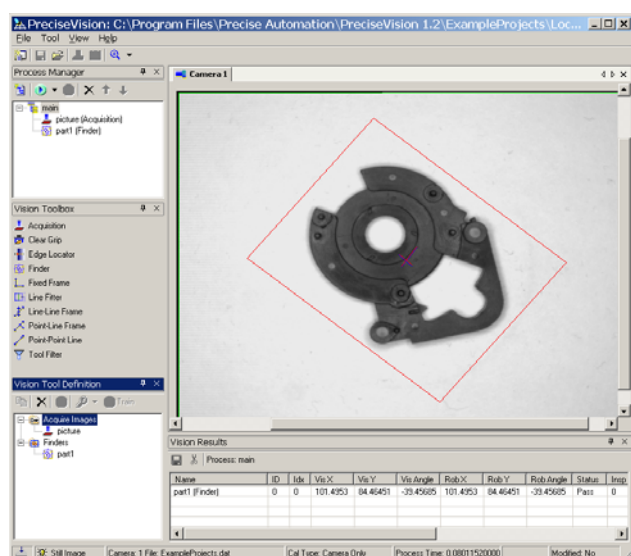




PreciseVision Machine Vision System



Introduction and Reference Manual

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Warning Labels

The following warning and caution labels are utilized throughout this manual to convey critical information required for the safe and proper operation of the hardware and software. It is extremely important that all such labels are carefully read and complied with in full to prevent personal injury and damage to the equipment.

There are four levels of special alert notation used in this manual. In descending order of importance, they are:



DANGER: This indicates an imminently hazardous situation, which, if not avoided, will result in death or serious injury.



WARNING: This indicates a potentially hazardous situation, which, if not avoided, could result in serious injury or major damage to the equipment.



CAUTION: This indicates a situation, which, if not avoided, could result in minor injury or damage to the equipment.

NOTE: This provides supplementary information, emphasizes a point or procedure, or gives a tip for easier operation

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PreciseVision Machine Vision System

PreciseVision Introduction

PreciseVision is a powerful, full featured 2D machine vision software package. This software application includes a complete toolkit with everything that is needed to acquire vision images, identify and locate randomly positioned and oriented parts, measure key features and inspect parts for specific defects. 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".

PreciseVision executes on a Windows PC system and includes a built-in interface to communicate with a Precise Controller via Ethernet. This software package has been designed to operate with the Guidance Programming Language, which executes on a Precise Guidance Controller, to produce flexible vision-guided motion applications. The Guidance Programming Language, GPL, includes a complementary built-in communications interface to PreciseVision and has classes and objects for easily controlling the operation of PreciseVision and retrieving vision results. A complete vision guided robot application consists of a list of vision tools executing in PreciseVision and a GPL program executing on a Guidance Controller that takes the vision results and utilizes this information to alter the actions of a robot.

PreciseVision includes a very easy-to-use visual programming interface that allows both simple and complex vision programs to be constructed by dragging-and-dropping tools into a list. Training of the tools is performed by visually positioning and sizing tools on top of a captured camera image. The parameters for each tool can also be access via a "Properties Table". Since each tool is a software object, the output of one tool can be easily linked to the input of other tools. This is a very powerful capability that allows the placement and the actions of tools to be a function of the results of previously executed tools and permits the results of several tools to be combined.

To capture an image, PreciseVision supports third party Ethernet and USB cameras. Vendor and part number information for purchasing and installing recommended hardware and drivers are provided in this document.

While the most common configuration is to have PreciseVision interfaced to a single robot, information is also provided on executing PreciseVision without a robot or when connected to multiple robots.

In addition to the normal mode of executing tools on a real camera image, this package also permits a sequence of images to be easily saved to disk and then subsequently played back. This allows vision tools to be tested off-line and provides a convenient means for customers to obtain assistance from Precise and its partner companies remotely.

In this document, instructions for installing PreciseVision and the supported 3rd party hardware is presented. This is followed by an overview and quick start section that introduces machine vision newcomers to PreciseVision's principal concepts and permits experienced individuals to quickly use the system. Finally, the last sections of this manual provide detailed information on the system's user interface, toolkit and camera calibration procedures.

PreciseVision

For further information on programming a vision guided robot application in GPL, please refer to the *Guidance Programming Language, Introduction to GPL*.

Supported Hardware and Software Installation

Supported Vision Hardware

PreciseVision is a software package and does not include hardware. This software is designed to capture vision images that are generated by either Ethernet or USB cameras. PreciseVision permits three camera options:

1. DALSA Genie™ GigE cameras that communicate via a 10/100/1000 Ethernet connection
2. IDS Imaging uEye™ cameras that communicate via a USB 2.0 connection
3. Other 3rd party USB cameras (***No customer support provided***)

Each of these options offers a range of camera resolutions, imaging element sizes and a choice of monochrome or color image capturing. The DALSA and IDS cameras have many of the same industrial features and are fully supported by PreciseVision. There are a host of other USB cameras available that range from very inexpensive web cams, to astronomy cameras, to industrial grade cameras, all with different prices, characteristics and installation procedures. Please contact Precise to determine if a specific 3rd party USB camera has been qualified with PreciseVision. ***Precise is not able to provide support for 3rd party USB cameras that have not been tested and qualified.***

When using the standard version of PreciseVision, the system can be connect to multiple DALSA cameras or multiple USB cameras. However, you cannot connect to both DALSA and USB cameras simultaneously. In the Multi-Instance version of PreciseVision, the same rule applies to each instance, i.e. a single instance cannot be connected to a mix of DALSA and USB cameras. However, different instances can be connected to either DALSA or USB cameras.

There are a number of trade-offs that should be considered when selecting the type of camera to use with PreciseVision. The following table summarizes the trade-offs between the DALSA and IDS cameras.

