IntelliGuide™ Vision Toolkit

User Manual

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Brooks Automation

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Revision History

Revision	ECO	Date	Action	Author
A	EC167577	September 25, 2025	Released manual at Rev. A to follow standard Brooks technical publication styles.	M. Ashenfelder

Table of Contents

1. Safety

Safety Setup

Brooks uses caution, warning, and danger labels to convey critical information required for the safe and proper operation of the hardware and software. Read and comply with all labels to prevent personal injury and damage to the equipment.

DANGER

Read the Safety Chapter

Failure to review the *Safety* chapter and follow the safety warnings can result in serious injury or death.

- All personnel involved with the operation or maintenance of this product must read and understand the information in this safety chapter.
- Follow all applicable safety codes of the facility as well as national and international safety codes.
- Know the facility safety procedures, safety equipment, and contact information.
- Read and understand each procedure before performing it.

Explanation of Hazards and Alerts

This manual and this product use industry standard hazard alerts to notify the user of personal or equipment safety hazards. Hazard alerts contain safety text, icons, signal words, and colors.

Safety Text

Hazard alert text follows a standard, fixed-order, three-part format.

- Identify the hazard
- State the consequences if the hazard is not avoided

- State how to avoid the hazard.

Safety Icons

- Hazard alerts contain safety icons that graphically identify the hazard.
- The safety icons in this manual conform to ISO 3864-1:2011 *Graphical symbols — Safety colours and safety signs* and ANSI Z535 standards.

Safety Icon Examples	
	Warning
	Two-Person Lift
	Electric Shock

Signal Words and Colors

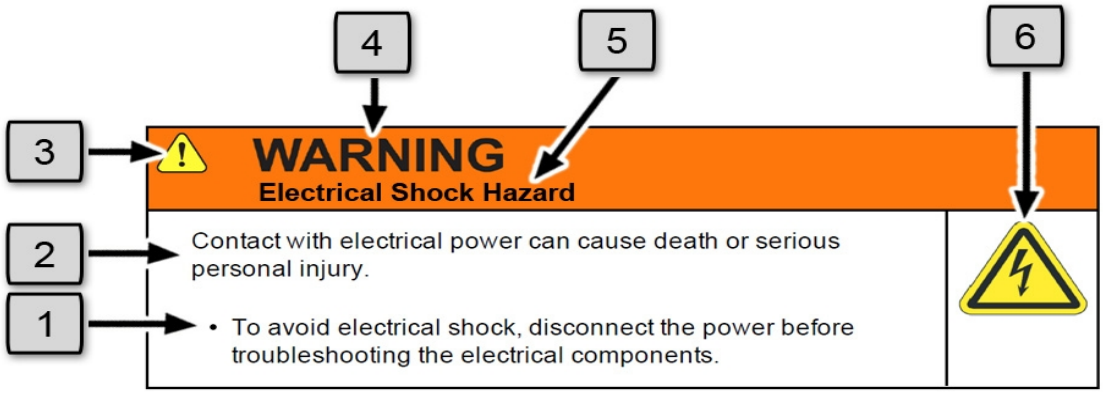
Signal words and colors inform of the level of hazard.

	Danger indicates a hazardous situation which, if not avoided, **will result in serious injury or death**. The Danger signal word is white on a red background with an exclamation point inside a yellow triangle with black border.

WARNING	Warning indicates a hazardous situation which, if not avoided, **could result in serious injury or death**. The Warning signal word is black on an orange background with an exclamation point inside a yellow triangle with black border.
CAUTION	Caution indicates a hazardous situation or unsafe practice which, if not avoided, **may result in minor or moderate personal injury**. The Caution signal word is black on a yellow background with an exclamation point inside a yellow triangle with black border.
NOTICE	Notice indicates a situation or unsafe practice which, if not avoided, **may result in equipment damage**. The Notice signal word is white on blue background with no icon.

Alert Example

The following is an example of a Warning hazard alert.



Number	Description
1.	How to Avoid the Hazard
2.	Source of Hazard and Severity
3.	General Alert Icon

Number	Description
4.	Signal Word
5.	Type of Hazard
6.	Hazard Symbol(s)

General Safety Considerations

WARNING

Software

Software is not safety rated. Unplanned motion can occur as long as power is supplied to the motors. Maximum torque could be momentarily applied that may cause equipment damage or personal injury.

- Only operate the robot with its covers installed.
- Guarantee that safety controller features are in place (for example, an emergency stop button and protective stop).
- Regularly test safety components to prove that they function correctly.

WARNING

Robot Mounting

Before applying power, the robot must be mounted on a rigid test stand, secure surface, or system application. Improperly mounted robots can cause excessive vibration and uncontrolled movement that may cause equipment damage or personal injury.

- Always mount the robot on a secure test stand, surface, or system before applying power.

WARNING

Do Not Use Unauthorized Parts

Using parts with different inertial properties with the same robot application can cause the robot's performance to decrease and potentially cause unplanned robot motion that could result in serious personal injury.

- Do not use unauthorized parts.
- Confirm that the correct robot application is being used.

WARNING

Magnetic Field Hazard

This product contains magnetic motors that can be hazardous to implanted medical devices, such as pacemakers, and cause personal harm or severe injury.

- Maintain a safe working distance of 30 cm from the motor when with an energized robot if you use a cardiac rhythm management device.

CAUTION

Unauthorized Service

Personal injury or damage to equipment may result if this product is operated or serviced by untrained or unauthorized personnel.

- Only qualified personnel who have received certified training and have the proper job qualifications are allowed to transport, assemble, operate, or maintain the product.

CAUTION

Damaged Components

The use of this product when components or cables appear to be damaged may cause equipment malfunction or personal injury.

- Do not use this product if components or cables appear to be damaged.
- Place the product in a location where it will not get damaged.
- Route cables and tubing so that they do not become damaged and do not present a personal safety hazard.

CAUTION

Inappropriate Use

Use of this product in a manner or for purposes other than for what it is intended may cause equipment damage or personal injury.

- Only use the product for its intended application.
- Do not modify this product beyond its original design.
- Always operate this product with the covers in place.

CAUTION

Seismic Restraint

The use of this product in an earthquake-prone environment may cause equipment damage or personal injury.

- The user is responsible for determining whether the product is used in an earthquake prone environment and installing the appropriate seismic restraints in accordance with local regulations.

Electrical Hazards

Refer to the specifications of the *Guidance Controller Quick Start Guide* for the electrical power.

DANGER

Electrical Shock Hazard

Contact with electrical power can cause personal harm and serious injury.

- To avoid electrical shock, disconnect the power before troubleshooting the electrical components.
- Check the unit's specifications for the actual system power requirements and use appropriate precautions.
- Never operate this product without its protection covers on.

WARNING

Electrical Burn

Improper electrical connection or connection to an improper electrical supply can result in electrical burns resulting in equipment damage, serious injury, or death.

- Always provide the robot with the proper power supply connectors and ground that are compliant with appropriate electrical codes.

WARNING

Electrical Fire Hazard

All energized electrical equipment poses the risk of fire, which may result in severe injury or death. Fires in wiring, fuse boxes, energized electrical equipment, computers, and other electrical sources require a Class C extinguisher.

- Use a fire extinguisher designed for electrical fires (Class C in the US and Class E in Asia).
- It is the facility's responsibility to determine if any other fire extinguishers are needed for the system that the robot is in.

NOTICE

Improper handling of the power source or connecting devices may cause component damage or equipment fire.

- Connect the system to an appropriate electrical supply.
- Turn off the power before servicing the unit.
- Turn off the power before disconnecting the cables.

Ergonomic Hazards

CAUTION

Heavy Lift Hazard

Failure to take the proper precautions before moving the robot could result in back injury and muscle strain.

- Use a lifting device and cart rated for the weight of the drive or arm.
- Only persons certified in operating the lifting device should be moving the product.

CAUTION

Tipover Hazard

This product has a high center of gravity which may cause the product to tip over and cause serious injury.

- Always properly restrain the product when moving it.
- Never operate the robot unless it is rigidly mounted.

CAUTION

Trip Hazard

Cables for power and communication and facilities create trip hazards which may cause serious injury.

- Always route the cables where they are not in the way of traffic.

Emergency Stop Circuit (E-Stop)

The integrator of the robot must provide an external emergency stop switch.

WARNING

Emergency Stop Circuit

Using this product without an emergency stop circuit may cause personal injury.

- Customer is responsible for integrating an emergency stop circuit into their system.
- Do not override or bypass the emergency stop circuit.

Recycling and Hazardous Materials

Brooks Automation complies with the EU Directive 2002/96/EU Waste Electrical and Electronic Equipment (WEEE).

The end user must responsibly dispose of the product and its components when disposal is required. The initial cost of the equipment does not include the cost of disposal. For further information and assistance in disposal, email Brooks Automation Technical Support at support_preciseflex@brooksautomation.com.

2. Overview

The IntelliGuide Vision Toolkit User Manual is intended for users of the IntelliGuide v23 and v60 grippers with the PreciseFlex family of robots. The tools presented in this guide are representative of a 2D machine-vision software package capable of acquiring images, locating workpieces, scanning a wide range of 1D and 2D barcodes, and localizing fiducial markers. Each of the basic vision functions is provided as a type of "tool" in the vision toolbox and is internally designed as a modern software "object."

IntelliGuide Vision executes on a Windows PC system embedded inside the gripper and is accessible through the *Guidance Development Studio (GDS)* software by Brooks Automation. This software package has been designed to operate with *Guidance Programming Language (GPL)*, which executes on a Brooks Guidance controller to produce flexible, vision-guided motion applications. GPL includes a complementary, built-in communications interface to IntelliGuide Vision and has classes and objects for easily controlling the operation of IntelliGuide Vision and retrieving vision results. A complete vision-guided robot application consists of a list of vision tools executing in IntelliGuide Vision and a GPL project executing on a Guidance controller that takes the vision results and utilizes this information to alter the actions of a robot.

For further information on programming a vision-guided PreciseFlex robot application in GPL, refer to the *Guidance Programming Language, Introduction to GPL* documentation. For more information on the UI and interaction with GDS, refer to the *Guidance Development Studio* documentation.

IntelliGuide v23 and v60 Grippers

IntelliGuide vision grippers have an integrated vision system with two 5 MP cameras (forward- and downward-facing), manually adjusted lenses, onboard processor, and PWM-controlled lighting. It is connected to the robot controller via Ethernet and is configured using Guidance Development Studio (GDS).

IntelliGuide vision grippers are calibrated and installed on PreciseFlex robots from the factory with a working distance of 150 mm.

Key Features:

- 1D/2D barcode reading for traceability
- AutoTeach for hands-off position teaching

- Object location and identification
- Classification for presence/absence tasks
- Onboard image processing

For more information on configuration and using the above key features, refer to the *IntelliGuide Gripper Users Manual*.

IntelliGuide Vision Toolkit Summary

The table below is a complete, quick reference to all of the accessible tools via IntelliGuide Vision in GDS. Comprehensive information on each of the tools will be displayed in subsequent chapters.

Vision Tool	Description
Acquisition Tool	Captures an image from a camera or loads it from a disk file, and stores the image into a frame buffer.
Arc Fitter Tool	Searches a specified region for arc edge points and returns the arc or circle that best fits the edges. Returns both the arc center point and radius.
Barcode Reader Tool	Reads a variety of standard 1D and 2D barcodes and returns the barcode type and the value of the barcode.
Blob Finder Tool	Searches a specified region for binary blobs and returns the centroid and other features of each blob. In addition, this tool can return data that defines the perimeter of any located blob.
Classifier Tool	Performs binary comparison of an image region of interest against a trained classifier model.
Clear Grip Tool	Verifies that there is no obstruction within the bounds of a defined window. Typically used to confirm that gripping a part will not result in a collision.
Color Pixel Window Tool	Tests if the general color of a rectangular or circular region matches a trained color within a specified tolerance. Also computes the mean HSV/HSI values for the region.
Edge Finder Tool	Detects edge points with sub-pixel accuracy along a linear path in a vision image and returns their positions. Alternately, this tool can return an array of the intensities along the linear path or a histogram of their values.
Fiducial Locator Tool	Finds all ArUco markers within a region of interest. Can be configured for various ArUco marker dictionaries.
Find Mid Tool	Searches a specified region for edge points and returns the centerline between two located bounding lines.

Vision Tool	Description
Fixed Frame Tool	Places a reference frame at a fixed image coordinate or at a constant offset relative to another vision object. Can optionally index the frame in an X and/or Y grid pattern to repeatedly execute any linked tools.
Image Process Tool	Performs image filtering, edge extraction, thresholding and morphological operations on a specified area in the camera image.
Light Control	Controls the LED lights on an IntelliGuide Vision gripper. Must be configured to work with either set of LEDs.
Line Fitter Tool	Searches a specified region for edge points and returns the line that best fits the edges.
Line-Line Frame Tool	Determines the intersection of two lines defined by vision objects and returns a reference frame. Alternately, computes and returns the midpoint of two reference frames defined by two vision objects.
Object Finder Tool	Performs general object location within a region of interest using a trained object finder model.
Pixel Window Tool	Counts edges or binary pixels or collects gray-scale statistics within a rotated rectangular or circular region. Used for quickly detecting the presence of features or collecting general intensity information about a region.
Point Finder Tool	Locates the edge point that is closest to the line that defines the start of the tool's search region. The XY position of the point is returned with sub-pixel accuracy along (and pixel accuracy perpendicular to) the search direction.
Point-Line Frame Tool	Takes a point and a line from two vision tools and returns a reference frame.
Point-Point Line Tool	Computes a line given two points from two vision tools.
Sensor Window Tool	Detects motion in a window region. Ensures the scene is stable prior to other operations or waits until motion is detected. Can be used in place of physical sensors in flexible parts feeding where parts can take time to settle.
Sharpness Detector Tool	Calculate the sharpness of edges and features within a region of interest.

3. IntelliGuide Vision Toolkit Descriptions

Standard Tool Properties

To simplify their application as much as practical, the vision tools make use of a common group of property names and associated operations. The following tables describe the standard tool properties that are common to many of the tools.

In these tables and the detailed tool descriptions, properties that are "read-only" have their name and data type dimmed. In addition, properties that have a counterpart property or method within the Guidance Programming Language include the GPL member name underlined and in italics bounded by square brackets preceded by "GPL:" and the class name, e.g. "[`GPL: Vision.ResultCount`]."

The Standard Identity properties in the table below specify the name of the tool and its basic tool type.

Property Name	Data Type	Range	Description
Name	**String**	N/A	This is the unique name that must be assigned to each instance (copy) of a general tool type. The name must follow the GPL variable naming conventions. That is, a name can be mixed case (upper and lower case characters) but when referenced by other tools, the names are not considered case sensitive (i.e. Abc and aBc refer to the same tool). Names must start with either a letter or an underscore "_" and can be followed by up to 127 additional letters, numbers, and underscores. *In GPL, this is the name by which a tool is referenced.*

Region of Interest

The *Placement/Size* properties in the table below define the position, orientation, and size of the tool in the coordinate system of the camera. If the tool is defined relative to another tool, the coordinates will be relative to the parent tool. Normally, it is easiest to graphically position and size each tool by dragging on the tool's handles displayed in the *Camera Display* window. In the range specifications, "AOI" is an abbreviation for "Area of Interest," and it refers to the size of the portion of the camera image that is being analyzed.

Property Name	Data Type	Range	Description
Angle	**Single**	-360 to 360	These values specify the orientation (in degrees) and the position (in pixel units) of the center of the vision tool in the coordinates of the vision image. These values are automatically updated when the tool is graphically re-positioned and re-oriented during training and if the vision tool is placed relative to another vision tool during runtime.
X Position	**Single**	0 - AOI (pixel)	
Y Position	**Single**	0 - AOI (pixel)	
Height	**Single**	0 - AOI (pixel)	These values define the height and width of the vision tool in pixel units. These values are automatically updated when the tool is adjusted with the mouse or can be manually entered for more precise adjustments.
Width	**Single**	0 - AOI (pixel)	

Operation Properties

The *Operation* properties in the table below define parameters that control the execution of the tool. For example, a tool might have an *Operation* property that defines if it should screen out black-to-white edges or the gray scale levels above which pixels are processed. Only the commonly used *Operation* properties are placed in this group.

Property Name	Data Type	Range	Description
Camera Number	**Integer**	1 - 2	Defines the number of the camera on which the tool operates.
Relative Tool	**List**	N/A	If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default tools are not relative to another tool and this property is blank.

Inspection Settings Properties

The *Inspection Settings* properties in the table below permit a single scalar result of the vision tool to be automatically tested (inspected) to verify that it is within limits. A *Pass/Fail* property is set accordingly, and a Pass/Fail label can be optionally displayed on the tool in the *Camera Display* window.

Property Name	Data Type	Range	Description
Inspection Type	**List**		Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select "None" to disable inspecting a result.

Property Name	Data Type	Range	Description
Inspection Label	**List**	None/Pass and Fail/Pass/ Fail/Real Value /Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the *Camera Display* window based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.
Inspection Maximum	**Single**		Maximum and minimum values permitted for the item specified in *Inspection Type* to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Minimum	**Single**		

Results Settings Properties

The Results Settings properties in the table below control the results that are computed by the vision tool. For example, if multiple sets of results can be computed by the tool, these properties can limit the number of sets of data computed and can select the set of data that is displayed in the Results properties.

Property Name	Data Type	Range	Description
Maximum Results	**Integer**	-1 or 1 to n	For tools that provide multiple sets of results, this property can limit the maximum number of sets of results that are computed and returned. A negative 1 (-1) indicates that all possible results should be collected.
Offset Angle	**Single**	Degrees	These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows repositioning of the results of a tool to a position and orientation that is more meaningful. The orientation change is in degrees and the shift is in pixel units. See the Fixed Frame Tool for an alternate method for implementing this offset.
Offset X	**Single**	Pixels	
Offset Y	**Single**	Pixels	
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Integer**		The scale to apply to the size of the result in the vision image display

Property Name	Data Type	Range	Description
Show Results	**List**	None/Point /Line/Frame	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Acquisition Tool

Vision tool that captures an image from a camera or loads it from a disk file and stores the image into a frame buffer. The table below shows the Acquisition Tool properties. For the IntelliGuide vision grippers, the **Acquire and Save**, **Play from Disk**, and **Save Only** options for the Acquire Mode property saves and reads images only from the embedded PC inside the gripper.

Prerequisites

None

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**	n/a	The camera the tool executes against
Name	**String**	n/a	The name of the tool instance
ADVANCED OPERATION			
Acquire Extension	**List**	BMP, PNG, JPG	Defines the type of file used when saving to disk or playing back an image from a disk file.
Acquire Max Save Images	**Integer**	0 - 99999	When the Acquire Mode is set to **Acquire and Save** or to **Save Only**, this property defines the total number of files that can be saved.

Property Name	Data Type	Range	Description
Acquire Mode	**List**	Normal Acquire, Acquire and Save, Clear Buffer, Play from Disk, Save Only	• **Normal Acquire** - acquires a single image from the specified camera and places it into a frame buffer. • **Acquire and Save** - performs the same operation as **Normal Acquire** and then saves the image to a disk file. • **Clear Buffer** - Sets all of the pixels in a buffer to the intensity value of zero. • **Play From Disk** - restores an image from a disk file. The disk file is specified by the Acquire Path and Acquire Prefix (see below). If there are multiple numbered image files with the prefix, each time the Vision Process is executed, the contents of the next sequential file will be copied to the image buffer. • **Save Only** - stores the contents of the current frame buffer to a disk file. This enables a GPL program to execute a vision process that saves selected frame buffers for later

Property Name	Data Type	Range	Description
			access.
Acquire Path	**String**	n/a	String that defines the path to the disk file when **Acquire Mode** is set to Acquire and **Save or Play from Disk**. If blank (""), the default path will be used. If the path does not contain a ':' (i.e. C:\...), `AcquirePath` will be appended to the path where the project files are stored
Acquire Prefix	**String**	n/a	String that defines the disk file name (excluding the extension) when Acquire Mode is set to **Acquire and Save** or **Play From Disk**. This string is combined with Acquire Path, a numerical index, and the file extension to generate the disk file name for saving or loading vision images.

