductor 1** and/or **Match Conductor 2** steps fail, or the **Separation** step fails.

By default, the **Inspection Status** is the logical AND of the **Step Status** of all the steps in the inspection. Because the conductor under inspection can match only one of the patterns you specified, one of the **Match Pattern** steps always fails, causing the entire inspection to fail.

Using the **Decision Making** step, you can create a Boolean result that is based on the results of the previous inspection steps. Vision Builder AI takes this Boolean result into account when determining the **Inspection Status**.

Follow these instructions to configure a **Decision Making** step that causes the inspection to pass when the conductor matches either the template in **Match Conductor 1** or **Match Conductor 2**, and the **Separation** step passes.

1. In the inspection steps palette, select the **Use Additional Tools** tab.
2. Click the **Decision Making** step. The property page appears in the main window.
3. Enter `Decision Making` in the **Step Name** control.
4. In the **First Operand** frame, set **Step** to **Separation**. Set **Measure** to **Pass/Fail Flag**.
Current Value displays the value of the measurement based on the current image.
5. Make sure **Second Operand** is set to **Constant**, and **Constant** is set to **True**.
6. Click **Add** to add this expression to the **Decision** table.
7. In the **First Operand** frame, set **Step** to **Match Conductor 1**. Set **Measure** to **Pass/Fail Flag**.
8. Make sure **Second Operand** is set to **Constant**, and **Constant** is set to **True**.
9. Click **Add** to add this expression to the **Decision** table.
 Notice the default binary operator **AND** in the last column of the **Decision** table.
10. In the **First Operand** frame, set **Step** to **Match Conductor 2**. Set **Measure** to **Pass/Fail Flag**.
11. Make sure **Second Operand** is set to **Constant** and **Constant** is set to **True**.
12. In the **Decision** table, click **Add** to add this expression to the **Decision** table.
13. Select the second expression, and click **AND/OR** to change the binary operator to **OR**.
14. Hold down <Shift>, and select the second and third expressions in the **Decision** table.
15. Click **()** to group the expressions.

The **Decision Making** property page should look like Figure 4-6.