Characteristic	DALSA GigE	IDS uEye USB
Cost	Typically more expensive	Typically 20% less expensive than equivalent DALSA cameras. Non-industrial 3rd party USB cameras can be significantly less expensive.
Resolutions	640x480 up to 1600x1200	640x480 up to 2560x1920 with even higher resolutions to be announced soon.
Acquisition time	Very similar to IDS for same resolution	Very similar to DALSA for same resolution using USB 2.0 (480 Mbits/sec). USB 3.0 (4.8Gbits/sec) due in 2011 will reduce the requisition time.
Hardware synchronization	Supports trigger input and acquisition output	Same as DALSA.

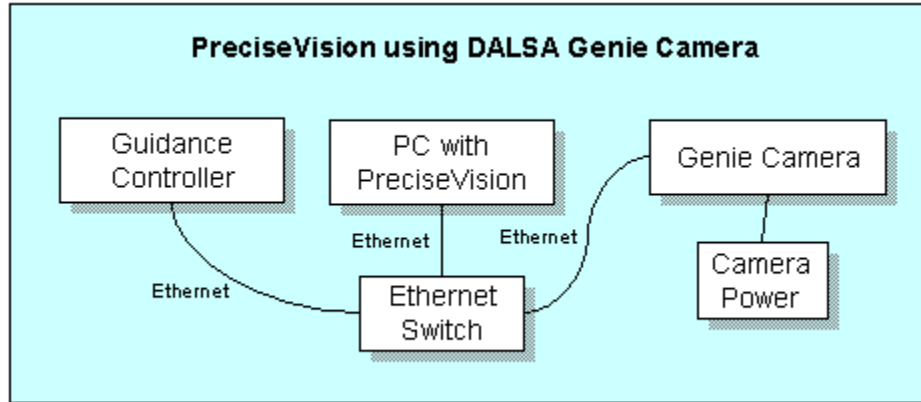
PC CPU Loading	Reduced load relative to USB cameras	Higher load relative to Ethernet cameras. Multiple cameras will require a higher performance CPU. 5 or more cameras may degrade acquisition time.
Cable length	100M	5M. Powered USB hubs might be able to extend length
Installation and support	Fewer steps but more prone to complications due to firewalls, Ethernet card compatibility, Ethernet switch problems, and somewhat more complicated driver installation.	Typically easier for single cameras if wired point to point since no firewalls, less issues with USB hardware interface, simpler driver installation. Multiple cameras are a bit more difficult to setup since each must be assigned an ID and registered with the DirectShow interface.
Arm-mounted cameras	Simpler to install on Precise robots since Ethernet cable and power available at end-of-arm	Requires extra external cable for Precise robots
Power	12VDC 4 watts provided in second cable from extra PS	5VDC taken from single USB cable
Size / weight	29x44x67 mm, <125g	34x32x34.4 mm, 75g

In the following sections, part numbers are provided to allow hardware to be directly purchased from the hardware vendors together with simplified wiring drawings that illustrate how the components should be connected.

Option 1: DALSA Ethernet Cameras

- PreciseVision supports up to 6 DALSA Genie™ GigE Ethernet cameras. See the table below for the recommended camera models.
- DALSA cameras can be directly connected to the PC running PreciseVision or through an Ethernet switch.
- The PC must include a standard Ethernet card, but a GigE card is recommended for the best performance.
- For more information, visit the DALSA website at www.imaging.com. For ordering, contact Manish Shelat at DALSA Digital Imaging, phone: (510) 249-5664, email: manish.shelat@DALSA.com.

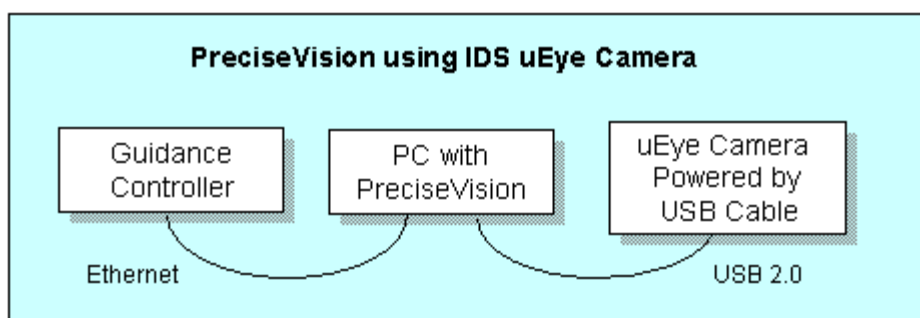




Hardware Specification	
ETHERNET CAMERAS	<p>PreciseVision fully supports the DALSA Genie GigE Vision Cameras. All models listed below provide Progressive scan, have metal cases, C-Mount or CS mount lens adapters, are available in monochrome (M) or color (C), and support an external trigger (DIN) and a digital output (DOUT). Effective frame-to-frame time depends on the exposure time that ranges from 100 microseconds to 4 seconds, controlled via software, plus PC overhead. For total time, add vision processing time, which is typically less than 100ms. PreciseVision supports up to 6 DALSA cameras.</p> <p>M640-1/3, 640x480 resolution, 60 frames/second raw frame rate, 1/3" sensor. M1024, 1034x779 resolution, 20 frames/second raw frame rate, 1/3" sensor. M1400, 1392x1040 resolution, 15 frames/second raw frame rate, 1/2" sensor. M1600, 1600x1200 resolution, 15 frames/second raw frame rate, 1/1.8" sensor.</p>
MOUNTING ADAPTER	Optional DALSA mounting bracket assembly, 1/4" screw mount, part # CA-GENA-BRA00. This bracket is used for mounting the camera on a standard tripod.
CAMERA POWER	<p>Each camera requires 4 watts, 11 VDC to 13 VDC.</p> <p>Option 1: If you wish to break out the camera's I/O pins, order DALSA part # CA-GENA-PS120 and the DALSA Genie I/O and power breakout cable assembly, part # CA-GENC-IOP00.</p> <p>Option 2: If you do not need I/O signal break out, an alternative is the Intercon PSISP10, which includes a connector compatible with the camera but no I/O signal break out, www.nortechsys.com/intercon/index.html</p>
ETHERNET SWITCH	Standard GigE Ethernet Switch. Netgear GS605 10/100/1000, or equivalent.
ETHERNET CARD	Standard GigE PC Ethernet card. Netgear GA311 PCI Gigabit Adaptor, or equivalent.
ETHERNET CABLE	Standard Cat-5 Ethernet cable. Total of 3 required.