Property Name	Data Type	Range	Description
Active Layer	**List**	Monochrome, Red Layer, Green Layer, Blue Layer	Specifies the type of data to be loaded into the image frame buffer for processing by subsequent vision tools. For grayscale cameras, only "Monochrome" image buffers are available and each pixel in the frame buffer has a value from 0 to 255 that defines its grayscale intensity. For color cameras, the frame buffer can be loaded with one of four types of data: monochrome, red, green or blue. The monochrome mode produces the same results as a grayscale camera. The red, green, and blue modes load the intensity data for a single color. For example, if **Red Layer** is selected, the image frame buffer will contain values that indicate the intensity (response) of only the red receptors of the camera. Tools that are applied to this image will only be operating on the red color layer of the camera. The one exception is

Property Name	Data Type	Range	Description
			the *Pixel Color Window* tool. When this tool is executed, it automatically accesses all three of the RGB color layers of an image and is unaffected by the setting of the `Active Layer` property.
Jpeg Quality	**Integer**	0-100	The Image quality for saving JPG images. From 0 to 100
Monochrome Display	**Boolean**	N/A	Does the image display as a monochrome image (true) or as a color image (false).
OPERATION			
Backlight Compensation	**Integer**	0-1	Backlight Compensation is a camera feature designed to improve image visibility when the subject is in front of a bright light source.
Brightness	**Integer**	0-15	Brightness controls the overall lightness or darkness of the image by adjusting the baseline intensity of all pixels. A middle of the range value indicates no-adjustment.
Contrast	**Integer**	0-15	Contrast controls the difference between the lightest and darkest parts of the image. It adjusts how much distinction there is between shadows and highlights.

Property Name	Data Type	Range	Description
Exposure	**Integer**	0-6	Exposure controls how long the camera sensor is exposed to light. The values can range from 0-6 where the times for each value are: • 0 = 0.00390625 • 1 = 0.0078125 • 2 = 0.015625 • 3 = 0.03125 • 4 = 0.0625 • 5 = 0.125 • 6 = 0.25
Gain	**Single**	0-9	Gain increases the brightness of the image by amplifying the signal from the image sensor.
Gamma	**Integer**	1-10	Gamma controls the nonlinear relationship between the input signal (sensor data) and the output brightness of the image. It adjusts mid-tone brightness without significantly affecting shadows or highlights.
Hue	**Integer**	-10 to +10	Changing the hue shifts the color to another point on the spectrum.

Property Name	Data Type	Range	Description
Saturation	**Integer**	0-15	Saturation controls the intensity or purity of colors in an image. Zero saturation results in a grayscale image. Higher values result in more vivid colors. Lower values result in more muted colors.
Sharpness	**Integer**	0-15	Sharpness in images refers to how clearly edges and fine details are defined. It affects how crisp or blurry an image appears.
WhiteBalance	**Integer**	2800-6500	White balance is a camera setting that adjusts the color temperature of an image so that white objects appear truly white under different lighting conditions.

Results Chart/List

The Acquire tool does not have any results.

Remarks/Best Practices

This tool performs a basic image capture operation and stores the image in a frame buffer. Consequently, this tool is normally the first tool in each Vision Process. To facilitate setting up a camera's gain, offset, and exposure, the camera image can also be continuously acquired and displayed in the *Camera Display* window. Most vision tools analyze the data stored in a frame buffer by an Acquisition tool, generate results, and leave the frame buffer unmodified. However, if an Image Process tool is executed (e.g. a low pass filter), the data stored in the frame buffer is altered so that all subsequent tools operate on the modified image data.

As a demonstration feature and an aid in remotely diagnosing problems, this tool can be used to easily store captured images to a disk file and to reload images stored to the disk. To store images, the Acquire Mode must be set to **Acquire and Save** or **Save Only**. To load files, the mode must be set to **Play From Disk**. For any of these modes, the disk file name is constructed by combining the Acquire Path with the Acquire Prefix and an optional numerical index followed by the selected file extension.

Each time that an Acquisition tool is executed with **Acquire and Save** or **Save Only** set, the system automatically increments the numerical index to create a new disk file. Likewise, each time that the Acquisition is executed with **Play From Disk**, the system automatically searches the file folder for the file with the next larger numerical index. This automatic indexing allows a series of images to be conveniently generated or replayed.

Arc Fitter Tool

Searches a specified region for arc edge points and returns the arc or circle that best fits the edges. Returns both the arc center point and radius.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest

Property Name	Data Type	Range	Description
Angular Size	**Single**		Specifies the angular size in degrees of the arc to be located. A value of 360 indicates that a complete circle is to be located. Values less than 360 specify that a partial circle (arc) is to be located.
Radius	**Single**		Specifies the nominal radius of the arc or circle to be located. This defines the mid-range value for the radius search.
Relative Tool	**String/List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default tools are not relative to another tool and this property is empty.
Search Radius Range	**Single**		This property defines the limits of the center point and radius search regions. The search region is centered about the XPos, YPos, and Radius values. So, if the `Radius` property is set to a value of N and the `SearchRadiusRange` is set to M, the radius can vary from N-M/2 to N+M/2, and the center point can vary by M in X and Y.

Property Name	Data Type	Range	Description
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
OPERATION			
Dark Outside	**Boolean**		Defines whether the pixels outside of the arc or circle are darker than the interior pixels. For example, to locate a circle with light interior pixels surrounded by darker pixels, this parameter must be set to `True`.
Edge Threshold	**Integer**		Specifies the threshold below which weak (low contrast) gradient edges are ignored. The lower this property is set, the more sensitive the system is in locating edges.
Find What	**List**	Center, Radius, Both	Defines if the radius should be fixed and only the center of the arc varied to find the best match or if the center is to be fixed and the radius varied or if both should be varied.

Property Name	Data Type	Range	Description
Use Which Edge	**List**	Middle Edges, Inner Edges, Outer Edges, Max Gradients	If multiple arcs exist within the search region, this parameter specifies which arc should be returned. The selected arc can be the one that is closest to the nominal radius, the arc closest to the minimum or maximum search radius, or the arc that has the greatest contrast (maximum gradients).
Maximum Edge Points	**Integer**		Maximum number of edge point searches to perform. Higher numbers produce greater accuracy at the expense of execution speed. The minimum value of this parameter is 3, and this value is automatically limited to the number of pixels across the width of the tool.
Maximum Iterations	**Integer**		Maximum number of iterations for filtering. The filtering algorithm repeatedly removes outlier points, refitting the arc each time until no more points need to be removed or the maximum number of iterations have occurred. A value of zero disables filtering.

Property Name	Data Type	Range	Description
Minimum Filter Distance	**Single**		Absolute minimum filter distance in pixels. No edge points closer to the fitted arc than this are discarded during the iterative process. A minimum distance is needed because the standard deviation of distances to the fitted arc can be less than a pixel with a good image of a clean edge.
Sigma Filter	**Single**		Filter width in units of standard deviations. This value is multiplied by the standard deviation of the edge points' distances to the fitted arc to compute the distance threshold beyond which edge points are removed during the iterative fitting process.
INSPECTION SETTINGS			

Property Name	Data Type	Range	Description
Inspection Label	**List**	None, Pass, Fail, Pass and Fail, Real Value, Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the Camera Display Window based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.
Inspection Maximum	**Single**		Maximum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Minimum	**Single**		Minimum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Type	**List**	None, RMS, Radius, Number of Edges Found, Number of Edges Used	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select "None" to disable inspecting a result.
RESULTS SETTINGS			

Property Name	Data Type	Range	Description
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees and the shift is in calibrated units (mm).
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees and the shift is in calibrated units (mm).
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display

Property Name	Data Type	Range	Description
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed
RMS	Root mean square of the arc fit
Edges Found	Number of edge points found
Edges Used	Number of edge points remaining after the filtering process.
Radius	Radius of the located arc

Remarks/Best Practices

The Arc Fitter searches the region defined by the Arc Region of Interest for edge points and fits an arc to the edge points using a least squares technique. By computing the edge positions to a sub-pixel accuracy and by employing multiple such edges in its computation, this tool is able to generate very accurate sub-pixel results.

This tool is very useful for accurately locating holes or curved edges of objects or fiducials. Once found, these fit arcs can be used to compute center points between important features, for generating reference frames that can accurately locate an object or features in an object or for measuring the diameters of holes.

To make this tool more discriminating, the Arc Fitter only utilizes edges whose dark and light sides have roughly the same orientation as the inner and outer boundaries of the region of interest. So, when positioning this tool, you should place the center (nominal) arc of the search region at approximately the position and orientation that you expect to find the arc with the inner region on the anticipated dark side of the object.

The operation of this tool is performed in two steps. First, all of the edges are extracted in the search region. Secondly, an arc is fit to the edges. Of the two operations, the tool spends most of its time extracting the edges. So, the speed and the accuracy of the Arc Fitter can be traded-off by adjusting Maximum Edge Points. This property determines how densely the tool scans to detect edges. This parameter must be set to at least 3 in order to detect the minimum number of edges to define an arc. At most, one edge search is performed for each pixel along the width of the Fitter. Execution time increases roughly in proportion to the value of Maximum Edge Points. On the other hand, the accuracy of the tools increases approximately as the square root of Maximum Edge Points. That is, if you increase Maximum Edge Points by a factor of 4, the tool execution time will quadruple but the accuracy will only double.

Once the edges are found, the Arc Fitter will optionally perform an iterative fitting process to increase the robustness of the results. During each pass, edge points that are too distant from the arc (outliers) are discarded. This filters out edges that are not a part of the arc and whose inclusion would incorrectly offset the result. Maximum Iterations specifies the maximum number of fits to perform. After each arc fit, edges that are beyond Sigma Filter standard deviations are rejected, unless the edge is within Minimum Filter Distance pixels of the fit arc. The iterative process stops if (1) Maximum Iterations are performed, (2) no further edges are discarded, or (3) only two edge points remain.

At the conclusion of this tool, the center position and radius of the best fit arc is returned along with statistical data on the number of edges finally used and the root mean square of the arc fit, which indicates the quality of the final fit. This statistical data can be tested via the "Inspect Settings" to yield a pass/fail indication for the operation..

Barcode Reader Tool

Reads a variety of standard 1D and 2D barcodes and returns the barcode type and the value of the barcode.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter Chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Height	**Single**		The height of the region of interest
Width	**Single**		The width of the region of interest
Relative Tool	**String/List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.
X Position	**Single**		The X coordinate of the center of the region of interest

Property Name	Data Type	Range	Description
Y Position	**Single**		The Y coordinate of the center of the region of interest
1D CODES			
Codabar	**Boolean**		Codabar is a linear, symbioses barcode that represents data using a series of bars and spaces of varying widths. It was developed in 1972 and is commonly used in libraries, blood banks, and other similar applications.
Code 128	**Boolean**		Code 128 is a high-density linear barcode symbology defined in ISO/IEC 15417:2007
Code 39	**Boolean**		Code 39 (also known as Alpha39, Code 3 of 9, Code 3/9, Type 39, USS Code 39, or USD-3) is a variable length, discrete barcode symbology defined in ISO/IEC 16388:2007.
Code 93	**Boolean**		Code 93 is a barcode symbology designed in 1982 by Intermec to provide a higher density and data security enhancement to Code 39.

Property Name	Data Type	Range	Description
EAN 13	**Boolean**		European Article Number barcodes (13 digits) are used worldwide for lookup at retail point of sale, but can also be used as numbers for other purposes such as wholesale ordering or accounting.
EAN 8	**Boolean**		European Article Number barcodes (8 digits) are used worldwide for lookup at retail point of sale, but can also be used as numbers for other purposes such as wholesale ordering or accounting
GS1 Databar	**Boolean**		The family of GS1 Databar barcodes, formerly known as Reduced Space Symbology (RSS-14)
IMB	**Boolean**		The Intelligent Mail Barcode (IMB) is a 65-bar barcode for use on mail in the United States.
ITF	**Boolean**		Interleaved 2 of 5 (ITF) is a continuous two-width barcode symbology encoding digits. It is used commercially on 135 film, for ITF-14 barcodes, and on cartons of some products.

Property Name	Data Type	Range	Description
Pharmacode	**Boolean**		Pharmaceutical Binary Code used in the pharmaceutical industry as a packing control system.
UPC EAN Extensions	**Boolean**		Detect any UPC-EAN add on text in the result.
UPC-A	**Boolean**		Universal Product Code - format A, used for tracking commercial items.
UPC-E	**Boolean**		Universal Product Code - format E, used for tracking commercial items.
2D CODES			
Aztec	**Boolean**		Aztec-Code is a high-capacity 2D matrix barcode symbology. It can encode ASCII and extended ASCII characters. ISO/IEC 24778:2008 standard defines Aztec-Code.
Data Matrix	**Boolean**		A Data Matrix is a two-dimensional code consisting of black and white "cells" or dots arranged in either a square or rectangular pattern, also known as a matrix. The information to be encoded can be text or numeric data. Usual data size is from a few bytes up to 1556 bytes.

Property Name	Data Type	Range	Description
Maxicode	**Boolean**		MaxiCode is a public domain, machine-readable symbol system originally created by the United Parcel Service (UPS).
PDF-417	**Boolean**		The PDF417 is a 2D barcode. It is based on stacked barcodes.
QR Code	**Boolean**		A QR code (short for " quick-response code ") is a type of two-dimensional matrix barcode.
RESULTS SETTINGS			
Find All	**Boolean**		When enabled, find all barcodes visible in the image. ***NOTE:*** *Take care when looking for barcodes of differing formats. Some barcode formats are similar and can result in multiple detections with different codes for the same barcode pattern.*
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Font Size	**Integer**		The font size of the barcode displayed in the image
Show Barcode Result	**Boolean**		Show the barcode text as a result in the image display.

Property Name	Data Type	Range	Description
Show Results	**List**	None, Point, Line, Frame	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	The barcode text
Format	The format code associated with the barcode

Remarks/Best Practices

This tool reads a variety of popular types of 1D and 2D barcodes. More than one barcode can be located within a single AOI and the barcodes can be of different types (although searching for multiple types of barcodes increases execution time). The value of the barcode as well as its type are returned by this tool and can optionally be displayed in the camera window on top of the identified barcode.

Blob Finder Tool

Searches a specified region for binary blobs and returns the centroid and other features of each blob. In addition, this tool can return data that defines the perimeter of any located blob.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter Chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest
Height	**Single**		The height of the region of interest
Width	**Single**		The width of the region of interest

Property Name	Data Type	Range	Description
Relative Tool	**String/List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
OPERATION			
Find Mode	**List**	Blobs, Blobs and Holes, Holes	Specifies if only blobs that have the correct ObjectColor are to be located or if blobs and/or holes are to be located. A hole is a region of the opposite ObjectColor that is contained within a blob. By default, only blobs are located.
Max Area	**Integer**		Specifies the maximum number of pixels that a valid blob must contain. Any blob that consists of a greater or lesser number of pixels will be ignored.

Property Name	Data Type	Range	Description
Min Area	**Integer**		Specifies the minimum number of pixels that a valid blob must contain. Any blob that consists of a greater or lesser number of pixels will be ignored.
Object Color	**List**	Light, Dark	After the image area is converted to binary, defines whether connected groups of black or white pixels should be considered as blobs.
Threshold	**Integer**		The threshold to apply when segmenting the image into a binary image.
ADVANCED OPERATION			
Ignore Clipped	**Boolean**		If "True," any blobs that are not completely inside of the Width and Height search area are ignored. If "False," even if a portion of a blob is clipped by the search area boundaries, it is still returned as a result.
Max Hole Area	**Integer**		Maximum number of pixels required before a hole in a blob is retained and not filled in.
Max Radius Length	**Single**		If this parameters is non-zero, the ResultMaxRadiusLength and the ResultMinRadiusLength of a blob must fall within these limits. Any blobs whose radiuses fall outside of this range will be ignored.

Property Name	Data Type	Range	Description
Min Hole Area	**Integer**		Minimum number of pixels required before a hole in a blob is retained and not filled in. If the minimum value is set to the total area of the image in pixels, holes will always be deleted.
Min Radius Length	**Integer**		If this parameters is non-zero, the ResultMaxRadiusLength and the ResultMinRadiusLength of a blob must fall within these limits. Any blobs whose radiuses fall outside of this range will be ignored.
Sample Rate	**Integer**		When the tool is set to return PERIMETER information, this properly specifies how many pixels to skip along the perimeter between each returned "result" position. A value of 0 will not skip any pixels and every perimeter point is returned.
INSPECTION SETTINGS			

Property Name	Data Type	Range	Description
Inspection Label	**List**	**None, Pass, Fail, Pass and Fail, Real Value, Integer Value**	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the *Camera Display* window based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.
Inspection Maximum	**Single**		Maximum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Minimum	**Single**		Minimum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."

Property Name	Data Type	Range	Description
Inspection Type	**List**	None, Num Blob Found, Max Radius, Min Radius, Max Radius Angle, Min Radius Angle, Major Axis Angle, Blob Area, Major Axis Length, Minor Axis Length, Premiter	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select "None" to disable inspecting a result.
RESULTS SETTINGS			
Maximum Result	**Integer**		For tools that provide multiple sets of results, this property can limit the maximum number of sets of results that are computed and returned. A negative 1 (-1) indicates that all possible results should be collected.
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display

Property Name	Data Type	Range	Description
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.
Result Mode	**List**	Blob Center, Max Radius, Min Radius, Major Axis, Minor Axis, Perimeter	The results to return with the detection
Result Sort	**List**	None, Max Area, Min Area, Center Most, Left Most, Right Most, Top Most, Bottom Most	The sorting to apply to detected results

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection

Result Name	Description
Insp. Actual	Actual property value that was tested by the tool Inspection.
Tool Status	Specifies if an error or warning condition occurred when the tool was executed.
Max Count	Total area of the blob in pixels excluding any holes within the blob.
Blob Area	Total area of the blob in pixels excluding any holes within the blob.
Min Radius Angle	Angle of the minimum radius for the blob. This radius is measured from the blob centroid to the point on the perimeter that is closest to the centroid.
Min Radius Length	Length of the minimum radius for the blob. This radius is measured from the blob centroid to the point on the perimeter that is closest to the centroid.
Max Radius Angle	Angle of the maximum radius for the blob. This radius is measured from the blob centroid to the point on the perimeter furthest from the centroid.
Max Radius Length	Length of the maximum radius for the blob. This radius is measured from the blob centroid to the point on the perimeter that is furthest from the centroid.
Major Axis Angle	Angle of the major axis of the best fit ellipse for the blob.
Major Axis Length	Length of the major axis of the best fit ellipse for the blob.
Minor Axis Angle	Angle of the minor axis of the best fit ellipse for the blob
Minor Axis Length	Length of the minor axis of the best fit ellipse for the blob
Blob Perimeter	The length of the perimeter of the blob.

Remarks/Best Practices

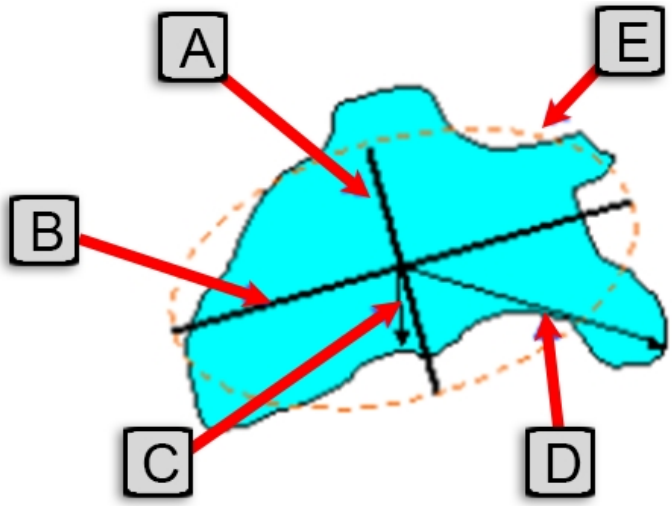
The blob finder tool performs a binary search of an image and groups adjacent pixels with the correct Object Color into blobs. Any blobs that do not satisfy the specified size limits as well as any interior blobs (i.e. blobs within blobs) are not returned. For all valid blobs, the position of their centroid and other key features are computed and returned as the results of this tool.

This tool locates multiple objects. This tool should be used for locating objects that do not have a fixed boundary and in applications that have high contrast with visually simple images. Parts that vary in size and shape are easily located using this tool. In addition, this tool has the ability to return the perimeter of any blob as a series of individual results points.

If the vision system must differentiate between objects that differ by subtle features, locate objects that touch other objects, locate objects that are not clearly differentiated from the background, or operate when thresholding may not be appropriate or robust, the Object Finder Tool should be utilized in place of the Blob Finder Tool.

Regarding the performance of the tool, even though this tool operates on binary images, the X & Y position of the centroid of blobs is normally accurate to within a fraction of a pixel. This is due to the fact that the centroid is computed by taking into consideration the positions of all of the perimeter pixels. In general, the larger the blob, the more accurate the centroid position. Consequently, the centroid position is a very good measure of where the blob is located.

In addition to the blob centroid, each blob has several other features computed as indicated in the following drawing.



Letter	Description
A	Minor axis
B	Major axis
C	Minimum radius
D	Maximum radius
E	Best-fit ellipse

These additional features can be used to determine the orientation of the blob. Depending upon the exact shape of the object, some of these features will be more useful than others. For example, if the blob is a rectangle, all four corners will be at the same maximum radius from the centroid, so the angle result can return any one of four values, all of which are correct. In many cases, the orientation of the major axis of the best-fit ellipse (Major Axis Angle) can provide a very good orientation estimation. But, it should be kept in mind that this parameter always has an 180° ambiguity due to the symmetry of an ellipse.