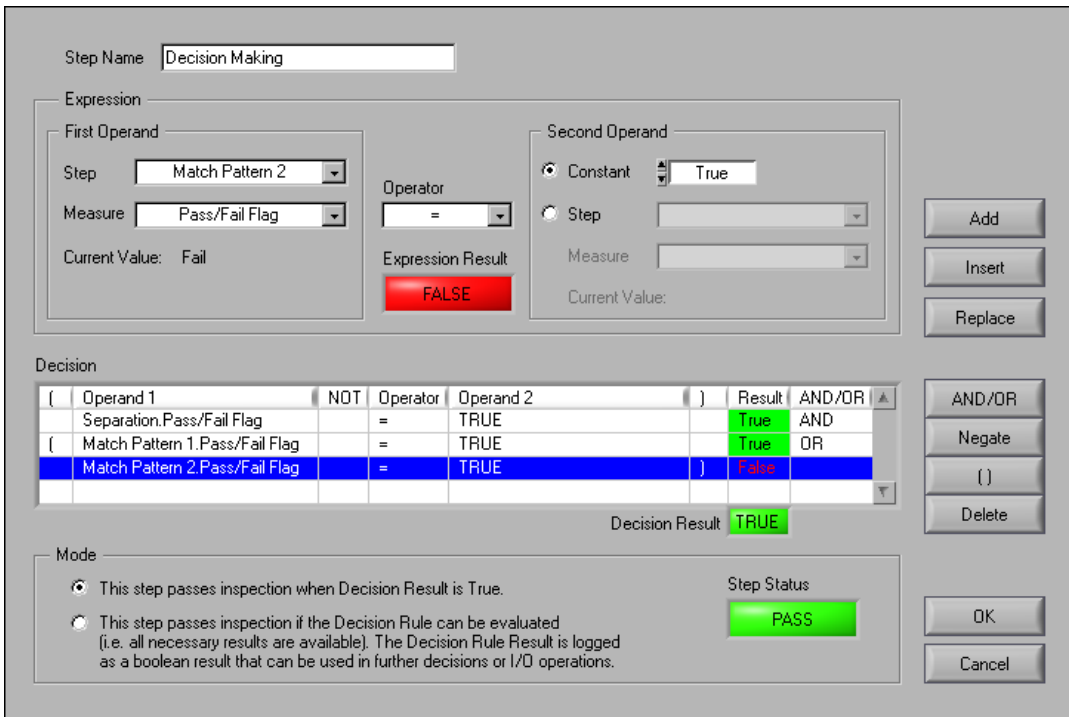


Figure 4-6. Decision Making Property Page

16. Click **OK** to add the step to the inspection.

Setting Global Decision Making Properties

Follow these instructions to configure Vision Builder AI to pass the inspection when the **Decision Making** step passes, regardless of the results of individual steps in the inspection.

1. Select **Tools»Configure Global Decision Making**. The **Global Decision Making Setup** dialog box appears.
2. Select **Inspection equals specified Decision Making step result**. **Decision Making** is the only **Decision Making Step** in the inspection and, therefore, is the default **Decision Making Step**.
3. Click **OK**.

Testing the Inspection

Test the inspection to make sure it returns the results you expect. Table 4-1 lists the test images, the inspection status to expect for each image, and an explanation of the status.

Table 4-1. Expected Results for the Gasket Inspection

Image Name	Inspection Status	Explanation
Image 01.jpg	PASS	All steps pass but one Match Pattern step.
Image 02.jpg	PASS	All steps pass but one Match Pattern step.
Image 03.jpg	PASS	All steps pass but one Match Pattern step.
Image 04.jpg	PASS	All steps pass but one Match Pattern step.
Image 05.jpg	PASS	All steps pass but one Match Pattern step.
Image 06.jpg	FAIL	The Separation step fails because the blade connectors are too close together.
Image 07.jpg	FAIL	Both Match Pattern steps fail because the conductor is blown.
Image 08.jpg	FAIL	Both Match Pattern steps fail because the conductor is melted.

Saving the Inspection

Save the example inspection with the following name and description:

- **Inspection Name**—Lesson 4
- **Description**—This inspection measures the distance separating the arms of a fuse and checks the integrity of the fuse filament.

Refer to the *Saving an Inspection* section of Chapter 1, *Getting Started in Vision Builder AI*, for more information.



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Glossary

Prefix	Meaning	Value
m-	milli-	10^{-3}

C

coordinate system A reference location (origin) and angle in an image that ROIs can relate to when positional and angular adjustments of the ROI are necessary. A coordinate system is depicted by two lines representing the orientation and direction of its two axes.

F

field of view Area of inspection that the camera can acquire as an image.

FieldPoint A modular distributed I/O system with industrial-grade performance.

focal point The pixel location in a pattern matching template whose coordinates are returned as the location of a match in the inspection image.

I

inspection A vision inspection application created in and ran from Vision Builder AI that can perform inline or offline visual inspections.

intensity The gray-level value of a pixel in a grayscale image.

M

match score A number ranging from 0 to 1,000 that indicates how closely an area of an acquired image matches the template image. A match score of 1,000 indicates a perfect match. A match score of 0 indicates no match.

O

object A connected region or grouping of pixels in an image in which all pixels have intensity levels in the same range.

P

pattern matching The technique used to quickly locate a grayscale template within a grayscale image.

pixel Picture element. The smallest division that makes up a digital image. For measurement tasks, optimum pixel dimensions are square (aspect ratio of 1:1, or the width equal to the height).

R

region of interest An area of the image that is graphically selected from a window displaying the image. This area can be used to focus further processing.

S

spatial calibration Assigning physical dimensions to the area of a pixel in an image.

step A component of a Vision Builder AI inspection that performs a specific visual inspection task or supporting tasks, such as decision making and serial communication.

T

template Pattern that you are trying to match in an image using the Match Pattern step. A template can be a region selected from an image or it can be an entire image.