Option 2: IDS uEye USB 2.0 Cameras

- PreciseVision supports up to 6 IDS uEye™ USB 2.0 cameras. See the table below for the recommended camera models.
- IDS cameras are typically connected directly to the PC running PreciseVision although a USB hub can be used.
- The PC must support USB 2.0 (not 1.0) and must have DirectX 9 or higher installed. PreciseVision uses DirectShow (DirectX) to interface to the camera driver.
- It is highly recommended that only uEye cameras that support "Global" shutters be utilized and not "Rolling" shutters. A Global shutter exposes all of the pixels of the imaging element at one time. A Rolling shutter exposes lines at different times. This can result in smearing if there is any movement in the image.
- For flexibility in selecting the appropriate lens for your application, a camera with a C-Mount or CS-Mount is highly desirable.



Hardware Specification	
USB CAMERAS	<p>PreciseVision fully supports the IDS Imaging Development Systems GmbH uEye Series-USB 2.0 Cameras. All models listed below have Global Shutters, metal cases, C-mount lens adapters, are available in monochrome (M) or color (C), DB9 signal/power connector, and support an external trigger (DIN) and a digital output (DOUT). Effective frame-to-frame time depends on the exposure time and PC overhead. For total time, add vision processing time, which is typically less than 100ms. PreciseVision supports up to 6 USB cameras.</p> <p>UI-2410-M/C, 640x480 resolution, 75 frames/second raw frame rate, 1/3" CCD sensor.</p> <p>UI-2230SE-M/C, 1024x768 resolution, 30 frames/second raw frame rate, 1/3" CCD sensor.</p> <p>UI-2240SE-M/C, 1280x1024 resolution, 15 frames/second raw frame rate, 1/2" CCD sensor.</p> <p>UI-2250-M/C, 1600x1200 resolution, 12 frames/second raw frame rate, 1/1.8" CCD sensor.</p>

CAMERA POWER	Power is supplied directly by the USB cable and is generated by the PC's power supply.
USB INTERFACE	PC must be equipped with USB 2.0 interface (not 1.0).
USB CABLE, TRIGGER SUPPORT, NO DOUT	IDS uEye industrial camera cable: High speed 2.0 Extension cable - Screw type 4-Pin USB type A (F) TO 5-Pin micro-USB type B (M). 3 meter length. Cable breaks out trigger input as separate input. CB-IDS-9UD-A-T-3M
USB CABLE, TRIGGER AND DOUT SUPPORT	Right angled trigger cable for uEYE-Cameras, 3 meter uEye Micro Sub-D connector, 90° angled with screws. USB signal via shielded USB 2.0 cable to USB-A. Breakout cable for trigger input and digital output, cable with open ends. CB-IDS-9UD-A-ST3M-RT

Option 3: Other 3rd Party USB 2.0 Cameras

There are a wide variety of 3rd party USB 2.0 cameras that are available for the home, hobbyist, commercial and industrial markets. Due to the large number of vendors, their different installation procedures and their individual idiosyncrasies, Precise cannot guarantee that any camera brand that you select will work properly and ***we cannot provide assistance for any camera that has not been tested and qualified by Precise.***

Nonetheless, if you wish to interface an unsupported camera without Precise's assistance, please consider the following when selecting a USB camera.

- PreciseVision utilizes DirectShow to interface to the camera. Therefore, the USB camera must be compatible with DirectShow, which is quite common.
- PreciseVision's image acquisition tool has been specially optimized for the IDS uEye family of cameras. Other USB cameras will take somewhat more time to acquire an image.
- For similar features, a camera in a plastic case will be less expensive than a camera in a metal case. You must determine if the additional ruggedness of a metal case is important for your environment.
- Many inexpensive cameras utilize the standard USB connectors that are retained by friction. It is relatively easy for these to become accidentally disconnected as compared to screw in DB connectors such as those used in the IDS uEye cameras.
- Many inexpensive cameras either have integrated fixed lens or lens mounts that do not support the full range of lens that are available. Also, many lens do not have screws for locking in the focus or F-stop adjustments.
- Most cameras do not have trigger inputs and digital outputs. These are important features for conveyor belt tracking and other real-time image capture requirements. Also, since communication standards have not been established for these features, even if the camera has these hardware features, PreciseVision will probably not be able to access this capability.

Installing PreciseVision on a PC

PreciseVision is distributed as a standalone application that executes on a Windows PC system. For the best results, it is suggested that this software be executed on the following equipment:

- 2.3Ghz or faster Pentium 4 PC running Windows XP

PreciseVision

- Depending upon the type of cameras to be utilized:
 - Gigabit Ethernet (recommended and required for certain cameras), otherwise 100Mb Ethernet interface
 - USB 2.0 interface
- 512 MB of RAM
- At least 1 GB of space on the PC's disk
- A 2x CD-ROM drive interfaced to the PC

While PreciseVision can be executed by itself to develop Vision Processes, the PC must be able to communicate with a Precise Guidance Controller via Ethernet in order to run a complete vision-guided motion application. **Please see the “Guidance System Setup and Operation, Quick Start Guide” for instructions for configuring the PC and the Guidance Controller to communicate with each other.**

If you previously installed PreciseVision on your computer, you should un-install the old version by performing the steps below. If you are installing PreciseVision for the first time, you can skip the first set of instructions.

- » Shut down all programs that are running including virus protection programs.
- » Bring up the Window's Control Panel by clicking “**Start > Settings > Control Panel**”.
- » Double click on the “**Add or Remove Programs**” selection.
- » In the “Add or Remove Programs” popup window, scroll down and click on “**PreciseVision**”.
- » Click the “**Remove**” button and click on “**Yes**” to confirm the action.
- » Close all of the windows that you opened.