The Result Mode property selects which of the properties is utilized to compute the orientation of each blob or if the orientation is to be fixed (Blob Center).

If the Result Mode property is set to `Perimeter`, this tool returns a series of results, one for each desired point on the perimeter of each located blob. Each VisResult contains the X and Y position of a point on the perimeter with the orientation angle set to be perpendicular to the perimeter of the blob. In this mode, the Sample Rate specifies if some pixels on the perimeter are to be skipped. For example, if the Sample Rate is set to 3 and two blobs are located, the coordinates of every 3rd pixel on the perimeter of the first blob will be returned in the VisResult and Result Object Index will be set to 1. After the last perimeter position of the first blob is transmitted, every 3rd pixel of the perimeter of the second blob will be returned with the Result Object Index set to a value of 2..

Classifier Tool

Performs binary comparison of an image region of interest against a trained classifier model.

Prerequisites

This tool requires a classifier model that has already been trained and an acquisition tool that has filled the camera buffer with an image for processing.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**	n/a	The camera the tool executes against
Name	**String**		The name of the tool instance
OPERATION			
Model Name	**List**		The model name to use when performing classification
RESULTS SETTINGS			
Negative Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to display when negative results are detected
Positive Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to display when positive results are detected

Property Name	Data Type	Range	Description
Result Scale	**Double**		The scale to apply to the size of the result display

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed
Prediction	Was the image classified as positive (1) or negative (0)
Confidence	The confidence score representing the quality of the match against the model
Training Width	The width of the region used for classification
Training Height	The height of the region used for classification

Remarks/Best Practices

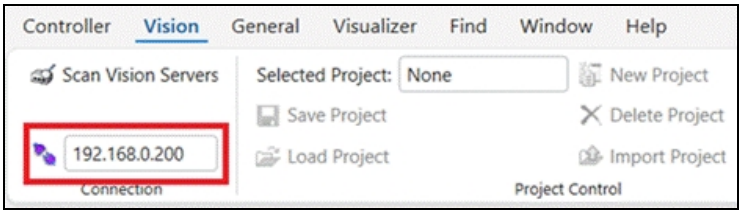
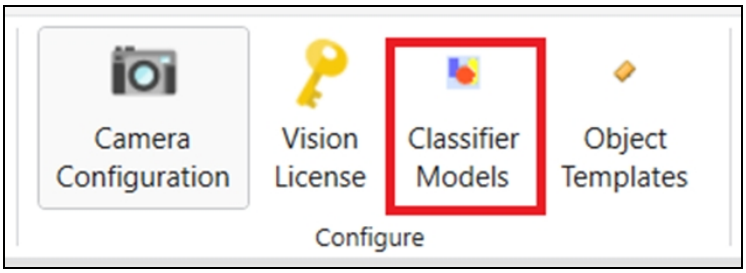
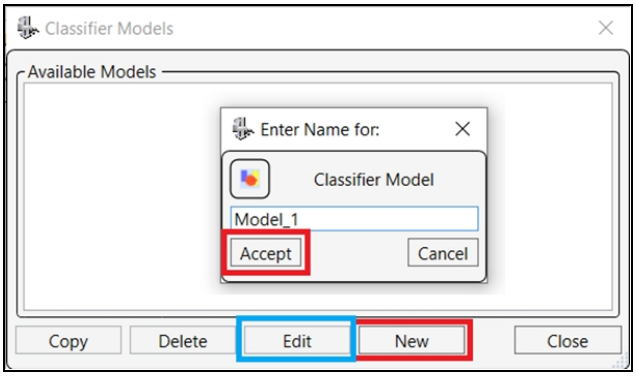
During the training phase, a Region of Interest (ROI) is first defined within each image to focus on the most relevant or salient areas. This helps eliminate background noise and ensures that only meaningful features are extracted. Within the ROI, both SIFT (Scale-Invariant Feature Transform) and HOG (Histogram of Oriented Gradients) features are computed and combined into a single feature vector. These vectors, along with their corresponding labels ("Yes" or "No"), are saved to a file for training.

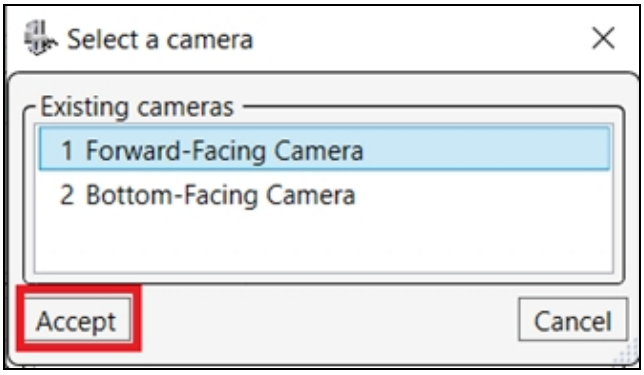
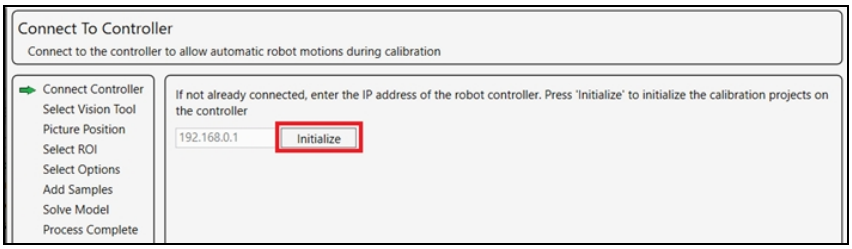
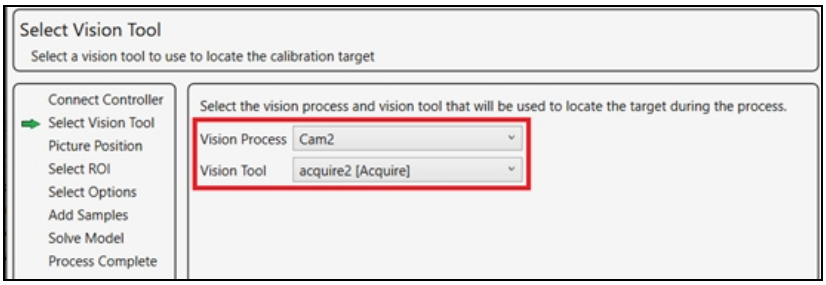
A Support Vector Machine (SVM) classifier is then trained on this dataset. The trained model is saved for later use. During prediction, the same ROI-based feature extraction process is applied to new images. The resulting feature vector is compared against the trained SVM model, which outputs a binary classification: "Yes" if the image matches the target class or "No" otherwise.

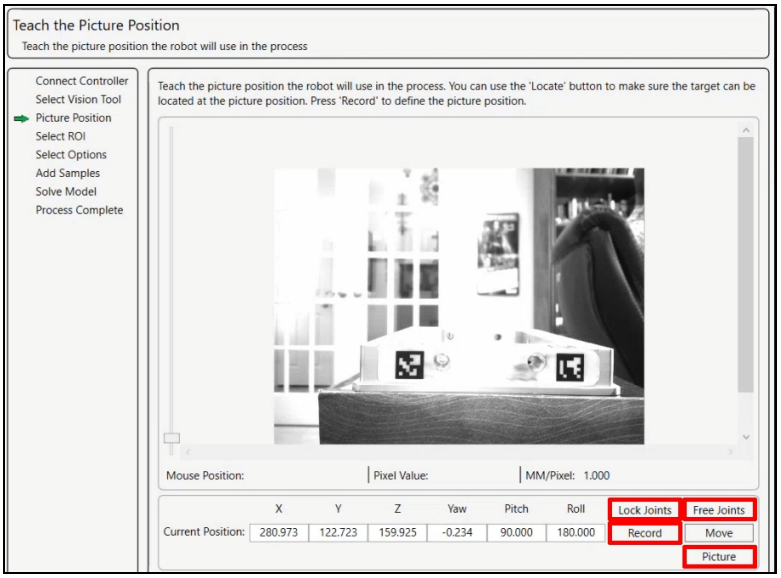
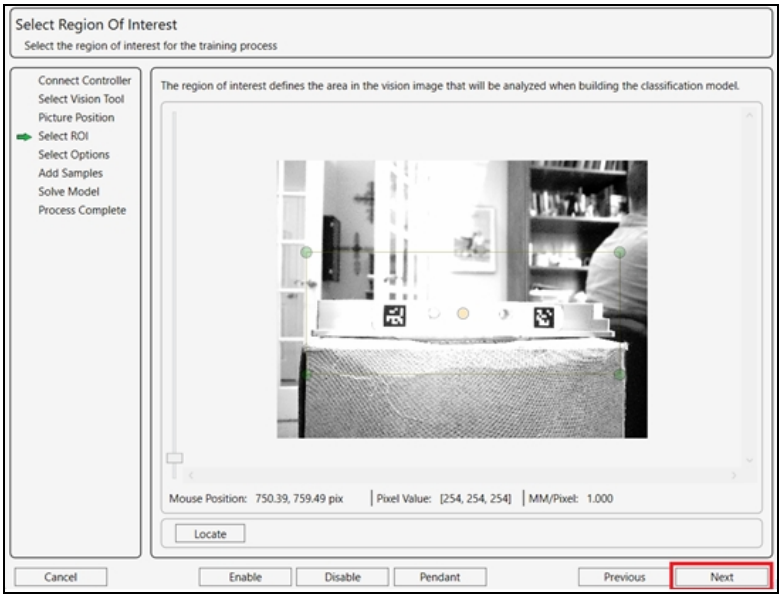
Training Process

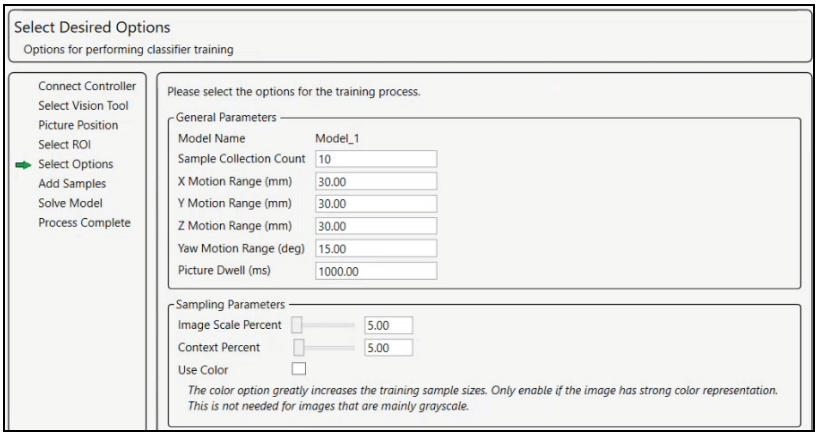
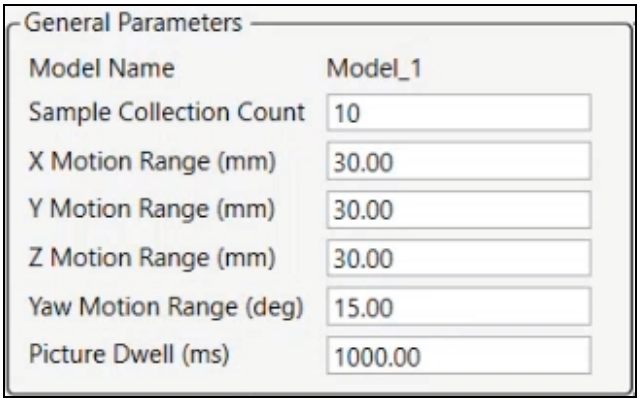
NOTE: If there are no existing Classifier Models, you must train an initial Classifier Model.

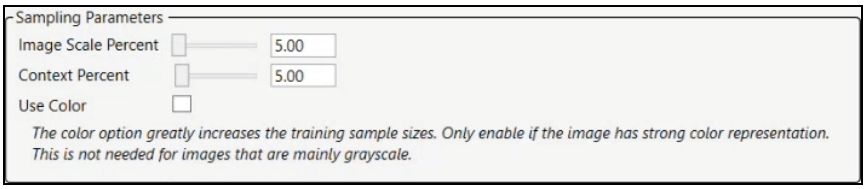
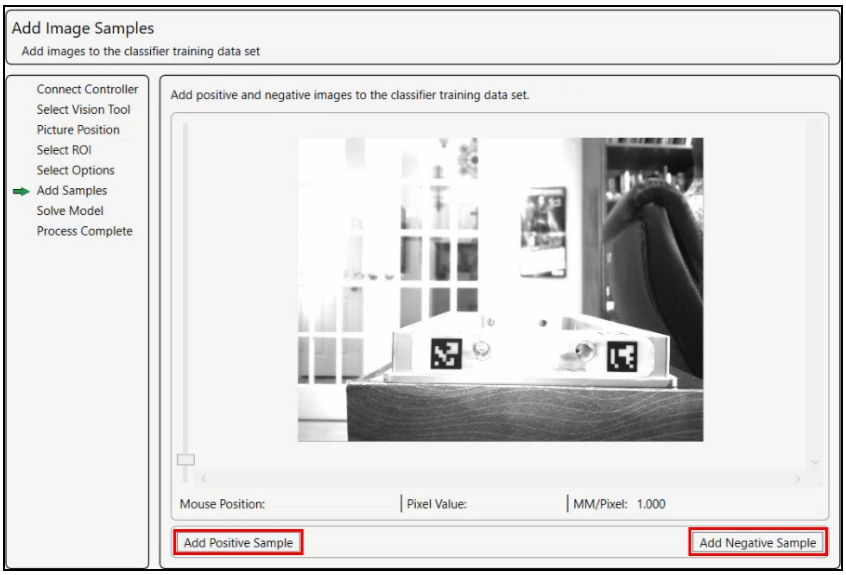
Follow the steps below to train a Classifier Model with GDS.

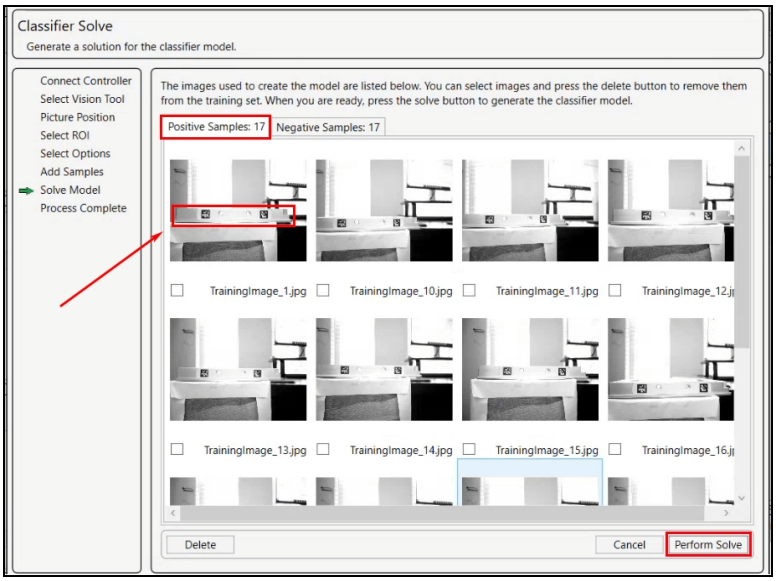
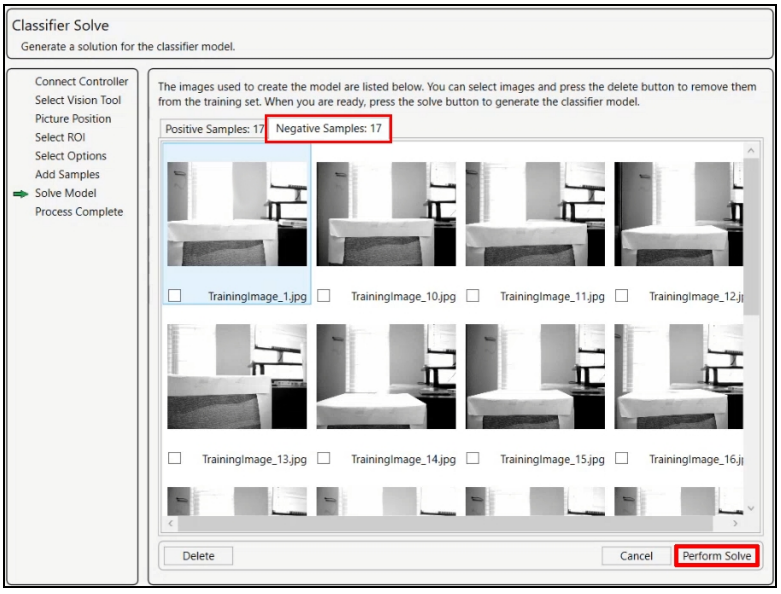
Step	Action
1.	Navigate to the **Vision** tab and click on the purple **Connection** button. 
2.	Click on the **Classifier Models** button. 
3.	In the *Classifier Models* window, click the **New** button, give the model a name, and click the **Accept** button. If a model already exists, click on the available model and click the **Edit** button to retrain the template. 

Step	Action
4.	In the *Select a Camera* window click on the camera identifier and click the **Accept** button. By default, the cameras names are "Cam1" and "Cam2" for the forward-facing and bottom-facing cameras, respectively. In this example, **Forward-Facing Camera** is selected. 
5.	In the *Classifier Training* window, click on the **Initialize** button to load the needed project files onto the controller for the rest of the training process. The wizard will then move onto the next step. 
6.	In the *Select Vision Tool* step, use the **Vision Process** drop-down menu to select a vision process that has been configured for the camera selected. If only one process exists, the drop-down menu will automatically select that process. Use the **Vision Tool** drop-down menu to select an Acquisition tool in the vision process. If only one Acquisition tool exists, the drop-down menu will automatically select that process. Click the **Next** button when finished. 

Step	Action
7.	In the *Picture Position* step, click the **Free Joints** button to position the camera in front of or above the workpiece. The distance between the workpiece and camera should beat the distance where the camera was focused. From the factory, this is 150 mm for IntelliGuide vision grippers. Click the **Lock Joints** button followed by the **Picture** button. If the picture is acceptable, click **Record** followed by **Next**. 
8.	In the *Select ROI* step, click the corners of the ROI tool and drag them to capture the workpiece. This will represent a specific area of the image that you want to analyze. The ROI defines the area in the picture that will be used when building the Classifier Model. Click **Next**. 

Step	Action
9.	In the *Select Options* step, you can adjust various parameters for capturing images to be used for the training process. The more variability that you add, the more reliable the Classifier Model will be in determining if the image it sees is Positive or Negative. The default settings are shown below. 
10.	For *General Parameters*, **Sample Collection Count** indicates that the robot will move to 10 different locations. From the starting point, the robot will move: • ± 30 mm in the **X-Motion Range MAX** • ± 30 mm in the **Y-Motion Range MAX** • ± 30 mm in the **Z-Motion Range MAX** • ± 30 degrees in the **Yaw-Motion Range MAX** • **Dwell** for 1000 ms before taking a picture sample The actual range of each individual move in X, Y, Z, and Yaw will be between 0 and the value set by these parameters. Each axis is scaled by a random number between 0 and 1, resulting in 10 random locations for example. 

Step	Action
11.	The *Sampling Parameters* window contains controls for scaling the image for the training process. Training with an image at 100% of its size will take more time than at a lower scale. Usually a range of 5% to 10% is a reasonable number. **Context percent** determines how much of the surrounding regions over and above the ROI customer selected will be used to add context to the image, which is useful for classifier algorithms. This is expressed as a percentage of the ROI size. 
12.	In the *Add Samples* step, you collect images to help train the Classifier Model. Click the **Add Positive Sample** or **Add Negative Sample** button, and images will be captured according to the parameters in the *Select Options* step. For example, for a workpiece presence/absence application, you may consider the absence of the workpiece in its fixture as a *positive* condition and anything other than its absence as a *negative* condition . 

Step	Action
13.	In the *Solve Model* step, you can select the *Positive Samples* and *Negative Samples* to be used for training the Classifier Model. The images below are examples of *Positive Samples* for the Classifier Model to be trained on. 
14.	The images below are examples of *Negative Samples* for the Classifier Model to be trained on. You can select and delete images. When finished selecting the *Positive Samples* and *Negative Samples*, click the **Perform Solve** button. 
15.	In the left column, select **Process Complete** when finished.

Clear Grip Tool

Verifies that there is no obstruction within the bounds of a defined window. Typically used to confirm that gripping a part will not result in a collision.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing. Typically this tool would be used with another location-based tool to search regions relative to the parent tool results.

Parameter Chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest
Height	**Single**		The height of the region of interest
Width	**Single**		The width of the region of interest
Relative Tool	**String/List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool, and this property is empty.

Property Name	Data Type	Range	Description
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
OPERATIONS			
Edge Threshold	**Integer**		Specifies the threshold below which weak (low contrast) gradient edges are ignored. The lower this property is set, the more sensitive the system is in locating edges.
INSPECTION SETTINGS			
Inspection Label	**List**	None, Pass, Fail, Pass and Fail, Real Value, Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the Camera Display Window based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.