To install PreciseVision on your computer, perform the following steps:

- » Shut down all programs that are running including virus protection programs.
- » Insert the PreciseVision CD-ROM into your computer's CD-ROM drive. A panel should pop up that welcomes you to the Setup Wizard. If the installer does not automatically start, click “**Start > Run**”, type in “**D:\setup.msi**” (where D is the CD-ROM drive), and click “**OK**”.
- » Follow the instructions in the Setup Wizard to install PreciseVision. Note, PreciseVision relies upon the Microsoft .NET Framework in order to operate. This is a standard module that Microsoft provides free of charge. If the Setup Wizard detects that this module is not available, you will be asked if you wish to install the Framework now. You should respond “**Yes**”. This will launch a browser to take you to the download site for the required software.

At the conclusion of this process, PreciseVision will be installed on your PC. This software by itself is sufficient to execute PreciseVision with camera images that have already been captured and saved to a disk file. But, to operate this software with a camera, **one of the camera interface installation procedures in the following sections must be performed**. In addition, in order to continue to use PreciseVision beyond the trial period, **you must register this product with Precise Automation**. The registration process is described in detailed in a following section.

Installing and Configuring the DALSA Genie™ Camera Interface


If your system is equipped with a DALSA Genie™ GigE camera, the procedure described in this section must be executed to interface and configure this device. If your system does not use this camera, please skip to the next section of the documentation.

Prior to executing this procedure, ensure that the following requirements are satisfied:




- The DALSA Genie™ camera must be interfaced to the PC via a 100MB or 1000MB (Gigabit) Ethernet card. A 1000MB card will produce the best performance although a 100MB card will produce acceptable performance for many applications.

The first step in the process is to install the DALSA device driver and its configuration software.

- » Insert the PreciseVision CD-ROM into your computer's CD-ROM drive.
- » In the **"DALSA/SaperaLT/"** folder, double click **"Setup.exe"** to execute the installation procedure.
- » Follow the instructions in the Setup Wizard to install the driver.
- » In the **"DALSA/Genie/"** folder, double click **"Genie_1.nn.nn.nnnn Release.exe"** to execute the installation procedure.
- » Follow the instructions in the Setup Wizard to install the driver.
- » After installing the Genie drivers, the PC must be rebooted.

After rebooting the PC, you should see a small camera icon.  in the task bar in the right hand corner but with a red 'X' over it.

Plug the Genie camera into the network. After a period of time the 'X' will disappear. If you hover over the icon, the tool tip will indicate the number of Genie cameras that have been located. If no cameras are located, please see the following "DALSA Genie Installation Trouble Shooting" table.

DALSA Genie Installation Trouble Shooting	
Trouble	Possible Solutions
When the PC boots up it is not displaying the little  camera icon in the system tray.	The Genie driver did not properly install. If you have VPN software installed, try removing this and re-installing the Genie driver.
The camera  icon is displayed but always has a red 'X' over it  .	<p>If you have multiple network cards, try opening up the 'DALSA Network Configuration Tool'. This is found in "Start -> DALSA -> Sapera Network Imaging Package".</p> <p>Select the "Network" Adapter you are using with the camera. Select the "DHCP/LLA" mode in the Device Configuration section.</p>

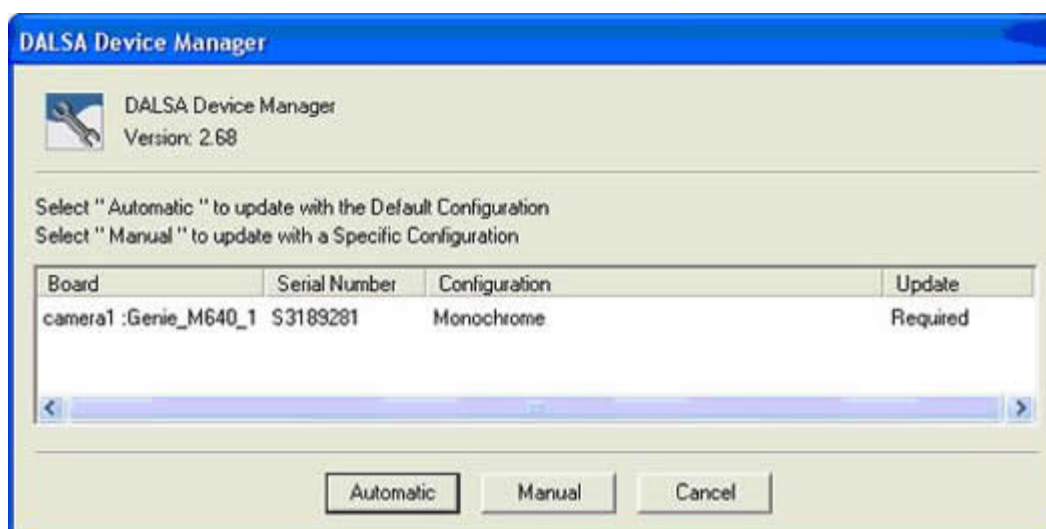
If you are still having difficulty with the operation of your DALSA camera, please see the [FAQ chapter of this manual for additional step-by-step trouble shooting instructions.](#)

Verifying the Camera Firmware is Up-to-Date

At this point, the basic camera driver installation is completed. However, it is possible that the firmware that shipped with your DALSA Genie camera may not match the PC driver that you just installed. If the firmware and the driver do not match, the camera may not operate reliably. To determine if the camera firmware needs to be updated, perform the following steps:

- » Ensure that the camera is properly communicating with the PC per the instructions above.
- » Open the DALSA Device Manager firmware update dialog. This is accomplished from the Window's Start menu by clicking: **"Start > Programs > DALSA > Genie > Firmware Update"**.

A list of available cameras will be displayed as shown in the following picture.



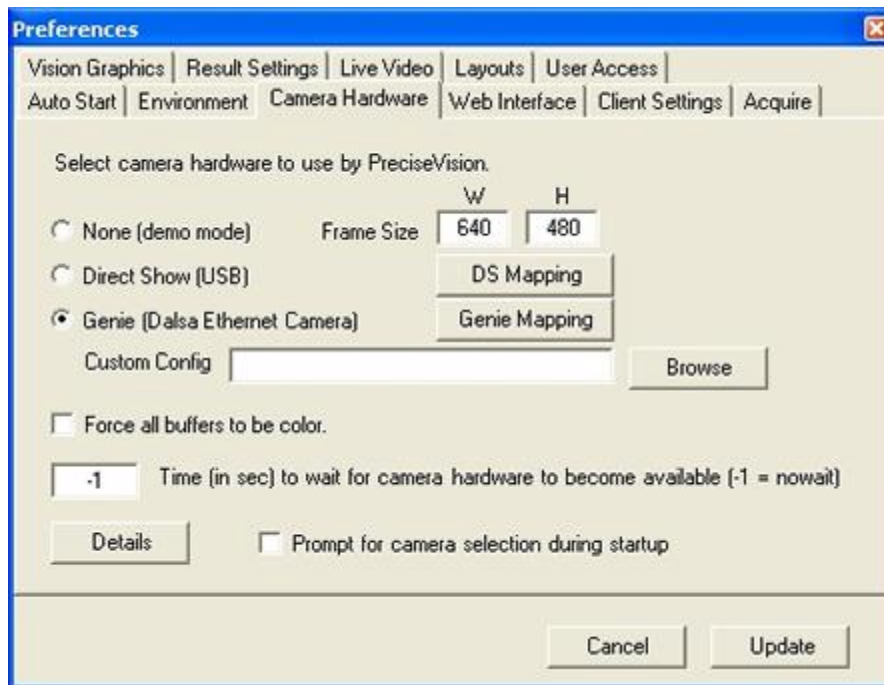
The right most column labeled "Update" indicates the firmware status of each camera.

- » If the "Update" status is "Not Required", the camera firmware matches the driver and the following steps can be skipped.
- » If "Required" is indicated, the camera firmware must be updated for proper operation. To update the firmware, click on the **"Automatic"** button.
- » Allow up to 3 min. for the camera to update. **Do NOT unplug the camera during this time.**
- » After the camera re-initializes the LED on the camera next to the power connector should return to a solid BLUE state. This indicates that the process is completed and you can now exit from the DALSA Device Manager.

Selecting Ethernet Cameras Instead of USB Cameras

PreciseVision can operate using either Ethernet cameras or USB cameras or in a demonstration mode without a camera. However, at any given time, only one camera type is permitted for each instance of PreciseVision. The first time PreciseVision is executed after being installed, it prompts for the type of camera to be used. Thereafter, the camera type is remembered until it is explicitly changed. The following procedure can be used to change the camera type or to verify that PreciseVision is properly configured to capture images from the correct type of camera.

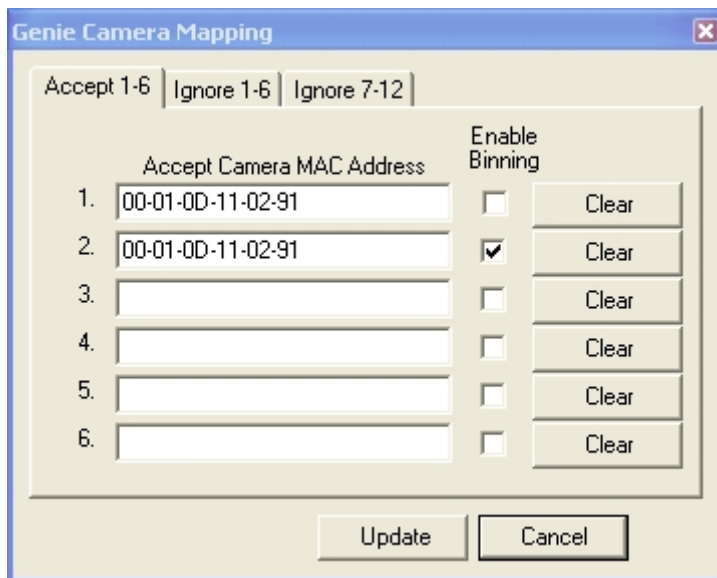
- » Launch PreciseVision by selecting "**Start > Programs > Precise Automation > PV_ > PreciseVision**".
- » Open the Preferences pop-up by selecting the following within PV: "**File > Preferences**" and open the "**Camera Hardware**" tab.
- » Ensure that the "**Genie (Dalsa Ethernet Camera)**" option is selected.
- » Restart PreciseVision if the selected camera type is changed.



Assigning (Mapping) Dalsa Cameras

The first time the DALSA Genie camera option is selected, PreciseVision will automatically scan for all available Genie cameras. When a camera is located, the camera list will be created. Each located camera is automatically assigned a camera number and will be identified by its MAC ID. The MAC ID is a unique number that is permanently assigned to every Ethernet compliant hardware component in the world.

- » To view the available Genie cameras and their assigned camera numbers, while still viewing the "**Camera Hardware**" tab as described above, click on the "**Genie Mapping**" button.



The image shows a Windows-style dialog box titled "Genie Camera Mapping". At the top, there are three tabs: "Accept 1-6", "Ignore 1-6", and "Ignore 7-12". The "Accept 1-6" tab is selected. Below the tabs is a table with six rows, numbered 1 to 6. Each row has a text field for "Accept Camera MAC Address" and a checkbox for "Enable Binning". Row 1 has the MAC address "00-01-0D-11-02-91" and the "Enable Binning" checkbox is unchecked. Row 2 has the same MAC address "00-01-0D-11-02-91" and the "Enable Binning" checkbox is checked. Rows 3 through 6 have empty MAC address fields and unchecked "Enable Binning" checkboxes. To the right of each row is a "Clear" button. At the bottom of the dialog are "Update" and "Cancel" buttons.