Property Name	Data Type	Range	Description
Inspection Maximum	**Single**		Maximum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Minimum	**Single**		Minimum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Type	**List**	None, Edge Count	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select "None" to disable inspecting a result.
RESULTS SETTINGS			
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display

Property Name	Data Type	Range	Description
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed
Edge Count	Number of edge pixels found
Area	Total number of pixels in the tested rectangular region

Remarks/Best Practices

This tool specifies a rectangular region of an image and tests it to ensure that it is free of obstacles. This tool is typically used to verify that the fingers of a robot's gripper can reach in and pick up a part without hitting another part. This visual tool verifies that the region is clear by extracting edges within the region and counting the number of edge pixels. If an excessive number of edge pixels exist, this indicates that a part or obstruction is in the region..

The Clear Grip region is normally defined relative to another vision tool, e.g. an Object Finder, that is used to locate the part. In fact, it is common for two or more clearance regions to be defined for a part, one for each of the gripper's fingers. When the Clear Grip tool is processed, all of the pixels within the region whose gray-scale gradient value exceeds the Edge Threshold are counted as edge pixels. By setting the **Inspection Type** to **Edge Count**, if the number of edges falls outside of the **Inspection Maximum** and **Inspection Minimum** limits, this tool will signal a failure.

Color Pixel Window

Tests if the general color of a rectangular or circular region matches a trained color within a specified tolerance. Also computes the mean HSV/HSI values for the region.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest
Height	**Single**		The height of the region of interest

Property Name	Data Type	Range	Description
Relative Tool	**String/List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
Width	**Single**		The width of the region of interest
OPERATION			
Blue Tolerance	**Single**		Define the minimum match percentages that must be satisfied for this color comparison to return PASS. The color match is performed in the specified region between the mean intensity values for each RGB color layer and the corresponding trained mean values. Higher tolerance values require a better color match, and lower tolerance values will accept a greater deviation in the color match.

Property Name	Data Type	Range	Description
Green Tolerance	**Single**		Define the minimum match percentages that must be satisfied for this color comparison to return PASS. The color match is performed in the specified region between the mean intensity values for each RGB color layer and the corresponding trained mean values. Higher tolerance values require a better color match, and lower tolerance values will accept a greater deviation in the color match.
Red Tolerance	**Single**		Define the minimum match percentages that must be satisfied for this color comparison to return PASS. The color match is performed in the specified region between the mean intensity values for each RGB color layer and the corresponding trained mean values. Higher tolerance values require a better color match, and lower tolerance values will accept a greater deviation in the color match.
Tool Shape Type	**List**	Square, Round	Shape of the window in which the pixels are analyzed. A square window has its aspect ratio forced to 1:1.

Property Name	Data Type	Range	Description
ADVANCED OPERATION			
Hue Offset	**Single**		The computed hue value for the region (`ResultHSVI_Hue`) will range from 0° to 360° . Green will nominally be at 120°, blue at 240°, and red can be either 360° or 0°. To simplify testing for red, the HueOffset is added to the returned hue value to rotate the color represented by 0° . This can avoid a 0/360 discontinuity.
INSPECTION SETTINGS			
Inspect Nominal Blue	**Single**		These properties define the nominal mean values for the three color layers. These values are compared to the actual mean values for the color layers in the region of interest to determine if the color matches the expected value.
Inspect Nominal Green	**Single**		These properties define the nominal mean values for the three color layers. These values are compared to the actual mean values for the color layers in the region of interest to determine if the color matches the expected value.

Property Name	Data Type	Range	Description
Inspect Nominal Red	**Single**		These properties define the nominal mean values for the three color layers. These values are compared to the actual mean values for the color layers in the region of interest to determine if the color matches the expected value.
Inspection Label	**List**	None, Pass, Fail, Pass and Fail, Real Value, Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the *Camera Display Window* based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.
Inspection Type		None, Normalized, Fixed	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select **None** to disable inspecting a result.
RESULTS SETTINGS			

Property Name	Data Type	Range	Description
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection.

Result Name	Description
Tool Status	Specifies if an error or warning condition occurred when the tool was executed.
Mean Red	Mean red color value of pixels in specified region
Mean Green	Mean green color value of pixels in specified region
Mean Blue	Mean blue color value of pixels in specified region
% Red	Match percentage for the red color layer
% Green	Match percentage for the green color layer
% Blue	Match percentage for the blue color layer
Hue	Mean Hue (color) of the pixels in the specified region.
Saturation	Mean Saturation (intensity of the Hue) of the pixels in the specified region.
Value	Maximum lightness of the RGB colors in the specified region
Intensity	Mean lightness or darkness of the color in the specified region. This is the average of the mean RGB readings

Remarks/Best Practices

This tool compares the general color of a region of interest with a taught color and returns a Pass/Fail value that indicates if the colors matched as well as or better than specified minimum match criteria. The region can be defined as a rectangular or circular shape. The color of the region is determined by computing the mean intensity value for each of the three color layers (RGB). These actual mean values are compared against three taught mean RGB values. If all three pairs of numbers match as well as or better than three specified % criterion, the color of the region is a match, and this tool returns a Pass indication.

To improve the robustness of this tool when the lighting conditions may vary, the **Inspection Type** can be set to **Normalized**. In this mode, the taught nominal values and the actual computed mean intensity values are adjusted for the over-all brightness of the region of interest.

This tool always accesses all three RGB color layers of the captured color image independent of which layer the Acquisition Tool loaded into the current frame buffer.

To permit further analysis of the computed mean color by other tools, this tool also returns the color characterized by its HSV (hue, saturation, value) and HSI (hue, saturation, intensity) components. These representations map the RGB results into cylindrical color coordinate systems that are a bit more intuitive to interpret. Each circular plane of the cylinder corresponds to a "color wheel." The hue is the angle of the color about the circle and smoothly transitions between red, green and blue. The central vertical axis of the cylinder represents the gray colors ranging from black to white.

Edge Finder Tool

Detects edge points with sub-pixel accuracy along a linear path in a vision image and returns their positions. Alternately, this tool can return an array of the intensities along the linear path or a histogram of their values.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter Chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest
Relative Tool	**String / List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest

Property Name	Data Type	Range	Description
Length	**Single**		The length of the line
OPERATION			
Edge Threshold	**Integer**		Specifies the threshold below which weak (low contrast) gradient edges are ignored. The lower this property is set, the more sensitive the system is in locating edges
ADVANCED OPERATION			

Property Name	Data Type	Range	Description
Algorithm	**List**	Binary Edge, Gradient Threshold, Subpixel, Precision Subpixel	*Binary Edge*: identifies edge transitions in a binary image. *Gradient Threshold*: identifies an edge position whenever the gray scale value crosses a specified threshold value. *Subpixel*: computes the positions of edges to a sub-pixel accuracy based upon the rate of change (gradient) of the gray scale values. This is the default setting. *Precision Subpixel*: similar to the sub-pixel mode except that a more precise interpolation technique is employed that provides more accurate sub-pixel edge locations at the cost of a small increase in execution time. In rare cases where very fine features (e.g. 2 or 3 pixel bumps) are contained in the edge and need to accurately accounted for, `EDGE_SUBPIX` may produce more accurate results since that method uses a smaller pixel region to compute its results.

Property Name	Data Type	Range	Description
Gradients	**List**	All, Positive, Negative	This parameter specifies whether all edges are to be detected (All) or only edges that occur when the gray scale value goes from dark-to-light (Positive) or only edges when the gray scale value goes from light-to-dark (Negative). Detecting only negative or positive edges helps disambiguate the edge being detected or can eliminate double edges that occur when thin dark or light features are encountered. Processing starts at the square resizing handle and ends at the round rotation handle.
INSPECTION SETTINGS			

Property Name	Data Type	Range	Description
Inspection Label	**List**	None, Pass, Fail, Pass and Fail, Real Value, Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the *Camera Display* window based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.
Inspection Maximum	**Single**		Maximum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Minimum	**Single**		Minimum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."

Property Name	Data Type	Range	Description
Inspection Type	**List**	None, Number of Points, Distance to First Point, Distance to Last Point, Distance from First to Last, Gray Level Average, Gray Level Min, Gray Level Max	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select "None" to disable inspecting a result.
RESULTS SETTINGS			
Maximum Result	**Integer**		For tools that provide multiple sets of results, this property can limit the maximum number of sets of results that are computed and returned. A negative 1 (-1) indicates that all possible results should be collected.
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees and the shift is in calibrated units (mm).
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display

Property Name	Data Type	Range	Description
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Property Name	Data Type	Range	Description
Result Mode	**List**	Edge Points, First Point, Last Point, Mid Point, Passthru Source, Histogram, Gray Level	Defines whether all edge points or selected edge points are to be returned in the results. The Passthru Source is a special mode where this tool returns the Results of its parent tool pointed to by `RelativeToolName`. This permits a process to add one or more Edge Finder Tools after it has computed the position of a part and used the Locators to perform additional visual verification tests but still have the process return the Results location of the parent tool. See the PassFailEdgeCount demonstration program that was shipped with PreciseVision for an example of the use of this feature. The Gray leve" and Histogram are special modes that return an array containing either the intensity (grayscale) value for each pixel along the length of the tool or the computed histogram of the distribution of intensity values. If either of these modes are selected, edge points are not detected.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool inspection
Insp. Actual	Actual property value that was tested by the tool inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed

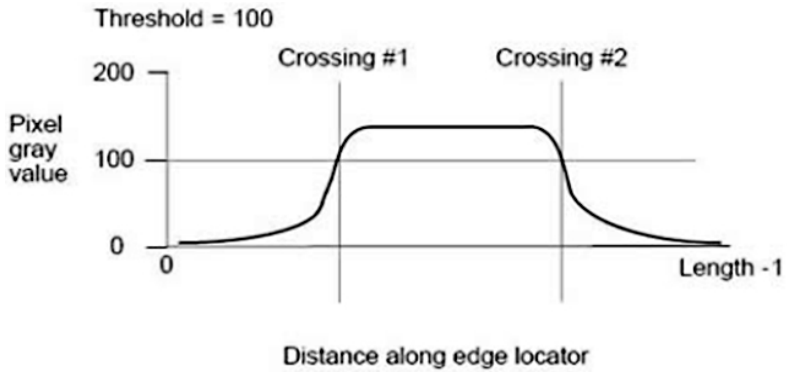
Remarks/Best Practices

This tool finds object boundaries, i.e. edges, along a linear path in an image. The edge positions can be used to measure the dimensions of objects or detect if key features are present or absent. The edges can be detected in a number of different modes (e.g. threshold, sub-pixel, etc). Alternately, the raw pixel values or a histogram of the grayscale values of the pixels along the path can be returned. In other vision systems, this type of tool is sometimes called a "caliper" or "ruler."

Locating Edge Points

When locating edge points, this tool operates by analyzing pixels along the specified line.

The primary mode of operation for this tool is specified by the Desired Algorithm property. If this parameter is set to **Grayscale Threshold**, an edge is detected whenever the gray scale value crosses the threshold specified by **Edge Threshold**. The graph below shows a typical example of how the gray scale values might appear along the length of an Edge Finder Tool. In this case, if the threshold is set to 100, two edges will be detected (Crossing #1 and #2) where the gray scale values cross the specified threshold value.



If the Desired Algorithm property is set to **Subpixel**, edge positions are computed to a sub-pixel accuracy by first computing the rate of change ("gradients") of the gray scale values along the length of the edge. For each region where the gradients exceed the **Edge Threshold** value, the peak of the gradient is computed with sub-pixel accuracy and returned as the location of the edge.

If *Desired Algorithm* is set to **High Precision Sub Pixel**, a higher-resolution sub-pixel position is computed by employing an even more accurate (and costly) sub-pixel determination method. This method analyzes a longer gradient neighborhood along the path of the Edge.

Finally, if *Desired Algorithm* is set to **Binary**, 0-to-1 or 1-to-0 transitions are detected in a binary image.

After all of the edges have been determined, this tool can return all of the located edges or a selected edge based upon the setting of the Result Mode property. Also, the standard "Inspection Settings" can be used to yield Pass/Fail results based upon the number of edges detected, various distance relationships or the average grayscale value along the entire length of the tool.

Computing Intensity Histogram

If the *Result Mode* is set to **Histogram**, rather than computing edge points, this tool counts the number of pixels along the specified line that has each of the possible 256 grayscale values and returns the pixel counts. This count of the grayscale distribution of pixels is called an intensity "Histogram." It is useful for determining the prevalent grayscale values and the intensity differences between the peak values. If you are executing GPL version 2.0 or later, an array of 256 counts (0 [black] - 255 [white]) can be fetched using the VisResults Info property.

Whenever this mode is selected, the X and Y position results represent the center of the specified line and can be used to further propagate the vision tree.

Returning Grayscale Values

If the *Result Mode* is set to **Graylevel** rather than computing edge points, this tool returns the grayscale (intensity) value for each pixel along the length of the specified line. Each grayscale value can range from 0 (black) to 255 (white).

If you are executing GPL version 2.0 or later, an array of up to 1500 pixel values can be fetched using the VisResults Info property.

Whenever this mode is selected, the X and Y position results represent the center of the specified line and can be used to further propagate the vision tree.

Fiducial Locator Tool

Finds all ArUco markers within a region of interest.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**	n/a	The camera the tool executes against
Name	**String**	n/a	The name of the tool instance
REGION OF INTEREST			
Height	**Single**		The height of the region of interest
Relative Tool	**String/ List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default tools are not relative to another tool and this property is empty.
Width	**Single**		The width of the region of interest

Property Name	Data Type	Range	Description
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
OPERATION			
Adaptive Threshold	**Integer**		This sets how many pixels around each point are used to decide if it's black or white. Use a larger number if lighting is uneven. Use a smaller number for sharp, well-lit images.
Calculate Intensity	**Boolean**		When enabled, the average intensity values of the fiducials black and white pixel values will be calculated.
Corner Max Iterations	**Integer**		This sets the maximum number of attempts the algorithm will use to fine-tune the corners of the marker. Increase it if corners are not accurate. Lower it to speed things up if detection is already working well.

Property Name	Data Type	Range	Description
Corner Min Accuracy	**Double**		This controls how precise the corner detection needs to be before the algorithm stops. Decrease if corners aren't accurate enough. The units are in pixels. It's a stopping threshold, not a measure of final precision.
Corner Refinement Method	**List**	None, SubPixel, Contour	The Corner Refinement Method specifies how OpenCV improves the accuracy of the detected marker corners. Sub-pixel is recommended for highest accuracy. "SubPixel" – Adjusts corner positions to fractions of a pixel, giving more precise results on a stable image. Less precise with image noise or blur. "Contour" – Adjusts corner positions at the pixel level, making it more robust to noise or blur. Less precise overall since it works on the pixel level.

Property Name	Data Type	Range	Description
Corner Window Size	**Integer**		This sets how many pixels around each corner are checked to fine-tune its position. Use a larger value if the corners are blurry or noisy. Use a smaller value if the image is sharp and well-lit. It must be an odd number.
Dictionary	**List**	• 4x4 (250) • 5x5 (250) • 6x6 (250) • 7x7 (250) • 7x7 (1000)	The dictionary to use for locating the fiducials. These set the X/Y square count (4x4) and the max number of unique IDs (250).
RESULTS SETTINGS			
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display

Property Name	Data Type	Range	Description
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Black Intensity	The intensity of the black fiducial regions.
Corner 1 X	The fiducial corner 1 pixel X coordinate
Corner 1 Y	The fiducial corner 1 pixel Y coordinate
Corner 2 X	The fiducial corner 2 pixel X coordinate
Corner 2 Y	The fiducial corner 2 pixel Y coordinate
Corner 3 X	The fiducial corner 3 pixel X coordinate
Corner 3 Y	The fiducial corner 3 pixel Y coordinate
Corner 4 X	The fiducial corner 4 pixel X coordinate
Corner 4 Y	The fiducial corner 4 pixel Y coordinate

Result Name	Description
Fiducial Code	The fiducial marker identifier
Index	The index of the result instance
Insp. Actual	Actual property value that was tested by the tool Inspection
Insp. Status	Pass/Fail results of the tool Inspection
Object ID	Secondary result instance index
Pixel X	The fiducial center pixel X coordinate
Pixel Y	The fiducial center pixel Y coordinate
Theta	The angle in degrees
Tool Status	Specifies if an error or warning condition occurred when the tool was executed
X	The X position in pixels
Y	The Y position in pixels
White Intensity	The intensity of the white fiducial regions.

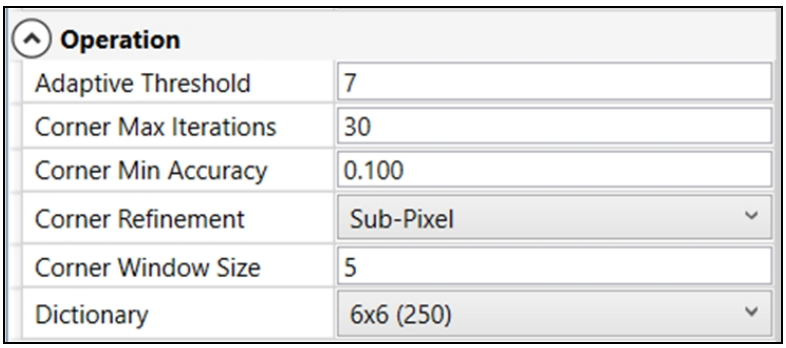
Remarks/Best Practices

The Fiducial Tool is designed for detecting and estimating the pose of ArUco markers, which are synthetic square markers with a unique identifier. It includes several predefined dictionaries of markers to suit different applications.

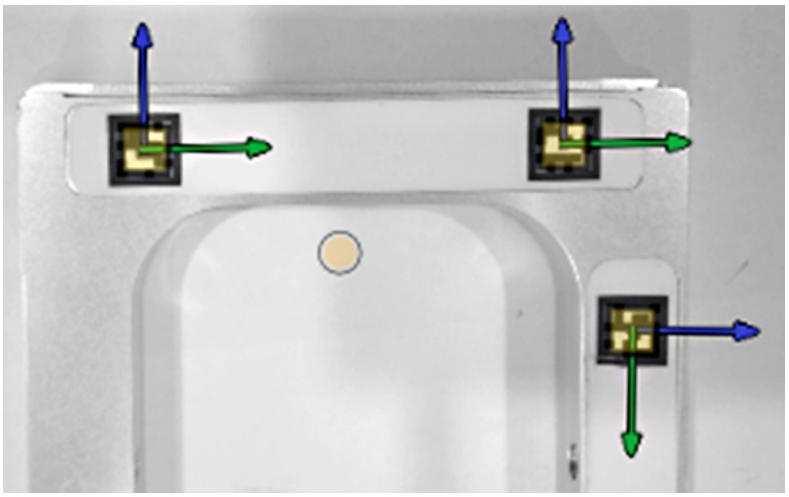
The detection of ArUco markers involves converting the acquired image to grayscale, scanning for high-contrast areas to identify potential markers, and precisely detecting the corners of each marker. The inner binary matrix of each marker is then decoded to determine its unique identifier.

Example

In the following example, the fiducial tool is configured to locate fiducials using the 6x6 (250) **Dictionary**. This dictionary is used in runtime to locate ArUcos on Brooks-supplied ArUco kits.

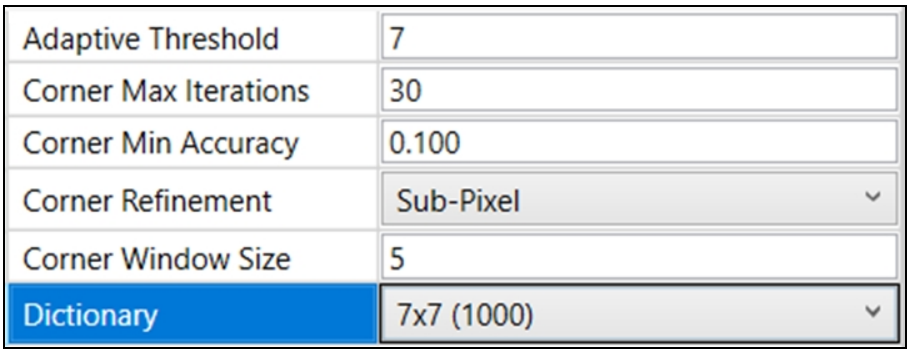


The dictionary used during runtime to locate ArUcos on Brooks-supplied kits

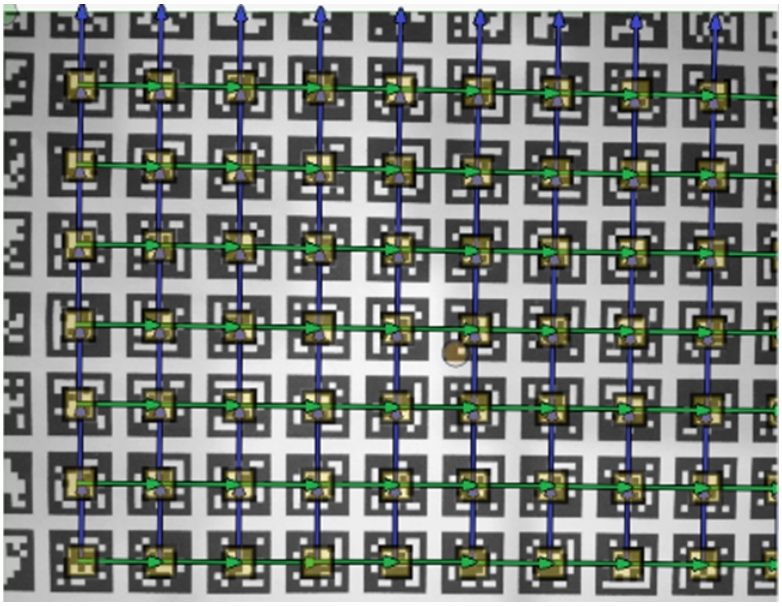


***Camera Display* window in GDS showing successful location of ArUco markers using Fiducial tool**

The **Dictionary** below can also be used to locate ArUcos on an IntelliGuide Calibration Target.