	Accept Camera MAC Address	Enable Binning	
1.	00-01-0D-11-02-91	<input type="checkbox"/>	Clear
2.	00-01-0D-11-02-91	<input checked="" type="checkbox"/>	Clear
3.		<input type="checkbox"/>	Clear
4.		<input type="checkbox"/>	Clear
5.		<input type="checkbox"/>	Clear
6.		<input type="checkbox"/>	Clear

Up to 6 Genie cameras can be "Accepted" for use by each instance of PreciseVision. Once the Genie camera list is created, a user can manually copy and paste MAC ID's to change the camera order. To have the changes take effect, PreciseVision must be restarted. Each time PreciseVision is started, the physical cameras will be assigned to the same logical camera numbers based upon the contents of this table and the camera's MAC ID numbers.

When PreciseVision is restarted, if a new camera is found on the network, the new camera will automatically be assigned to the first available slot (logical camera number).

If a camera is disconnected or powered down, the slot for this camera is NOT cleared. This is important since there are unique calibration files for each physical camera and vision applications expect to take pictures using specific cameras.

With the Genie camera, it is possible to assign the same camera to several camera slots. This allows different calibrations for the same camera if needed.

For a single camera configuration, simply start PreciseVision and the camera will be assigned to the first camera slot and can be referenced as logical camera #1.

Camera "Binning"

For DALSA cameras, the system supports "binning". At the camera hardware level, this process combines every other pixel horizontally and vertically and returns half of the standard number of pixels in each row and only every other row of pixels.

This process has the advantage of increasing the contrast in an image in the same manner as averaging two images. Also, since there are fewer pixels transmitted by the camera, the image acquisition time is reduced. However, the acquisition time is not reduced proportionally to the reduction in pixels. Although there are only 1/4th the number of pixels, for a 640x480 camera the speed improvement is only a few percent and for a 1392x1040 camera the speed improvement is approximately a factor of two. This is because the camera performs the vertical binning in the analog domain, which results in a 2x improvement, but the horizontal binning is performed in the digital domain so all pixels in a row are still sampled. In addition, there is some overhead that further reduces the speed improvement. Nonetheless,

for high resolution Dalsa cameras, binning can be used to reduce the image capture time when lower resolution is acceptable.

- » If you wish to turn on binning for a camera, in the **"Genie Camera Mapping"** panel shown above, check the **"Enable Binning"** next to the camera's MAC address.
- » If you wish to access a camera in both full resolution and binning mode, in the **"Genie Camera Mapping"** panel, copy the MAC address to another logical camera number and enable binning on one of the logical cameras for the same physical camera.
- » PreciseVision must be restarted to have any changes take effect.

Whenever a logical camera with binning enabled is accessed, binning will automatically be performed.

When binning is turned on for a camera, the camera calibration for this logical camera must be re-computed. This is required since the pixel to mm scale factors will have changed.

Releasing DALSA Cameras to Other PreciseVision Applications

For multiple cameras on the same Ethernet network that are accessed by a different PC or for cameras that are accessed by a different instance of Multi-Instance PreciseVision on the same PC, there is an ignore list. Cameras that are listed as one of the "Ignore" entries are released from the current PreciseVision and available for use by other copies of PreciseVision.

- » If you do not wish to utilize a camera within the current PreciseVision application, cut and paste the camera's MAC ID from the **"Accept"** list to the **"Ignore"** list.
- » PreciseVision must be restarted to have any changes take effect.

The screenshot shows the 'Genie Camera Mapping' window. It has three tabs: 'Accept 1-6', 'Ignore 1-6', and 'Ignore 7-12'. The 'Ignore 1-6' tab is active. Under this tab, there is a list of six 'Ignore Camera MAC Address' entries. The first entry is '00-01-0D-11-04-E3'. Each entry has a 'Clear' button next to it. At the bottom of the window are 'Update' and 'Cancel' buttons.

This completes the DALSA Genie™ camera setup. PreciseVision can now acquire camera images via this camera(s).

Installing and Configuring the IDS uEye™ USB Camera Interface

If your system is equipped with an IDS uEye™ USB camera, the IDS uEye device driver must be installed and the camera must be configured. PreciseVision utilizes DirectShow and the IDS driver to communicate with the camera. If your system does not use this type of camera, please skip to the next section of the documentation.

Prior to executing this procedure, ensure that the following requirements are satisfied:

- Initially, it is preferable if your IDS camera is NOT connected to the PC. After the IDS driver is installed, the camera can be attached and the PC will automatically discover the camera.

The first step in the process is to install the IDS USB device driver and its associated configuration and diagnostic software.

- » Insert the PreciseVision CD-ROM into your computer's CD-ROM drive.
- » In the **"uEye"** folder, double click **"uEye32_3500.exe"** to execute the installation procedure. If your computer contains a 64bit version of Windows, then visit the IDS web site to download the 64bit version of the driver.
- » Follow the instructions in the Setup Wizard to **"Install driver"**. When asked what type of installation should be performed, select **"USB"**. You should NOT install any Ethernet or custom drivers.

At this point, the required system driver and the support software have been loaded and installed.

- » Plug the uEye cameras into the PC. This will permit the PC to discover this new hardware and configure the cameras for use.
- » Execute the uEye demo software to verify that the cameras are functioning properly. Launch the demo software by clicking: **"Start > Programs > IDS > uEye > uEye Demo"**.

Assigning ID's to Multiple uEye Cameras

For Ethernet cameras, each camera's Ethernet MAC ID uniquely identifies the camera and is used to associate each camera with the same vision operations whenever PreciseVision is restarted. Unfortunately, USB connections do not have a similar identification mechanism. So, to ensure that the correct cameras are associated with vision operations, a unique camera ID must be stored into the NVRAM of each IDS camera.

The camera ID ranges from 1 to n and is automatically added to the name of each camera. For example, if the ID is set to 3, the camera will be identified as "uEye Capture Device 3".