The dictionary used during calibration to locate ArUcos on IntelliGuide calibration targets



***Camera Display* window in GDS showing successful location of ArUco makers using Fiducial tool**

Find Mid Tool

Searches a specified region for edge points and returns the centerline between two located bounding lines.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter Chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest

Property Name	Data Type	Range	Description
Height	**Single**		The height of the region of interest
Relative Tool	**String / List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
Width	**Single**		The width of the region of interest
OPERATION			

Property Name	Data Type	Range	Description
Edge Mode	**List**	Nearest Dark, Nearest Nominal, Nearest Light, Max Gradients, Max Concentration	If multiple lines exist within the search region, this parameter helps to distinguish which line should be returned. In addition to selecting the line closest to the dark side, light side, nominal (center line), or greatest concentration of edges, you can also select the line with the highest contrast. The concentration mode is particularly useful if there are two or more distinct non-colinear groups of edges and the returned fit line is attempting to span multiple groups. If concentration mode is specified, this tool will select the largest cohesive group of edges as the basis for the line fitting.
Edge Threshold	**Integer**		Specifies the threshold below which weak (low contrast) gradient edges are ignored. The lower this property is set, the more sensitive the system is in locating edges.
ADVANCED OPERATION			

Property Name	Data Type	Range	Description
Bias Filter	**List**	**None, Light, Dark**	For boundary lines with an irregular or jagged edge, this parameter can be set to provide extra weight (importance) to edges that are closest to the light or dark side of the search region. For example, for a saw toothed pattern, this property could be set to fit each boundary line to the tips of the high or low points of the pattern.
Maximum Edge Points	**Integer**		Maximum number of edge point searches to perform across the width of this tool. Higher numbers produce greater accuracy at the expense of execution speed. The minimum value of this parameter is 2. This value is automatically limited to the number of pixels along the height of the tool. The default value is 30.

Property Name	Data Type	Range	Description
Maximum Iterations	**Integer**		Maximum number of iterations for filtering per boundary line. The filtering algorithm repeatedly removes outlier points, refitting a boundary line each time, until no more points need to be removed or the maximum number of iterations have occurred. A value of 0 disables filtering. The default value is 5.
Minimum Filter Distance	**Single**		Absolute minimum filter distance in pixels. No edge points closer to a boundary line than this are discarded during the iterative process. A minimum distance is needed because the standard deviation of distances to a fit line can be less than a pixel with a good image of a clean edge. The default value is 1.
Sigma Filter	**Single**		Filter width in units of standard deviations. This value is multiplied by the standard deviation of the edge points' distances to a boundary line to compute the distance threshold beyond which edge points are removed during the iterative boundary line fitting process. The default value is 1.5.

Property Name	Data Type	Range	Description
INSPECTION SETTINGS			
Inspection Label	**List**	None, Pass, Fail, Pass and Fail, Real Value, Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the Camera Display Window based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.
Inspection Maximum	**Single**		Maximum values permitted for the item specified in **InspectType** to Pass the inspection. Values outside of this range are marked as Failed.
Inspection Minimum	**Single**		Minimum values permitted for the item specified in **InspectType** to Pass the inspection. Values outside of this range are marked as Failed.

Property Name	Data Type	Range	Description
Inspection Type	**List**	None, RMS, Number of Edges Found, Number of Edges Used, Line Thickness	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select **None** to disable inspecting a result.
RESULTS SETTINGS			
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index.
Index	The index of the result instance
X	The X position in pixels.
Y	The Y position in pixels.
Theta	The angle in degrees.
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection.
Tool Status	Specifies if an error or warning condition occurred when the tool was executed.
RMS	Root mean square of the boundary line fits
Edges Found	Number of edge points found during the boundary line fitting
Edges Used	Number of edge points remaining after the filtering process for the boundary lines.
Line Thickness	Average distance between the two bounding lines measured at the center of the tool

Remarks/Best Practices

This tool searches the region of interest for edge points, computes the best fit for two bounding lines, and returns the centerline between the bounding lines. This is a convenience routine that internally executes two Line Fitter tools to accurately locate the bounding lines using least squares fitting and sub-pixel edge extraction techniques. The search area for each Line Fitter is identical to the region specified for the Find Centerline tool. The orientation of the two Line Fitters differs by 180°. After the Line Fitters have completed execution, the center line between the fit boundary lines is returned by this tool.

This tool is very useful for accurately locating a center line between two outer edges of an object. Once found, the center line can be used to compute distances between important features or for generating reference frames that can accurately locate an object or features in an object. This tool also returns the average thickness between the two boundary lines measured at the center of the tool.

When positioning this tool, you should place the center line of the search region at approximately the position and orientation that you expect to find the center line.

For a detailed explanation of the operation of the boundary line fitting operation and the effect of this tool's various properties on the fitting process, refer to the Remarks section of the Line Fitter tool.

At the conclusion of this tool, the center position and orientation of the computed center line are returned. In addition, statistical data on the number of edges used in the line fitting operations and the root mean square of the line fits are returned. This statistical data indicates the quality of the final fits and can be tested via the "Inspect Settings" to yield a pass/fail indication for the tool's operation.

Fixed Frame Tool

Places a reference frame at a fixed image coordinate or at a constant offset relative to another vision object. Can optionally index the frame in an X and/or Y grid pattern to repeatedly execute any linked tools.

Prerequisites

This tool requires a link with other vision tools to provide results to offset.

Parameter Chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest
Relative Tool	**String / List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.

Property Name	Data Type	Range	Description
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
ADVANCED OPERATION			
Frame X Count	**Integer**		The number of slots in the X direction
Frame X Pitch	**Single**		The spacing of the slots in the X direction
Frame Y Count	**Integer**		The number of slots in the Y direction
Frame Y Pitch	**Single**		The spacing of the slots in the Y direction
Target Display Size	**Single**		The target display size
Target Display Type	**List**	None, Square, Circle	The target display type
RESULTS SETTINGS			
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display

Property Name	Data Type	Range	Description
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed.

Remarks/Best Practices

A Fixed Frame can be used in several different ways. It can be defined relative to another vision object with a fixed position and angular offset. This is an alternative to directly setting an offset in the Results Settings of most tools and has the advantage of allowing the offset to be graphically specified by dragging the Fixed Frame in the vision window.

Alternately, a Fixed Frame can be placed in an image at a specified position and orientation and can then serve as a datum from which other measurements are made.

Lastly, if the Pattern properties are utilized, a Fixed Frame can be automatically indexed about an X and/or Y grid pattern. This has the benefit of repeatedly executing any tools linked to (i.e. defined Relative-to) the Fixed Frame in a grid pattern.

Image Process Tool

Performs image filtering, edge extraction, thresholding, and morphological operations on a specified area in the camera image.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest
Height	**Single**		The height of the region of interest

Property Name	Data Type	Range	Description
Relative Tool	**String/List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool, and this property is empty.
Width	**Single**		The width of the region of interest
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
OPERATION			
Invert Binary	**Boolean**		(BINARY) For `BINARY_* ProcessModes`, if this parameter is True, after the binary pixels values are extracted, their values will be inverted before the remainder of the processing is performed.
Iterations	**Integer**		Specifies the number of times that the `ProcessMode` should be applied to the area of interest. This is often used to repeatedly execute the morphological operations.

Property Name	Data Type	Range	Description
Process Mode	**List**	Binary Erode, Binary Dilate, Binary Threshold, Edge DL, Edge DR, Edge Horizontal, Edge Vertical, Gaussian, Laplacian, Laplacian Gaussian, Low Pass, Low Pass Horizontal, Low Pass Vertical, Sharpen, Edge Threshold	Specifies the image processing operation to be performed on the selected area-of-interest. These are destructive operations that alter the contents of the camera buffer so that all subsequent tools operate on the modified data.
Threshold	**Integer**		(`BINARY_*`) This is the value used to convert grayscale values into black and white pixels. (`CONV_*`) This value is not utilized. (`EDGE_*`) Specifies the threshold below which weak (low contrast) gradient edges are ignored. The lower this property is set, the more sensitive the system is in locating edges. Please see the description of the Edge Finder Tool for more information on edge gradients. The default value is 30.
ADVANCED OPERATION			

Property Name	Data Type	Range	Description
Convolution Size	**List**	3x3, 5x5	Specifies whether the convolution kernel is a 3x3 or 5x5 matrix. The size of the kernel determines how many neighboring pixels are considered in the computation of each new pixel value.
RESULTS SETTINGS			
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

The Image Processing tool does not have any results.

Remarks/Best Practices

This tool performs an image-filtering, edge-extraction, thresholding, or morphological operation on a specified area in the camera image. For example, an operator can be applied to smooth a region to eliminate noise due to poor lighting. Conversely, the image can be sharpened to highlight features.

While most vision tools analyze the data in the camera image and leave the data unmodified, these operators all alter the raw data in the image buffer. All subsequent vision tools will operate on the modified image data and not the raw information captured by the camera.

The following table describes each of the image processing operations:

Edge DL	Extracts edges with a bias for edges that slope down from the left
Edge DR	Extracts edges with a bias for edges that slope down from the right
Edge Horizontal	Extracts edges with a bias for horizontal edges
Edge Vertical	Extracts edges with a bias for vertical edges
Gaussian	Reduces image noise by blurring the region. This is a smoothing operator.
Laplacian	Extracts edges using a Laplacian operator
Laplacian Gaussian	Extracts edges after smoothing with a Gaussian to reduce noise
Low Pass	Reduces image noise by eliminating high-frequency changes. This is a smoothing operator.
Low Pass Horizontal	Reduces image noise by eliminating high-frequency changes but only in the horizontal direction. This is a 1D smoothing operator.
Low Pass Vertical	Reduces image noise by eliminating high-frequency changes but only in the vertical direction. This is a 1D smoothing operator.
Sharpen	Accentuates or enhances edges in the image.
Edge Threshold	Computes each pixel's edge strength and sets all strong edges to white and all weak edges to black.
Binary Erode	Binary thresholds the region and shrinks white groups of pixels
Binary Dilate	Binary thresholds the region and grows white groups of pixels
Binary Threshold	Converts all pixels to white or black

Light Control

Control LED Lights on an IntelliGuide gripper.

Prerequisites

This tool has no prerequisites.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
OPERATION			
Brightness %	**Integer**		The brightness level from 0-100
LED Bank	**Integer**		The bank of LEDs to modify, starting at bank 1. If the back is set to zero, the default bank will be used.
Time Delay (ms)	**Integer**		The delay in ms.

Results Chart/List

This tool has no results.

Remarks/Best Practices

This tool is used primarily to change the LED light intensity as part of the IntelliGuide gripper. After the **Brightness %** is set, the execution will pause by the amount specified in **Time Delay (ms)**.

Line Fitter Tool

Searches a specified region for edge points and returns the line that best fits the edges.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter Chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest
Height	**Single**		The height of the region of interest
Relative Tool	**String / List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.
X Position	**Single**		The X coordinate of the center of the region of interest

Property Name	Data Type	Range	Description
Y Position	**Single**		The Y coordinate of the center of the region of interest
Width	**Single**		The width of the region of interest
OPERATION			
Edge Mode	**List**	Nearest Dark, Nearest Nominal, Nearest Light, Max Gradients, Max Concentration	If multiple lines exist within the search region, this parameter helps to distinguish which line should be returned. In addition to selecting the line closest to the dark side, light side, nominal (center line), or greatest concentration of edges, you can also select the line with the highest contrast. The concentration mode is particularly useful if there are two or more distinct non-colinear groups of edges and the returned fit line is attempting to span multiple groups. If concentration mode is specified, this tool will select the largest cohesive group of edges as the basis for the line fitting.
Edge Threshold	**Integer**		Specifies the threshold below which weak (low contrast) gradient edges are ignored. The lower this property is set, the more sensitive the system is in locating edges.

Property Name	Data Type	Range	Description
ADVANCED OPERATION			
Allowed Angular Range	**Single**		(`MAX_CONCENTRATION` mode only) This limits the orientation of the line that will be returned. It is specified in degrees and is a plus or minus rotation relative to the nominal angle of the tool. In special cases when there are multiple uneven edges, this parameter can be utilized in combination with the `MAX_CONCENTRATION` mode to locate the dominant line with a selected orientation.
Bias Filter	**List**	None, Light, Dark	For boundary lines with an irregular or jagged edge, this parameter can be set to provide extra weight (importance) to edges that are closest to the light or dark side of the search region. For example, for a saw-toothed pattern, this property could be set to fit each boundary line to the tips of the high or low points of the pattern.

Property Name	Data Type	Range	Description
Maximum Edge Points	**Integer**		Maximum number of edge point searches to perform. Higher numbers produce greater accuracy at the expense of execution speed. The minimum value of this parameter is 2. This value is automatically limited to the number of pixels across the width of the tool. The default value is 30.
Maximum Iterations	**Integer**		Maximum number of iterations for filtering. The filtering algorithm repeatedly removes outlier points, refitting the line each time, until no more points need to be removed or the maximum number of iterations have occurred. A value of zero disables filtering. The default value is 5.
Minimum % Edges	**Integer**		The minimum percentage of edges for detection

Property Name	Data Type	Range	Description
Minimum Filter Distance	**Single**		Absolute minimum filter distance in pixels. No edge points closer to the fitted line than this are discarded during the iterative process. A minimum distance is needed because the standard deviation of distances to the fitted line can be less than a pixel with a good image of a clean edge. The default value is 1.
Sigma Filter	**Single**		Filter width in units of standard deviations. This value is multiplied by the standard deviation of the edge points' distances to the fitted line to compute the distance threshold beyond which edge points are removed during the iterative fitting process. The default value is 1.5.
RESULTS SETTINGS			

Property Name	Data Type	Range	Description
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.
INSPECTION SETTINGS			

Property Name	Data Type	Range	Description
Inspection Label	**List**	None, Pass, Fail, Pass and Fail, Real Value, Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the Camera Display Window based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.
Inspection Maximum	**Single**		Maximum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Minimum	**Single**		Minimum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."

Property Name	Data Type	Range	Description
Inspection Type	**List**	None, RMS, Angle, Num Edges Found, Num Edges Used	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select "None" to disable inspecting a result.
RESULTS SETTINGS			
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed
RMS	Root mean square of the line fit
Edges Found	Number of edge points found
Edges Used	Number of edge points remaining after the filtering process

Remarks/Best Practices

The Line Fitter searches the region defined by its region of interest rectangle for edge points and fits a line to the edge points using a least squares technique. By computing the edge positions to a sub-pixel accuracy and by employing multiple such edges in its computation, this tool is able to generate very accurate sub-pixel results.

This tool is very useful for accurately locating straight edges of objects. Once found, these fit lines can be used to compute distances between important features or for generating reference frames that can accurately locate an object or features in an object.

In order to make this tool more discriminating, the Line Fitter only utilizes edges whose dark and light sides have roughly the same orientation as the search area. So, when positioning this tool, you should place the center (nominal) line of the search region at approximately the position and orientation that you expect to find the line with the starting side on the anticipated dark side of the object.

The operation of this tool is generally performed in the following three steps:

1. All of the edges in the rectangular region are extracted by performing **Maximum Edge Points** number of linear edge searches using the Edge Threshold.

2. For each edge search, the single edge point that best fits the **Edge Mode** criteria (nearest dark, nearest light, etc.) is retained and the other edge points are discarded.
3. A straight line is fit to the selected edge points.

Typically, the Line Fitter will perform the fitting process iteratively to increase the robustness of the results. During each line fitting pass, edge points that are too distant from the line (outliers) are discarded. This filters out edges that are not a part of the line and whose inclusion would incorrectly offset the result. **Maximum Iterations** specifies the maximum number of fits to perform. After each line fit, edges that are beyond **Sigma Filter** standard deviations are rejected, unless the edge is within **Minimum Filter Distance** pixels of the fit line. The iterative process stops if (i) **Maximum Iterations** are performed, (ii) no further edges are discarded, or (iii) only two edge points remain.

Of the various operations, the tool spends most of its time in the first step, extracting all of the edges. So, the speed and the accuracy of the Line Fitter can be traded off by adjusting **Maximum Edge Points**. This property determines how densely the tool scans to detect edges. This parameter must be set to at least 2 in order to detect the minimum number of edges to define a line. At most, one edge search is performed for each pixel along the width of the Fitter. Execution time increases roughly in proportion to the value of **Maximum Edge Points**. On the other hand, the accuracy of the tools increases approximately as the square root of **Maximum Edge Points**. That is, if you increase **Maximum Edge Points** by a factor of 4, the tool execution time will quadruple but the accuracy will only double.

To address some unusual cases, the Line Fitter provides special modes of operation. For lines with an irregular or jagged edge, the **Bias Filter** property can provide extra weight (importance) during the line fitting operation to edges that are closest to the light or dark side of the search region. This has the effect of causing edge points that are furthest from the biased edges to be discarded.

As another special case, if the search area has two or more distinct groups of edges and it is not possible to utilize the **Edge Mode** nearest dark, light or nominal methods to distinguish the desired line, the **Max Concentration** mode can be utilized to locate the most prominent line. During Step 2, this method analyzes all of the edge points and computes a best guess line within the specified range of orientation that has the highest concentration of strong edges. Then, for each edge search, the point that is closest to this best guess line is retained and all other edges points are discarded. Step 3 progresses as usual to compute the best fit line to the selected edge points.

At the conclusion of the Line Fitter, the center position and orientation of the best fit line are returned. In addition, statistical data on the number of edges finally used and the root mean square of the line fit are returned. This statistical data indicates the quality of the final fit and can be tested via the Inspect Settings to yield a pass/fail indication for the operation.

Line-Line Frame Tool

Determines the intersection of two lines defined by vision objects and returns a reference frame. Alternately, computes and returns the midpoint of two reference frames defined by two vision objects.

Prerequisites

This tool requires links with other vision tools to perform the intersection calculation.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
OPERATION			
Line 1 Source	**Integer**		The name of the tool providing a line for the calculation
Line 2 Source	**Integer**		The name of the tool providing a line for the calculation
Result Mode	**List**	Line to Line Intersection, Midpoint - Average Angle, Midpoint - Source 1 Angle, Midpoint - Source 2 Angle, Midpoint - 0 Angle	The result mode of operation
INSPECTION SETTINGS			

Property Name	Data Type	Range	Description
Inspection Label	**List**	None, Pass, Fail, Pass and Fail, Real Value, Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the *Camera Display Window* based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.
Inspection Maximum	**Single**		Maximum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Minimum	**Single**		Minimum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."

Property Name	Data Type	Range	Description
Inspection Type	**List**	None, Angle	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select "None" to disable inspecting a result.
RESULTS SETTINGS			
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed

Remarks/Best Practices

This computational tool combines the results of two vision tools to compute a new reference frame.

If the **Result Mode** is set to **Line to Line Intersect**, the inputs must be two vision objects that define two intersecting, non-parallel lines. The X-axis of the new reference frame will be collinear with the first input line. The origin of the new frame will be at the point where the two lines intersect.

This method is often used to uniquely define the position and orientation of a simple object or a section of an object. The resulting reference frame can then be used to position additional vision tools. As another example, this method can be utilized to compute the position of a corner of an object as determined by its two adjacent straight sides.

If the **Result Mode** is set to one of the **Midpoint** methods, the origin of the returned reference frame will represent the midpoint between the origin of the two source vision objects. The orientation of the returned reference frame can be selected as: the average of the orientations of the two source vision objects, the orientation of one of the two source vision objects, or zero.

Object Finder Tool

Performs general object location within a region of interest using a trained object finder model.

Prerequisites

This tool requires that an Object Finder model has been trained and an acquisition tool has filled the camera buffer with an image for processing.

Parameter chart

Identity	Property Name	Data Type	Range
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Height	**Single**		The height of the region of interest
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
Width	**Single**		The width of the region of interest
OPERATION			
Clearance Pixels	**Integer**		The number of pixels of clearance to check for around the detected object. -1 to disable the search.
Generate Debug Images	**Boolean**		When enabled, debug images are saved to the drive
High Precision Mode	**Boolean**		Refine the coarse position of the result with a search at a finer resolution
Ignore Color	**Boolean**		When enabled, color information is ignored.
Max Location Time	**Integer**		The maximum amount of time to spend locating templates (in ms)

Identity	Property Name	Data Type	Range
Return Unknown Objects	**Boolean**		When enabled, tool returns the position of objects detected even when not matched to a template
Template 1	**List**	Available Templates	The template to match
Template 2	**List**	Available Templates	The template to match
Template 3	**List**	Available Templates	The template to match
Template 4	**List**	Available Templates	The template to match
THRESHOLDS			
Color Similarity %	**Double**	1-100	The percentage of Color similarity for matching objects.
Hog Similarity %	**Double**	1-100	The percentage of HOG similarity for matching objects.
Scale Similarity %	**Double**	1-100	The percentage of scale similarity for matching objects. The object scale is the percentage match against the trained image scale. This threshold represents a ± match against that calculated size.
ADVANCED OPERATION			

Identity	Property Name	Data Type	Range
Maximum Search Angle	**Double**		The min/max angle variables limit the maximum allowed orientation delta between object that is being detected and the template. Default is 0 – 360. This is useful when an object is symmetrical along one or more axes. If an object is symmetrical along an axis, then search can be limited to a 180° window, ± 90°. This speeds up the detection and more importantly robots will not make unnecessary wrist joint movements
Minimum Search Angle	**Double**		See description above
RESULTS SETTINGS			
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Font Size	**Integer**		The font size of the template name displayed in the image
Result Scale	**Double**		The scale to apply to the size of the result display
Show Template Name	**Boolean**		Show the name of the template in the image display.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The orientation delta between the object and the template in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed
Template Index	The index of the template that was matched
Scale %	The scale match between the template and the object
Aspect Match %	The matching of the height and width ratio between the template and the object
HOG Match %	The matching of internal features between the template and the object
Match %	A combined measure of matching between the template and the object
Result Refined	Was accuracy refinement performed on the object
Color Similarity	How closely was the color matched with the template
Occluded	Does the object appear to be cut off or overlapping other objects
Is Clear	Was the perimeter of the object clear of obstructions

Remarks/Best Practices

The Object Finder tool first detects each of the objects visible in the image. It then attempts to match each of the objects with a list of selected templates. Among the potential matches that satisfy the minimum match thresholds, the template with the highest combined match score is picked.

The location algorithm performs a two-step operation using a coarse-template representation followed by a fine-template representation. If speed is more important than accuracy, the **High Precision** mode can be disabled. In this case, only the coarse model will be used for the location of the objects.

The tool can operate using either color or grayscale image processing. If **Ignore Color** is enabled, then the tool will only perform grayscale template matching.

The match is determined by the **Color Similarity %**, **HOG Similarity %**, and **Scale Similarity %**. If a feature does not meet all the thresholds for any of the template models, it is considered an unknown object. If the **Return Unknown Objects** is enabled, the unmatched feature regions will be returned as valid results with a Template index of -1.

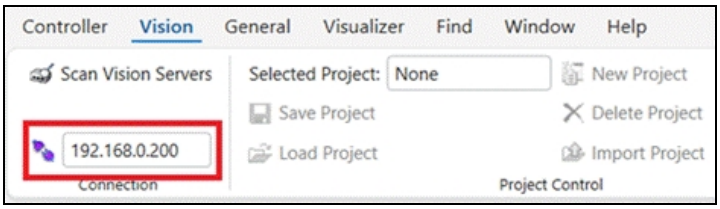
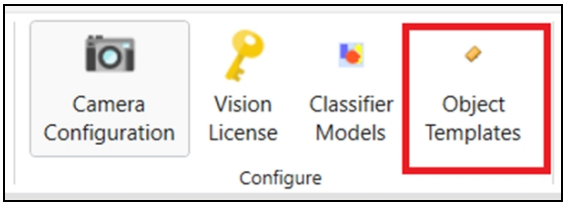
If the **Clearance Pixels** property is greater than -1, the location algorithm will include a clearance check to see if the detected objects are touching or overlapped with other features or objects in the scene.

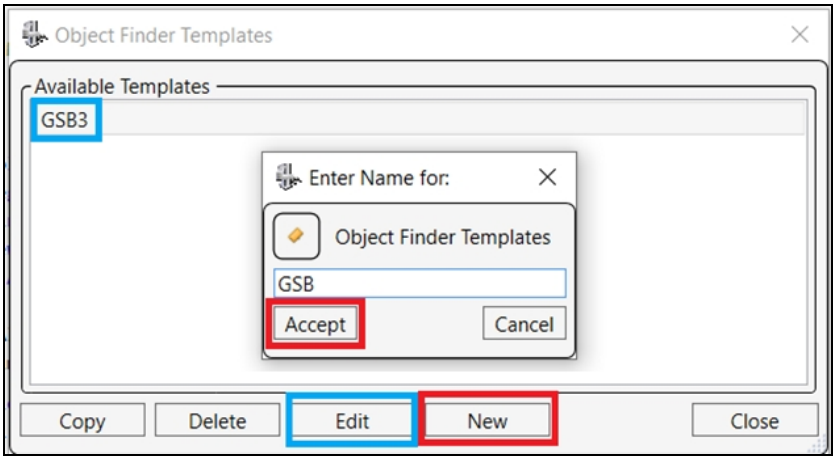
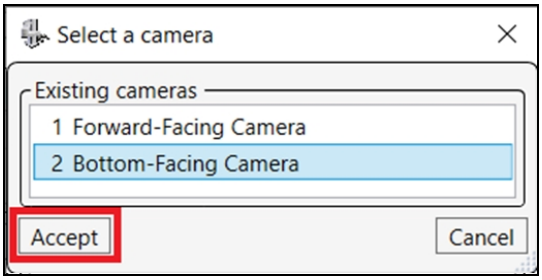
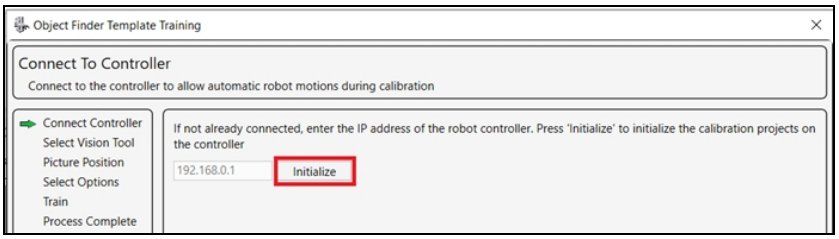
The detection algorithm will also detect if an object is fully within the field of view of the camera image. If not, it is considered occluded and will be marked as such in the results.

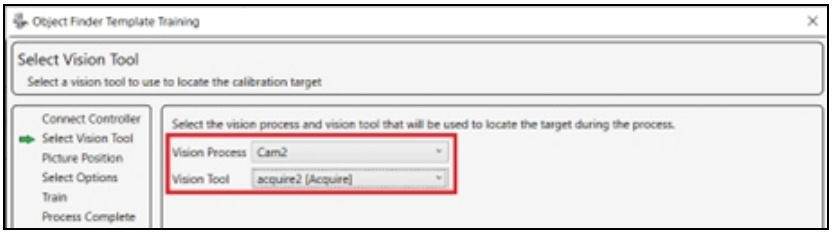
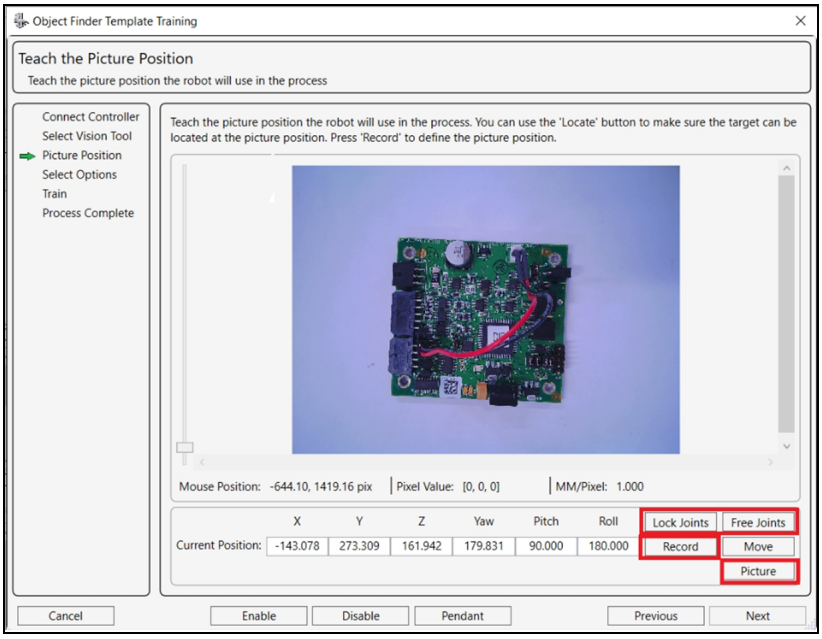
The tool relies on adequate contrast between the workpiece and a simple surface/ background. Too much detail in the background will cause the tool to fail. For best results, background contrast, lighting and distance between the camera and workpiece should be consistent between training and executing the tool during runtime.

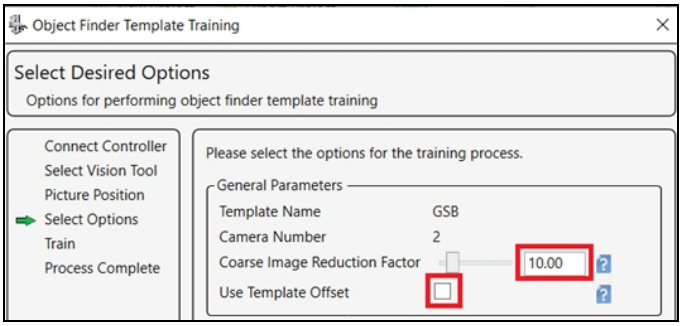
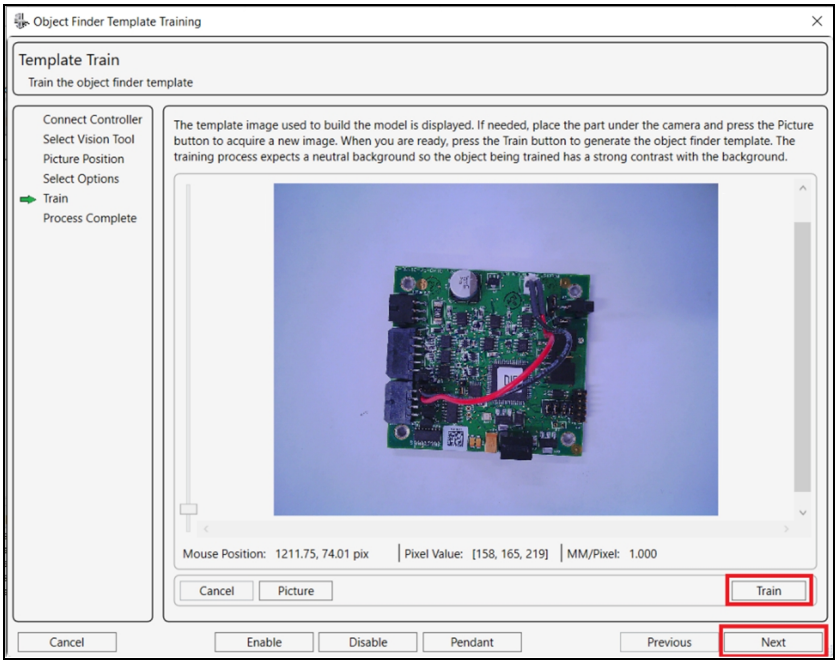
Training Process

Follow the steps below to train an Object Finder template with GDS.

Step	Action
1.	Navigate to the Vision tab then click on the purple Connection button. 
2.	Click on the **Object Templates** button. 

Step	Action
3.	In the *Object Finder Templates* window, click the **New** button, name the template, and click the **Accept** button. If a template already exists, instead click on the available template and click the **Edit** button to retrain the template. 
4.	In the *Select a Camera* window, click on the camera identifier that corresponds to the bottom-facing camera of your IntelliGuide vision gripper, and click the **Accept** button. By default, the name is “Cam2.” In this example, **Bottom-Facing Camera** is selected. 
5.	In the *Object Finder Template* window, click on the **Initialize** button to load the needed project files onto the controller for the rest of the training process. The wizard will then move onto the next step. 

Step	Action
6.	In the Select Vision Tool step, use the **Vision Process** drop-down menu to select a vision process that has been configured for the bottom-facing camera. If only one process exists, the drop-down menu will automatically select that process. Use the **Vision Tool** dropdown menu to select an Acquisition tool in the vision process. If only one Acquisition tool exists, the drop-down menu will automatically select that process. Click the **Next** button. 
7.	In the *Picture Position* step, click the **Free Joints** button to position the bottom-facing camera above the workpiece. The distance between the workpiece and camera should be at the distance where the camera was focused. From the factory, this is 150 mm for IntelliGuide vision grippers. Click the **Lock Joints** button followed by the **Picture** button. If the picture is acceptable, click **Record** followed by **Next**. 

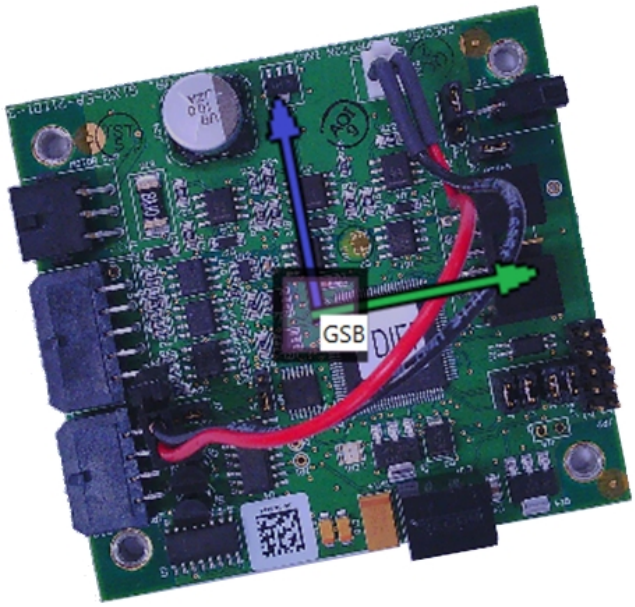
Step	Action
8.	In the *Select Options* step, enter a value for the **Coarse Image Reduction Factor**. This is used to scale the image used in training the model. Smaller values result in faster processing but less detail will be used. By default, 10% is used. Check the **Use Template Offset** box if you'd like to move the calculated center position of the workpiece. In this example it is unchecked. Click **Next**. 
9.	In the *Train* step, click the **Train** button to begin the training process. Depending on the Coarse Image Reduction Factor value from the previous step, training should take ~5 seconds. Click **Next**. 
10.	On the *Process Complete* step, click the **Next** button to complete the training process.

The newly trained template can be referenced in the Object Finder tool property **Template 1-4**. To teach an offset relative to the center position of the workpiece found with the Object Finder tool, click the **Teach a vision pick offset** button inside a .gpo file. This offset can be used for pick-and-place or handling applications.

For more information on teaching a pick offset, refer to the *IntelliGuide Gripper User Manual*.

Example

Here is a sample image taken during the training of a circuit board.



Pixel Window Tool

Counts edges or binary pixels or collects gray-scale statistics within a rotated rectangular or circular region. Used for quickly detecting the presence of features or collecting general intensity information about a region.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest
Height	**Single**		The height of the region of interest
Relative Tool	**String / List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
Width	**Single**		The width of the region of interest
OPERATION			
Count White Pixels	**Boolean**		(`BINARY`) If TRUE, indicates that the white pixels are to be counted. Otherwise, black pixels are counted.

Property Name	Data Type	Range	Description
Pixel Mode	**List**	Binary, Gray, Edge	When this tool executes, it operates in one of three different modes: `BINARY_STATS` counts white/black pixels after thresholding. `GRAY_STATS` returns gray-level statistics (i.e. mean gray levels). `EDGE_LEVEL` counts edge pixels after a gradient operator is applied. Where a property is only relevant for a specific mode, the property is labeled as BINARY, GRAY, or EDGE.

Property Name	Data Type	Range	Description
Threshold	**Integer**		(BINARY) This is the value used to convert gray scale values into black and white pixels. (GRAY) This value is ignored. (EDGE) Specifies the threshold below which weak (low contrast) gradient edges are ignored. The lower this property is set, the more sensitive the system is in locating edges. See the description of the Edge Finder Tool for more information on edge gradients. The default value is 30.
Tool Shape Type	**List**	Square, Round	Shape of the window in which the pixels are analyzed. A square window has its aspect ratio forced to 1:1.
INSPECTION SETTINGS			

Property Name	Data Type	Range	Description
Inspection Label	**List**	None, Pass, Fail, Pass and Fail, Real Value, Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the *Camera Display* window based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.
Inspection Maximum	**Single**		Maximum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Minimum	**Single**		Minimum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."

Property Name	Data Type	Range	Description
Inspection Type	**List**	None, Num Pixels, Mean, Standard Deviation, Min Pixel Value, Max Pixel Value, Pixel Sum, Pixel Sum Squared	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select "None" to disable inspecting a result.
RESULTS SETTINGS			
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass / Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed
Pixel Count	(BINARY,EDGE) Total number of counted binary or edge pixels in the rectangular region
Mean Value	(GRAY) Mean gray-scale value of all pixels in the region
Std. Dev.	(GRAY) Standard Deviation of the gray-scale values for all pixels in the region
Min Value	(GRAY) Minimum gray-scale value of all pixels in the region
Max Value	(GRAY) Minimum gray-scale value of all pixels in the region
Sum	(GRAY) Sum of gray-scale values of all pixels in the region

Remarks/Best Practices

This tool very quickly processes a rectangular or circular region of a gray-scale image and either counts black or white pixels after thresholding, counts edge pixels after applying a gradient operator or collects image statistics, such as mean, maximum, minimum, and standard deviation of the pixel gray-scale values.

This tool provides a very efficient means for quickly extracting gross statistical information about a rectangular or circular region. This tool is often used to quickly verify the presence of a feature or obstacle or to collect gray-scale statistics. For example, this tool can be employed to inspect a part to ensure that expected holes are present or that tabs have been removed. The **Binary Statistics** mode can be applied to detecting defects in a uniform area such as inspecting for scratches or pits in a lens. The **Grayscale Statistics** mode can be used as a simple light meter to adjust the threshold for other operations or can determine the gray-scale uniformity of the region.

When this tool is operated in the **Binary Statistics** mode, the specified region is converted to white and black pixels based upon the Threshold property. Then, either the white or the black pixels are

counted based upon the **Count White Pixels** property. The number of counted pixels and the centroid of all of the positions of the counted pixels are returned in the results.

If this tool is operated in the **Edge Level** mode, the specified region is converted to edge pixels using a gradient operator and the setting of the **Threshold** property to select only strong edges. Then, the edge pixels are counted. The number of edge pixels and the centroid of all of their positions are returned in the results.

If this tool is operated in **Grayscale Statistics** mode, statistics are collected on all of the pixel gray-scale values within the specified region. The returned results include the mean value, maximum value, minimum value, sum of the squares, and standard deviation.

Point Finder Tool

Locates the edge point that is closest to the line that defines the start of the tool's search region. The XY position of the point is returned with sub-pixel accuracy along (and pixel accuracy perpendicular to) the search direction.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter Chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest
Height	**Single**		The height of the region of interest

Property Name	Data Type	Range	Description
Relative Tool	**String / List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
Width	**Single**		The width of the region of interest
OPERATION			
Threshold	**Integer**		The threshold to apply when detecting the squares
RESULTS SETTINGS			
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display

Property Name	Data Type	Range	Description
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed

Remarks/Best Practices

This tool searches a region of interest for the edge point that is closest to the line that defines the start of the rectangular search region. The distance between the edge point and the line is measured along the perpendicular to the starting line that passes through the point.

This tool is useful for locating the closest position between a part's boundary and a reference line. This tool is very convenient if the boundary is not a smooth curve or has points of interest such as corners or cusps.

The position of the returned point can be used in combination with other tools to establish the position or thickness of an object.

Point-Line Frame Tool

Takes a point and a line from two vision tools, and returns a reference frame.

Prerequisites

This tool requires links with other vision tools to perform the calculation.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
OPERATION			
Line Source	**String / List**		The line to use in the calculation
Point Source	**String / List**		The point to use in the calculation
INSPECTION SETTINGS			

Property Name	Data Type	Range	Description
Inspection Label	**List**	None, Pass, Fail, Pass and Fail, Real Value, Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the *Camera Display* window based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.
Inspection Maximum	**Single**		Maximum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Minimum	**Single**		Minimum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."

Property Name	Data Type	Range	Description
Inspection Type	**List**	None, Angle	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select "None" to disable inspecting a result.
RESULTS SETTINGS			
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass / Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed

Remarks/Best Practices

This computational tool combines the results of two vision tools to compute a new reference frame. The inputs to this method from the vision objects are a line and a point that is not on the line. The X-axis of the new reference frame will be collinear with the input line. The Y-axis of the new frame will pass through the specified point.

This method is often used to uniquely define the position and orientation of a simple object or a section of an object. The resulting reference frame can then be used to position additional vision tools.

Alternately, this method can be utilized to compute the distance between a point and a line since the origin of the generated reference frame defines the position on the line that is closest to the input point.

Point-Point Line Tool

Computes a line given two points from two vision tools.

Prerequisites

This tool requires links with other vision tools to perform the calculation .

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
OPERATION			
Point 1 Source	**String / List**		Name of the vision object that defines one of the two points on the line.
Point 2 Source	**String / List**		Name of the vision object that defines one of the two points on the line.
INSPECTION SETTINGS			
Inspection Label	**List**	None, Pass, Fail, Pass and Fail, Real Value, Integer Value	Indicates if a Pass/Fail label or a numeric value is to be displayed on the tool in the Camera Display Window based upon the results of the inspection. The items in the list indicate if no label should be displayed, only a Pass label, only a Fail label, either a Pass or Fail label, or a real or integer numeric value. The Pass indicator is displayed in green and the Fail is written in red. This selection is used for display purposes only and has no effect on the results of the inspection.

Property Name	Data Type	Range	Description
Inspection Maximum	**Single**		Maximum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Minimum	**Single**		Minimum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed."
Inspection Type	**List**	None, Angle	Specifies the single scalar result that is to be inspected. The items in the list vary from one tool to the next. Select "None" to disable inspecting a result.
RESULTS SETTINGS			
Offset Angle	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).

Property Name	Data Type	Range	Description
Offset X	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Offset Y	**Single**		These Offset values permit the results of a vision tool to be shifted and rotated from their standard location. This allows you to re-position the results of a tool to a position and orientation that is more meaningful to you. The orientation change is in degrees, and the shift is in calibrated units (mm).
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display

Property Name	Data Type	Range	Description
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass / Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed
Start X	The Pixel X coordinate of the line start point
Start Y	The Pixel Y coordinate of the line start point
End X	The Pixel X coordinate of the line end point

Result Name	Description
End Y	The Pixel Y coordinate of the line end point

Remarks/Best Practices

This computational tool combines the results of two vision tools to compute a line. The inputs to this method from the vision objects are two points. The resulting line will intercept each of the two input lines.

Once computed, the resulting line can be combined with other vision results to establish reference frames or as a datum for measurements.

Sensor Window Tool

Detects motion in a window region. Ensures the scene is stable prior to other operations or waits until motion is detected. Can be used in place of physical sensors in flexible parts feeding where parts can take time to settle.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Angle	**Single**		The angle of the region of interest
Height	**Single**		The height of the region of interest

Property Name	Data Type	Range	Description
Relative Tool	**String / List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
Width	**Single**		The width of the region of interest
OPERATION			
Delay After Complete	**Single**		Specifies an amount of time to wait after the operation is completed (post-processing dwell time)
Edge Threshold	**Integer**		Specifies the threshold below which weak (low contrast) gradient edges are ignored. The lower this property is set, the more sensitive the system is in locating edges.
Maximum Timeout	**Single**		Specifies a maximum time (in seconds) that the tool will execute. If this time is exceeded, the tool stops processing and returns an error.

Property Name	Data Type	Range	Description
Pixel Change Amount	**Integer**		If more than this specified number of edge pixels' change between successive images, this tool declares that motion has been detected.
Sense Mode	**List**	Wait Motion Start, Wait Motion Stop	Specifies the operating mode of this tool. The default is to "wait for no motion."
RESULTS SETTINGS			
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed
Pixel Count	Actual number of pixels detected during the operation

Remarks/Best Practices

This motion sensing tool acquires a series of pictures sequentially and compares successive images to detect how many edges are changing. Based upon the number of changed edges, this tool decides upon whether any movement has been detected.

This tool determines movement by performing the following operations. First, it acquires a new image. Then the new image is subtracted from the previous image. A cross-gradient edge-extraction algorithm is performed across the resulting image, and the edges are thresholded to produce a binary image. The binary image is eroded to eliminate insignificant changes. The resulting binary edges are counted and compared to the Pixel Change Amount to determine if sufficient pixels have changed to declare that movement has been detected. Based upon the setting of the Sense Mode property, this tool either takes another picture and repeats the process, or it terminates.

This tool requires successive images, so a minimum of two pictures is always taken.

This tool can be applied in applications where parts may be falling or moving (e.g. rolling parts). Instead of applying a worst-case fixed-delay time, the Sensor Window Tool can be used to ensure the parts are not moving before locating or executing the remaining processes.

Sharpness Detector Tool

Calculates the sharpness of edges and features within a region of interest.

Prerequisites

This tool requires an acquisition tool to fill the camera buffer with an image for processing.

Parameter chart

Property Name	Data Type	Range	Description
IDENTITY			
Camera Number	**Integer**		The camera the tool executes against
Name	**String**		The name of the tool instance
REGION OF INTEREST			
Height	**Single**		The height of the region of interest
Relative Tool	**String / List**		If a tool is to be positioned relative to another tool, this is the name of the referenced tool. Tools can be relative to any vision tool that returns a vision coordinate position. By default, tools are not relative to another tool and this property is empty.
X Position	**Single**		The X coordinate of the center of the region of interest
Y Position	**Single**		The Y coordinate of the center of the region of interest
Width	**Single**		The width of the region of interest

Property Name	Data Type	Range	Description
OPERATION			
Lower Threshold	**Integer**		The lower threshold is used to find faint pixels that are actually a part of an edge. If a pixel gradient value is below the lower threshold, it is rejected.
Upper Threshold	**Integer**		The upper threshold is used to mark edges that are definitely edges. If a pixel gradient is higher than the upper threshold, the pixel is accepted as an edge.
RESULTS SETTINGS			
Result Color	**List**	Gold, Blue, Violet, Red, Black, White	The color to use when rendering the result markers
Result Scale	**Double**		The scale to apply to the size of the result display

Property Name	Data Type	Range	Description
Show Results	**List**	None, Point, Line, Frame, Arc	Alters how the results of a tool are graphically displayed. Each vision tool has a default method for display, e.g. a line or a frame. This property allows the graphical display to be changed. For example, a Fixed Frame Tool is normally displayed as a reference frame. However, if it is being used as a datum line or a point, its display can be changed to a line or a point for visual clarity. This property does not affect the actual results of the tool.

Results Chart/List

Result Name	Description
Object ID	Secondary result instance index
Index	The index of the result instance
X	The X position in pixels
Y	The Y position in pixels
Theta	The angle in degrees
Insp. Status	Pass/Fail results of the tool Inspection
Insp. Actual	Actual property value that was tested by the tool Inspection
Tool Status	Specifies if an error or warning condition occurred when the tool was executed
Sharpness	The average intensity difference around edge pixels. Higher values indicate sharper images.

Remarks/Best Practices

The sharpness value is calculated by performing edge extraction in the region of interest. The contrast is calculated by comparing the number of edges detected with the gray scale intensity changes.

The calculated sharpness value is a relative measurement. A typical usage of the tool would be calculating an initial sharpness value, then introducing a change into the system like a slight movement of the robot towards or away from the object. A second sharpness value can be obtained and compared with the original to see if the image is more or less in focus.

4. Stereo-Locator Class

The following pages detail the various properties and methods of the StereoLocator class. This class is used to perform AutoTeach tasks in various applications using ArUco markers as fiducials. It relies on using a vision process that includes an Acquisition tool and a Fiducial Locator tool.

The StereoLocator class is not included in the *GPL Object Library*, but it is available as a series of GPL project files that may be included in any GPL or GP Flow project. For GP Flow projects, simply include an AutoTeach statement, generate the sequence, and the StereoLocator class and its files will be available in the project. For GPL projects, GDS 5.3 and newer makes the StereoLocator class and its files available via the resource toolbox. GDS 5.2 and older make the StereoLocator class and its files available via C:\Program Files\Precise GDS UI 5.2\GPL\AutoTeachSample. The files are protected and unable to be edited by users.

These files are:

- Lib_stereocal.gpp
- Lib_StereoFunctions.gpp
- Lib_StereoLocator.gpp

A StereoLocator class can be constructed and used with either camera on an IntelliGuide vision gripper. For both cameras, the method **LocateTargetStereoDualArucos** is the primary function used to perform AutoTeach. For the bottom-facing camera, the properties BoolFixedZ and FixedZValue can be used to treat the camera as a fixed-mount camera, and reduces the cycle time of AutoTeach tasks as well as enables object location and detection with the Object Finder tool.

The table below summarizes the properties and methods of the class.

StereoLocator Class Member	Type	Description
New	Constructor Method	Creates an empty **StereoLocator** object.

StereoLocator Class Member	Type	Description
*Stereolocator_obj.*Aruco1Num	Property	The first ArUco number used when resolving a fiducial location position. Used in both single and dual ArUco modes.
*Stereolocator_obj.*Aruco2Num	Property	The second ArUco number used when resolving fiducial location positions. Used only in the dual ArUco mode.
*Stereolocator_obj.*BoolFixedZ	Property	Is the stereo locator using Fixed-Z mode (True) or ArUco mode (False).
*Stereolocator_obj.*CameraNumber	Property	The camera number defining the calibration to use. Camera 1 is the front facing camera. Camera 2 is the downward camera.
*Stereolocator_obj.*DistanceBetweenArucos	Property	The distance between ArUco 1 and ArUco 2. Only used in Dual ArUco mode. ***NOTE:*** *This is used only to validate vision result – as a final sanity check before returning location info to the calling function.*
*Stereolocator_obj.*ExitAutoTeach	Method	Force the stopping of the Stereo Location process resulting in a termination of robot motions.
*Stereolocator_obj.*FixedZValue	Property	The Z-Height of the vision plane in robot coordinates. This is used in Fixed-Z mode only.
*Stereolocator_obj.*GetPositionFromVisionResult	Method	Get the location using Fixed-Z mode using the specified picture position and vision result handle. This can only be called if BoolFixedZ is True.

StereoLocator Class Member	Type	Description
Stereolocator_obj. LocateTargetStereoDualArucos	Method	Locate the target using Dual ArUco Stereoscopic vision.
Stereolocator_obj. LocateTargetStereoSingleAruco	Method	Locate the target using Single ArUco Stereoscopic vision
*Stereolocator_obj.*MaxArucoDistEstErr	Property	The maximum allowable distance error between the measured ArUco positions and the user-supplied value. Only used in dual ArUco mode.
*Stereolocator_obj.*NumAttemptsToFindArucoPos	Property	Maximum number of attempts allowed to locate the 3D position of ArUco in the single or dual ArUco(s) mode.
Stereolocator_obj. NumAttemptsToReachTargetPos	Property	Maximum number of attempts allowed to re-compute ArUco 3D position(s) if they do not meet the accuracy thresholds. Used for both single and dual ArUco modes.
*Stereolocator_obj.*OptimumDistanceToTarget	Property	Robot makes (even repeated) moves until the camara is at this distance from the ArUco(s) before vision returns the final position, ensuring the repeatability of the vision result. This value must be between the minimum and maximum optimum distance range that was set during calibration.

StereoLocator Class Member	Type	Description
*Stereolocator_obj.*OptimumWindowScaleFactor	Property	This is a scaling factor that controls how precise and repeatable the calculated vision position ought to be. This value scales the tolerance ranges used in the vision algorithms. Lower values lead to higher repeatability but may lead to more retries taking more time. Default is 1.0. Recommended values are 0.25 to 1.5.
*Stereolocator_obj.*ProcessName	Property	The name of the vision process to use when resolving to a stereo location position.
*Stereolocator_obj.*RetryMotion_ArmTooClose_Offset	Property	The horizontal XY retract-offset applied to the robot position when the arm is too close to the ArUco(s) before retrying. Used for Camera-1 only. This offset will be applied repeatedly until the robot position is in range for the stereo vision model.
*Stereolocator_obj.*RetryMotion_ArmTooFar_Offset	Property	The horizontal XY extend-offset applied to the robot position when the arm is too far from the ArUco(s) before retrying. Used for Camera-1 only. This offset will be applied repeatedly until the robot position is in range for the stereo vision model.

StereoLocator Class Member	Type	Description
*Stereolocator_obj.*RetryMotion_NoArucosDetected	Property	The motion offset to apply to the robot position when no ArUco(s) are visible. It is assumed that robot is too close to the ArUco(s) and thus not able to see them. For Camera-1 this offset is applied as a retract offset in XY plane. For Camra-2 this is applied as an up-offset in the vertical direction.
*Stereolocator_obj.*RetryMotion_TooCloseToCenter_Offset	Property	The horizontal XY extend-offset applied when the robot is not extended enough in the horizontal XY direction. Used for Camera-2 only. This offset will be applied repeatedly until the robot position is in range for the stereo vision model.
*Stereolocator_obj.*RetryMotion_TooFarAboveArucos_Offset	Property	The vertical Z up-offset applied to the robot position when the arm is too far above the ArUco (s) before retrying. Used for both cameras. This offset will be applied repeatedly until the robot position is in range for the stereo vision model.
*Stereolocator_obj.*RetryMotion_TooFarBelowArucos_Offset	Property	The vertical Z down-offset applied to the robot position when the arm is too far below the ArUco(s) before retrying. Used for both cameras. This offset will be applied repeatedly until the robot position is in range for the stereo vision model.

StereoLocator Class Member	Type	Description
*Stereolocator_obj.*RetryMotion_TooFarFromCenter_Offset	Property	The horizontal XY retract-offset applied when the robot is extended too far in the horizontal XY direction. Used for Camera-2 only. This offset will be applied repeatedly until the robot position is in range for the stereo vision model.
*Stereolocator_obj.*RobotNumber	Property	The robot number being operated on
*Stereolocator_obj.*StereoProfile	Property	The motion profile used in single ArUco and dual ArUco mode.
*Stereolocator_obj.*ToolName	Property	The name of the vision tool to use when resolving to a stereo location position.
*Stereolocator_obj.*WaitMsecs	Property	The amount of time (in milliseconds) to wait before a picture is acquired to allow for settling of the robot. This is not used in Fixed-Z mode.
*Stereolocator_obj.*WristAxisIdx	Property	The Index of the axis used to rotate about in Single ArUco or Dual ArUco modes. This is not used in Fixed-Z mode.

StereoLocator_Object **Aruco1Num Property**

Prerequisites

None

Parameters

None

Remarks

Aruco1Num refers to the first ArUco marker used when determining the position of a fiducial location. This designation is relevant in both single and dual ArUco modes. In dual ArUco mode, **Aruco1Num** is the marker positioned on the left when the markers are arranged horizontally. If the markers are placed vertically, **ArUco1Num** is the one located at the top.

StereoLocator_Object **Aruco2Num Property**

Prerequisites

None

Parameters

None

Remarks

Aruco2Num is the right or bottom ArUco marker used for horizontal or vertical orientations, respectively. (See **Aruco1Num** description above).

StereoLocator_Object **BoolFixedZ Property**

Prerequisites

None

Parameters

None

Remarks

Set this flag to True to enable FixedZ mode for an AutoTeach task (only available for the bottom camera). Use this mode when fiducials are always at a known, fixed height—like on a flat surface. FixedZ mode reduces cycle time by requiring only a single image and requiring no robot motion, while a standard AutoTeach task requires two images and three wrist movements (left, right, and back to center).

To determine the Z-height for FixedZ mode, use the **Locate a vision target** button via a .gpo file with the *Fiducial Detection* mode. A pair of ArUco markers are required and need to be placed on the work surface.

The output will be a location object and it's cartesian Z-value can be used as the Z-height for FixedZ mode.

StereoLocator_Object **CameraNumber Property**

Prerequisites

None

Parameters

None

Remarks

The IntelliGuide vision gripper camera number defining the calibration model to use. A value of "1" is the front-facing camera. A value of "2" is the downward-facing camera.

StereoLocator_Object **DistanceBetweenArucos Property**

Prerequisites

None

Parameters

None

Remarks

This value represents the distance between the centers of ArUco 1 and ArUco 2 and is only used in Dual-ArUco mode. It serves solely as a validation step to ensure the vision result is reliable before returning the location information to the calling function.

StereoLocator_Object **ExitAutoTeach Method**

Prerequisites

None

Parameters

None

Remarks

Forces the stopping of the AutoTeach process and results in stopping the robot motions used in the process.

StereoLocator_Object **FixedZValue Property**

Prerequisites

None

Parameters

None

Remarks

This property should be set to the value of the Z-coordinate returned from using the **Locate a vision target** button via a .gpo file. See remarks from **BoolFixedZ**.

StereoLocator_Object **GetPositionFromVisionResult Method**

Prerequisites

None

Parameters

The robot location where the image was taken

Remarks

The StereoLocator class is typically used with ArUco markers, but it can also function without them. If you have a pixel location in the image and know the corresponding Z height in the real world, you can use this function to call stereo model in FixedZ mode to compute the full 3D position of that point.

A common example is object localization. If you can identify a pixel point

on an object—such as its geometric center—and you know the height of the object at that point, you can pass the pixel coordinates to the stereo model. The model will then estimate the 3D position of the point in robot space. If the object's orientation is also known, this information can be used to perform tasks like pick-and-place operations.

Example

```
' Run the vision process
Dim vis As New Vision
vis.Process(processName)

' Make sure only 1 result is found
Dim nResults As Integer = vis.ResultCount()

' Get the result
Dim visRes As VisResult = vis.Result(toolName, 1)

' Get the robot location
Dim robotLocation As New Location
robotLocation.Here()

' Perform the calculation
Dim visionTargetLocation As Location
visionTargetLocation = locator.GetPositionFromVisionResult(robotLocation, visRes)
Return visionTargetLocation
```

StereoLocator_Object **LocateTargetStereoDualArucosMethod**

Prerequisites

None

Parameters

None

Remarks

Execute this method to perform AutoTeach with a pair of ArUco markers.

In dual-ArUco mode, the 3D position returned is the midpoint between the centers of the two ArUco markers. The approach yaw is calculated as the angle of the line that is perpendicular to the plane formed by both markers.

This mode provides higher accuracy for both position and orientation compared to single-ArUco mode, making it the preferred choice when space allows and precision is important.

Example

```
Dim visionTargetLocation As Location

If fiducialMode = FiducialMode_Double Then
    visionTargetLocation = locator.LocateTargetStereoDualArucos()
Else
    visionTargetLocation = locator.LocateTargetStereoSingleAruco()
End If
Return visionTargetLocation
```

StereoLocator_Object LocateTargetStereoSingleAruco Method

Prerequisites

None

Parameters

None

Remarks

In single ArUco mode, the system returns the 3D position of the center of the single ArUco marker. The approach yaw is calculated as the angle of the line perpendicular to the plane in which the marker lies.

In contrast, dual ArUco mode provides more accurate results for both the 3D position and the approach yaw. This is generally the recommended mode for most use cases due to its higher precision.

However, single ArUco mode can be useful when:

- There is limited space and only one marker can be placed
- Accuracy requirements are less strict

Greater flexibility is needed for example, when placing markers in various locations around a tool or workspace to define custom coordinate frames.

Example

```
Dim visionTargetLocation As Location

If fiducialMode = FiducialMode_Double Then
    visionTargetLocation = locator.LocateTargetStereoDualArucos()
Else
    visionTargetLocation = locator.LocateTargetStereoSingleAruco()
End If
Return visionTargetLocation
```

StereoLocator_Object MaxArucoDistEstErr Property

Prerequisites

None

Parameters

None

Remarks

This property is related to the **DistanceBetweenArucos** property. **DistanceBetweenArucos** is used as a final sanity check of the position estimation. After calculating the center of each of the ArUco(s) and comparing the measured distance between ArUcos to user supplied value, if the delta between them exceeds the value specified by this property, then the position is discarded.

StereoLocator_Object NumAttemptsToFindAruco Property

Prerequisites

None

Parameters

None

Remarks

The properties **NumAttemptsToFindAruco** and **NumAttemptsToReachTargetPos** work together to determine the ArUco marker's 3D position in both single and dual-ArUco modes.

The process begins with locating the 3D position of the ArUco marker(s). If **NumAttemptsToFindAruco** is set to 3, the **StereoLocator** method will make up to three attempts to detect and compute the marker's position.

There are several reasons why the ArUco position might not be available:

- In dual ArUco mode, only one marker may be visible
- The markers may be too close or too far from the camera, falling outside the valid stereo range
- Detection noise may result in an unreliable 3D position

No user intervention is required during this process. The StereoLocator algorithm automatically handles these scenarios and adjusts accordingly.

If the ArUco position cannot be determined after the specified number of attempts for this property, an exception is raised.

Once the ArUco marker's position is determined, the robot adjusts the gripper to position the camera at the optimal distance from the marker as defined by the **OptimumDistanceToTarget** property. This adjustment ensures the most consistent and repeatable detection of the ArUco marker. The robot makes up to **NumAttemptsToReachTargetPos** attempts to reach this optimal position.

The **OptimumWindowScaleFactor** property (default value: 1) controls how strictly the vision algorithm evaluates whether the robot's current position is sufficiently close to the optimal one. A lower value enforces a tighter tolerance, while a higher value allows more flexibility. For more details, refer to the description of this property.

StereoLocator_Object **NumAttemptstoReachTargetPos Property**

Prerequisites

None

Parameters

None

Remarks

See **NumAttemptsToFindAruco**property description above.

StereoLocator_Object OptimumDistanceToTarget Property

Prerequisites

None

Parameters

None

Remarks

During stereo calibration, the user can specify an optimum distance range (e.g., 150 mm to 190 mm) based on the expected working distance from the camera to the fiducials. This range should match the typical distances at which fiducials will be read during operation. More calibration data is collected within this range, providing denser coverage of the model space and improving repeatability.

Note: The camera focus must be adjusted so that fiducials appear sharp throughout the specified distance range.

In applications with multiple stations performing pick-and-place operations, it is recommended to assign a fixed **OptimumDistanceToTarget** value for each station. This helps ensure maximum repeatability in the computed 3D positions.

From the factory, IntelliGuide vision grippers are calibrated with an **OptimumDistanceToTarget** value of “150”.

StereoLocator_Object OptimumWindowScaleFactor Property

Prerequisites

None

Parameters

None

Remarks

This property is closely tied to the **OptimumDistanceToTarget** setting. When StereoLocator methods are called, the robot moves so that the camera is positioned at the specified distance from the fiducials before returning the computed 3D position. The **OptimumWindowScaleFactor** defines how close the robot must be to this ideal position for the resulting 3D calculation to be considered valid. A lower value enforces a tighter constraint, which can improve repeatability but may require additional robot movements. The default value is 1, which is sufficient for most applications.

StereoLocator_Object **RetryMotion_ArmTooClose_Offset Property**

Prerequisites

None

Parameters

None

Remarks

If the camera is too close to the ArUcos, the stereo model may no longer be valid. In such cases, the robot performs a fixed retraction move away from the fiducials by the distance specified by this property.

This setting applies only to the forward-facing camera. The offset will be applied repeatedly until the robot is positioned within the valid range for the stereo vision model.

StereoLocator_Object **RetryMotion_ArmTooFar_Offset Property**

Prerequisites

None

Parameters

None

Remarks

If the camera is too far from the fiducials, the stereo model may no longer be valid. In such cases, the robot performs a fixed forward move towards the fiducials by the distance specified by this property.

This setting applies only to the forward-facing camera. The offset will be applied repeatedly until the robot is positioned within the valid range for the stereo vision model.

StereoLocator_Object **RetryMotion_NoArucosDetected Property**

Prerequisites

None

Parameters

None

Remarks

The motion offset to apply to the robot position when no ArUcos are visible. It is assumed that the robot is too close to the ArUcos and thus not able to see them. For the forward-facing camera, this offset is applied as a retract offset in XY plane. For the bottom-facing camera this is applied as an upward z-offset in the vertical direction.

StereoLocator_Object **RetryMotion_TooCloseToCenter_Offset Property**

Prerequisites

None

Parameters

None

Remarks

The horizontal XY extend-offset applied when the robot is not extended enough in the horizontal XY direction. Used for the bottom-facing camera only. This offset will be applied repeatedly until the robot position is in range for the stereo vision model.

StereoLocator_Object RetryMotion_RetryMotion_TooFarAboveArucos_Offset Property

Prerequisites

None

Parameters

None

Remarks

The upward vertical Z-offset applied to the robot position when the arm is too far above the ArUco(s) before retrying. Used for both cameras. This offset will be applied repeatedly until the robot position is in range for the stereo vision model.

StereoLocator_Object RetryMotion_TooFarBelowArucos_Offset Property

Prerequisites

None

Parameters

None

Remarks

The downward, vertical Z-offset applied to the robot position when the arm is too far below the ArUco(s) before retrying. Used for both cameras. This offset will be applied repeatedly until the robot position is in range for the stereo vision model.

Example

StereoLocator_Object RetryMotion_TooFarFromCenter_Offset Property

Prerequisites

None

Parameters

None

Remarks

The horizontal XY retract-offset applied when the robot is extended too far in the horizontal XY direction. Used for the downward-facing camera only. This offset will be applied repeatedly until the robot position is in range for the stereo vision model.

StereoLocator_Object **RobotNumber Property**

Prerequisites

None

Parameters

None

Remarks

The number of the robot to perform the AutoTeach process. For PreciseFlex robots, this value should be “1.”

StereoLocator_Object **StereoProfile Property**

Prerequisites

None

Parameters

None

Remarks

The name of the motion profile to use for the AutoTeach process as a string type. The value of this property should reference a motion profile object that is properly configured.

StereoLocator_Object **ToolName Property**

Prerequisites

None

Parameters

None

Remarks

The name of the vision tool to use for stereo location position, as a string type. The value of this property should reference a Fiducial Locator tool configured for the correct camera

StereoLocator_Object **WaitMs Property**

Prerequisites

None

Parameters

None

Remarks

This property specifies the extra time (in milliseconds) to wait after motion completion before capturing an image, allowing the robot to fully settle. This value should be set at a minimum value of “500.” It is possible to reduce this value to as low as “250” but is dependent on the robot mechanics.

StereoLocator_Object **WristAxisIdx Property**

Prerequisites

None

Parameters

None

Remarks

Specifies the index of the axis used for rotation when capturing stereo images. This setting is not applicable in Fixed-Z mode, which relies on a single image and does not involve rotational movement.

For PreciseFlex robots, this value should be set to “4.”

StereoLocator_Object **StereoRotationAngle Property**

Prerequisites

None

Parameters

None

Remarks

The +/- angle delta on robot axis specified by WristAxisIdx moves to create stereo images.

5. Error Codes

The following error codes can be generated by the vision server in response to a GPL vision operation. Some of the codes can only be generated when interacting with the vision server using low-level GPL instructions.

Error Code	Error Message	Description
-4005	Cannot execute tool with models trained at different resolutions	An object finder tool is executing with multiple templates trained with different resolutions. Retrain the models to have the same resolution or create different object finder tools for templates of different resolutions.
-4011	General Exception	This error should never be seen. An internal failure has occurred. Contact customer support at support_preciseflex@brooksautomation.com for further details.
-4012	Unknown Process Name	A vision command is referencing an unknown process. Correct the command to resolve the issue.
-4013	Unknown Vision Tool	A vision command is referencing an unknown vision tool. Correct the command to resolve the issue.
-4014	Index out of Range	A vision command is referencing an index that is out of range. Correct the command to resolve the issue.
-4015	The command has failed	A general command failure has occurred. This is not likely to be seen by the end user. It represents an invalid command relative to the mode of operation of the server.

Error Code	Error Message	Description
-4016	Invalid Arguments	The arguments to a GPL level command are invalid. Correct the command to resolve the issue.
-4017	Property not found	
-4019	Acquisition Failure	Typically, this will be seen in the execution of a Sensor Window tool when it is unable to acquire a comparison image from the camera.
-4021	Invalid Project Name	A command is referencing an invalid project name. Correct the command to resolve the issue.
-4023	The loaded project has not been saved	Some commands require a modified project to be saved before execution. Save the project before issuing the command to resolve the issue.
-4024	Vision Tool Results not Found	A command references a vision tool result and the vision tool does not have results available. Re-execute the vision tool to acquire results.
-4027	No Project Loaded	Some commands require a project to be loaded before continuing. Load a project, and re-execute the command to resolve the issue.
-4028	Project Already Exists	A command references a project that already exists. Ensure a unique project name is used, and re-issue the command to resolve the issue.
-4029	Duplicate Tool Name	A command references a tool that already exists. Ensure a unique tool name is used, and re-issue the command to resolve the issue.
-4030	Invalid Tool Name	The vision tool name is invalid. Use a valid vision tool name, and re-issue the command to resolve the issue.
-4030	Error_InvalidSettings	There are errors with settings. Examples are: invalid robot number, no stereo vision model available, **optimumDistanceToTarget** is not within min/max range, trying to use fixed-Z with Camera-1, etc.

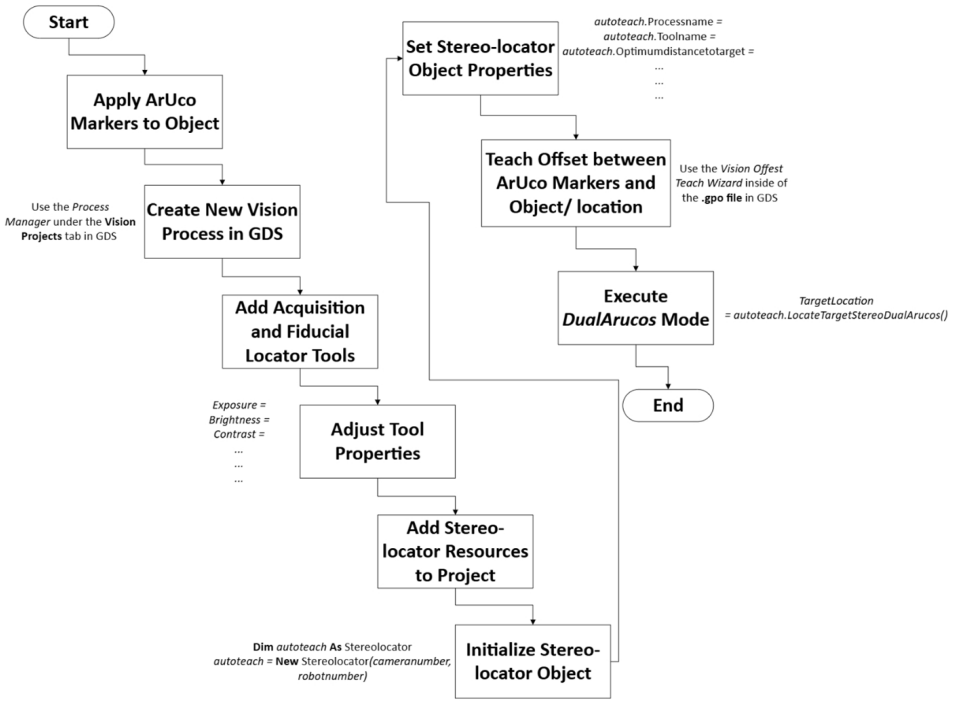
Error Code	Error Message	Description
-4031	Error_InvalidCameraNumber	The number is not a valid camera number.
-4032	Error_CameraResolutionMismatch	The current camera resolution does not match the resolution used in stereo vision model.
-4033	Error_InvalidCalibrationParameters	The calibration parameters are not valid.
-4034	Error_InvalidCalibrationVersion	There is incompatibility between the current software version and the version of the stereo vision model.
-4040	Error_ArmTooCloseToArucoBoard	There is not enough clearance between the gripper and ArUco board during calibration. This may cause a potential collision during the data collection step. Increase the **minDistToTarget**.
-4041	Error_CameraNotInFocus	The image-sharpness criteria failed during the camera focus. Check the calibration distance range.
-4042	Error_ VisualServoingFailedToReachTarget	The ArUco board corner(s) position estimation failed during stereo calibration. Possible causes include: vibrations, high robot speed, etc.
-4043	Error_UnableToDetectCornerAruco	The robot is unable to see corner ArUcos. The robot looks for the corner ArUcos in a fixed order. The likely causes are board orientation or image quality (poor lighting, vibration etc.).
-4044	Error_ FailureWhileSolvingForStereoModel	There is a failure while solving the stereo model with the collected calibration data, resulting in insufficient or bad data.
-4045	Error_ PoorCornerArucoPositionEstimates	The vision-based corner position estimates don't match the board dimensions.
-4046	Error_PoorPositionEstimate	The position estimate is poor while using the stereo model.

Error Code	Error Message	Description
-4047	Error_CameraFocusOutOfRange	The camera focus is poor, and the fiducials are not visible during focus check.
-4050	Error_ArmTooClose	The robot arm is too close to the target and should be moved back.
-4051	Error_MidPlateAngleToLarge	The calculated angle difference between the gripper direction and the located target(s) is too large.
-4052	Error_TooFarAbove	The robot arm is too far above the target and should be moved down.
-4053	Error_TooFarDown	The robot arm is too far below the target and should be moved up.
-4054	Error_ArmTooFar	The robot arm is too far from the target and should be moved closer.
-4055	Error_TooCloseToCenter	The robot arm is too close to the robot base when searching for ArUcos.
-4056	Error_TooFarFromCenter	The robot arm is too far from the robot base when searching for ArUcos.
-4060	Error_NoTargetFound	The ArUco or ArUcos were not seen.
-4064	Error_ CannotResolveTargetPosToPrecision	Cannot resolve ArUco(s) positions to the required precision
-4090	Unknown Command	An unknown command has been detected. Correct the command name to resolve the issue.
-4091	Unknown Error	This error should generally not be seen. It represents a command failure. Contact customer support at support_ preciseflex@brooksautomation.com for further details.
-4092	Invalid License	The vision server license is missing or invalid. Contact customer support at support_ preciseflex@brooksautomation.com for further details.

Error Code	Error Message	Description
-4093	Invalid Camera Configuration	The expected configuration of cameras is not detected. A camera is likely offline or missing. This can represent a hardware failure. Reboot the vision system. Contact customer service at support_preciseflex@brooksautomation.com if the problem persists.

Appendices

Appendix A: Auto-Teach Application: Flow Chart



The above flow chart outlines the steps taken to perform an Auto-Teach application with an IntelliGuide Vision gripper and PreciseFlex robot. Some pseudocode is provided for more guidance with GPL programming.

For users of the TCS API the *Stereo-locator* resources are included with the project files starting with version 3.0D2.

For GP Flow users the *Stereo-locator* resources are added to the project as soon as you include an Auto-Teach statement to your sequence and compile the project. The resources will be highlighted with bold text in the *GPL Projects* window.

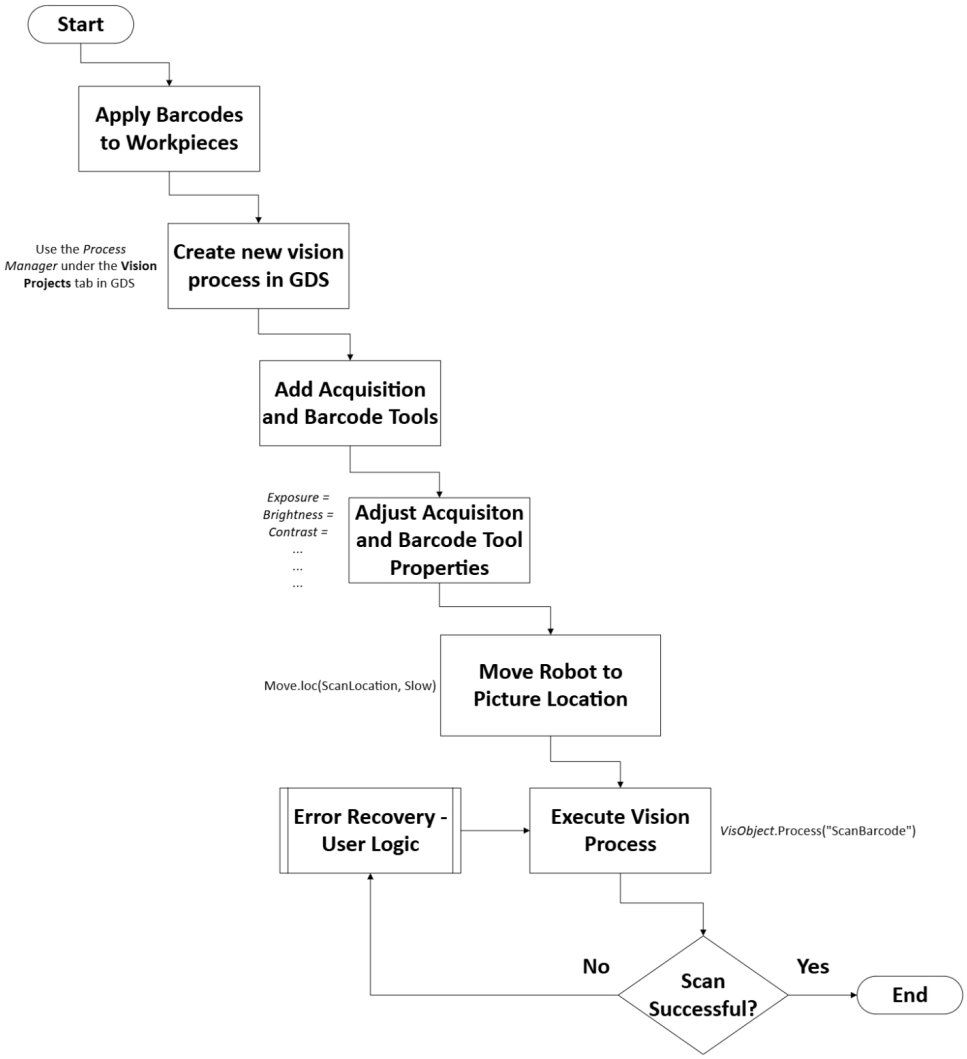
For GPL users with GDS version 5.2 the Stereo-locator resources are available via *C:\Program Files\Precise GDS UI 5.2\GPL* via the folder *AutoTeachSample*. The resources files can be included into any user built GPL project. With GDS version 5.3 the *Stereo-locator* resources are available with the *Resources Toolkit*.

For comprehensive details on the Stereo-locator object and its methods and properties, refer to *IntelliGuide Vision Toolkit Guide Rev A*.

For comprehensive details on GDS, refer to *Guidance Development Studio*.

For comprehensive details on GPL, refer to *Guidance Programming Language Dictionary Rev A*.

Appendix B: Barcode Scanning Application: Flow Chart



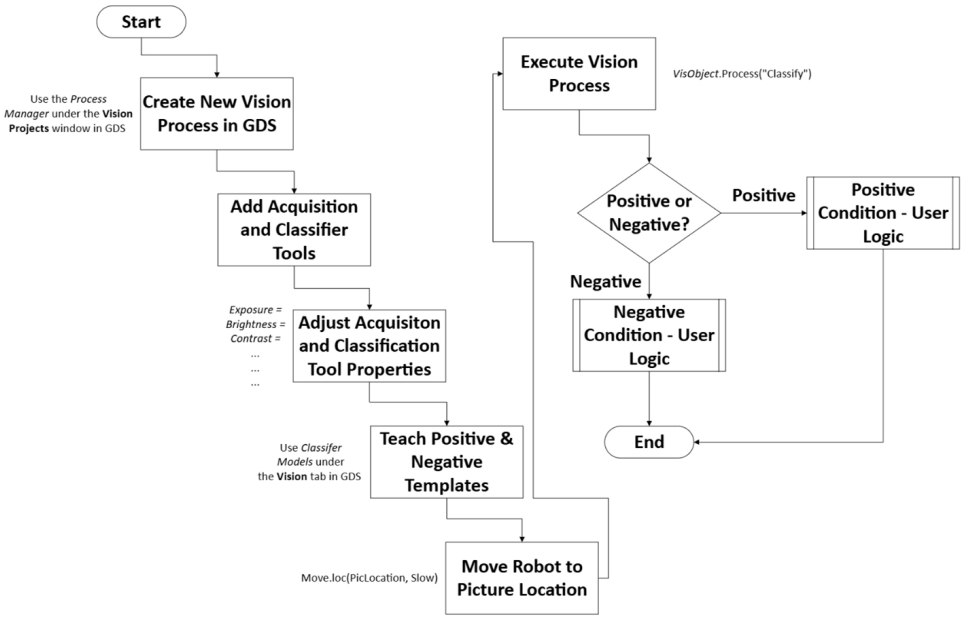
The above flow chart outlines the steps taken to perform a barcode scanning task in an application with an IntelliGuide Vision gripper and PreciseFlex robot. Some pseudocode is provided for more guidance with GPL programming.

For comprehensive details on the barcode scanner tool, refer to the *IntelliGuide Vision Toolkit Guide Rev A*.

For comprehensive details on GDS, refer to *Guidance Development Studio Rev A*.

For comprehensive details on GPL, refer to the *Guidance Programming Language Dictionary*

Appendix C: Classifier Application: Flow Chart



The above flow chart outlines the steps taken to perform a classification task in an application with an IntelliGuide Vision gripper and PreciseFlex robot. Some pseudocode is provided for more guidance with GPL programming.

For comprehensive details on GDS, refer to *Guidance Development Studio.*

For comprehensive details on GPL, refer to the *Guidance Programming Language Dictionary.*