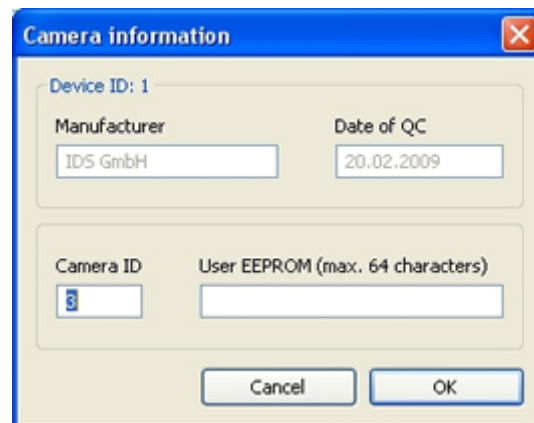
If you only intend to connect a single USB camera to your PC, you can skip to the next section since the cameras default ID of 1 can be used.

- » To assign camera ID's, execute the uEye Camera Manager by clicking on **"Start >**

Programs > IDS > uEye > uEye Camera Manager".



» Select a desired camera by clicking on a line in the Camera List and click **"Camera Information"**.



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- » Change the "Camera ID" to a unique number. These should be assigned so there are no gaps in the numbering (1,2,3,..).
- » When completed, click **"OK"** and close the Camera Manager when done.

Before PreciseVision can discover multiple USB cameras, they must be registered using the uEye DirectShow Capture Device Manager.

- » To register each of the IDS cameras, click **"Start > Programs > IDS > uEye > DirectShow device manager"**.



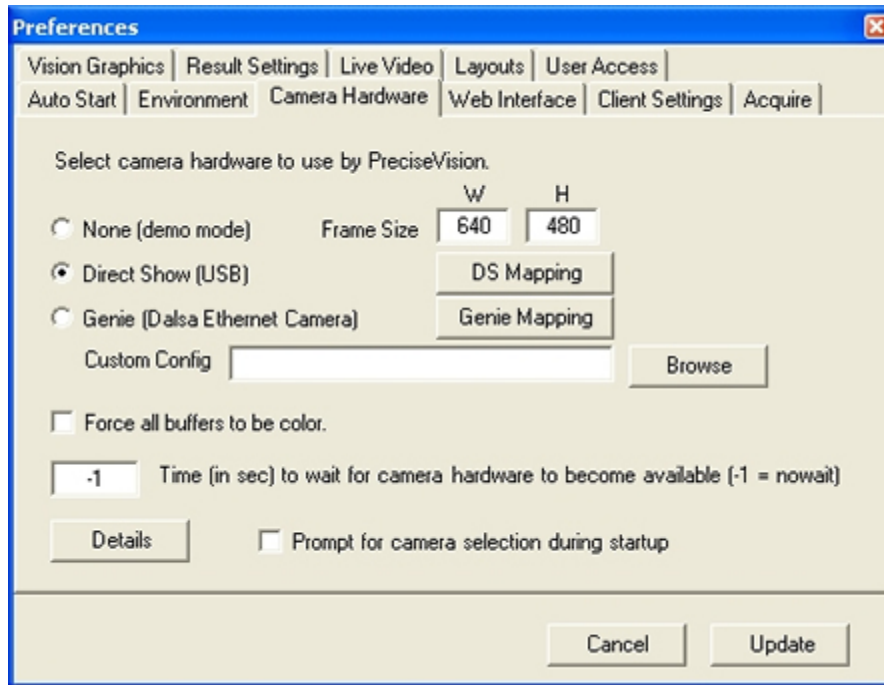
- » Clear the list by clicking on **"remove device"** multiple times.
- » Populate the list by clicking on **"add device"** a number of times until the highest camera ID that you have defined is listed. If the camera ID's were not sequentially assigned, there can be N/A placeholders as shown above. This will not create a problem.

Selecting USB Cameras Instead of Ethernet Cameras

PreciseVision can operate using either Ethernet cameras or USB cameras or in a demonstration mode without a camera. However, at any given time, only one camera type is permitted for each instance of PreciseVision. The first time PreciseVision is executed after being installed, it prompts for the type of camera to be used. Thereafter, the camera type is remembered until it is explicitly changed. The following procedure can be used to change the camera type or to verify that PreciseVision is properly configured to capture images from the correct type of camera.

- » Launch PreciseVision by selecting **"Start > Programs > Precise Automation > PV_ > PreciseVision"**.
- » Open the Preferences pop-up by selecting the following within PV: **"File > Preferences"** and open the **"Camera Hardware"** tab.
- » Ensure that the **"DirectShow (USB)"** option is selected.

» Restart PreciseVision if the selected camera type is changed.



Assigning Cameras, Selecting the Camera Resolution and Display Mode

When the PC boots or whenever a USB camera is connected or disconnected, Windows automatically assigns each camera an index in a list of cameras. The ordering of the cameras is dependent upon the USB interface to which they are connected. For a given configuration of cameras, the index of each camera will always be the same. However, if a new camera is connected, it will not necessarily be added to the start or the end of the list.

Unlike Ethernet cameras, USB cameras typically have several different formats that can be used to retrieve the image data at different resolutions. The formats that PreciseVision and its DirectShow interface support include the following:

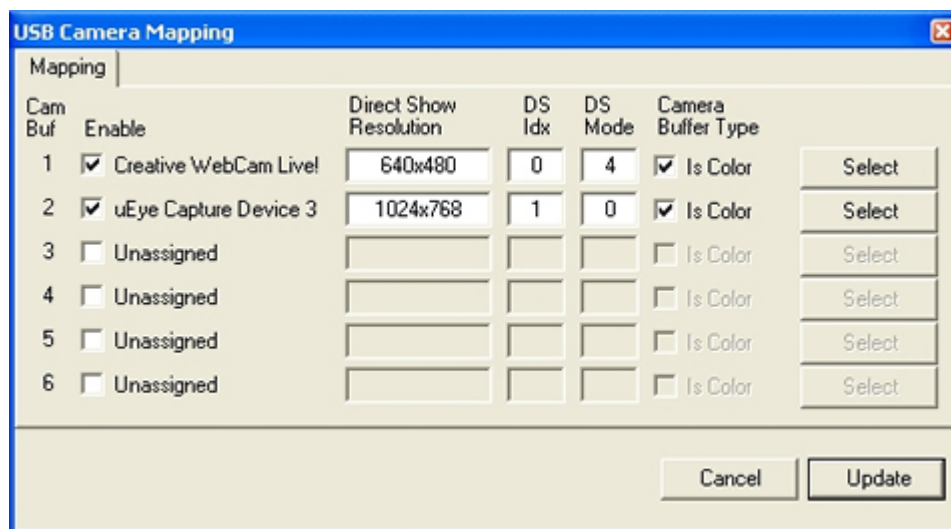
RGB8 (8-Bit Grayscale)
 RGB24 (24-bit color with 8-bit R,G,B components)
 YUY2 (16-bit color)

When PreciseVision is started, it retrieves information on all of the connected USB cameras and automatically assigns them to a logical camera buffer and selects a format with the highest resolution. PreciseVision permits these automatic assignments to be manually over-written.

To review or change the current camera assignments and settings, perform the following.

» While still displaying the PreciseVision **"Preferences"** pop-up, and viewing the **"Camera Hardware"** tab (as shown above), click on the **"DS Mapping"** button.

PreciseVision

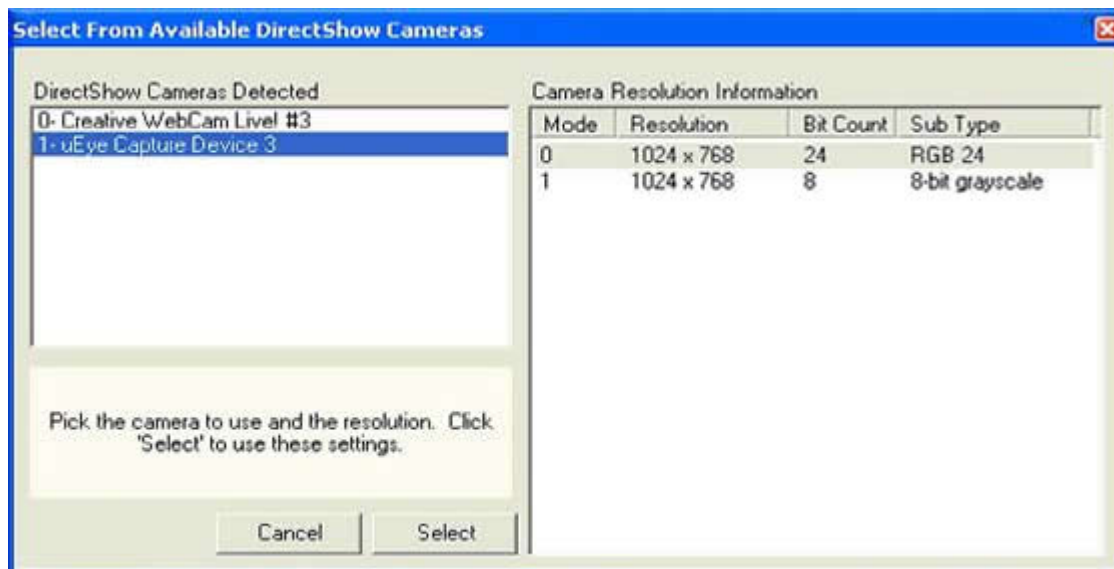


For each discovered USB camera, this panel displays the logical number (Camera buffer) that it has been assigned, together with its resolution and format, and the index number that Windows has automatically assigned. The "Enable" checkmark indicates that a camera will be exclusively used by the current instance of PreciseVision.

» If the Multiple-Instance version of PreciseVision is being executed, a camera can be released for use by another instance by unchecking **"Enable"** and restarting PreciseVision.

If you wish to assign a camera a different logical camera number or change its format and resolution, do the following.

» While still displaying the USB Camera Mapping panel, click on the **"Select"** button for the camera of interest.



If you wish to access the same camera in different formats or want to utilize more than one set calibration data, the same camera can be assigned to multiple logical camera/buffer numbers.

Subsequent Changes in Camera Assignments

If a USB camera is disconnected or a new camera is connected to the PC, the next time that PreciseVision is started, the Windows camera index numbers can all be changed. If a camera name is unambiguous, as is the case for IDS cameras that have been assigned unique camera ID numbers, PreciseVision attempts to assign the cameras to the same logical camera number/buffer as the last session independent of their Windows index number. If camera names are not unique, PreciseVision utilizes the Windows camera index numbers to determine their logical camera numbers. At the end of this process, if the camera mapping has changed relative to the previous session of PreciseVision, the following message is displayed to alert you to a possible problem.



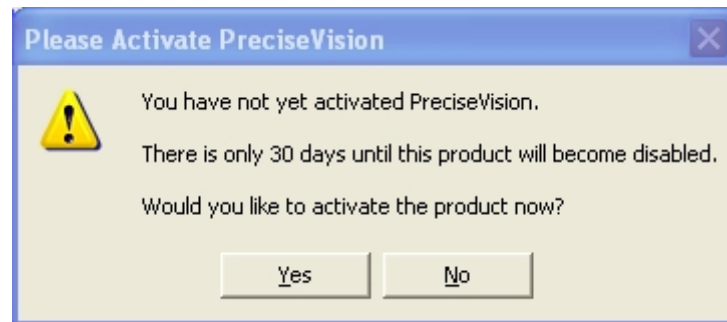
» If the error message above is displayed, review the USB camera assignment by going to **"File > Preferences > Camera Hardware > DS Mapping"** and correcting any errors.

This completes the IDS uEye USB configuration setup. PreciseVision can now acquire camera images via this camera(s).

Activating PreciseVision

To begin using PreciseVision, you must start the application on the PC.

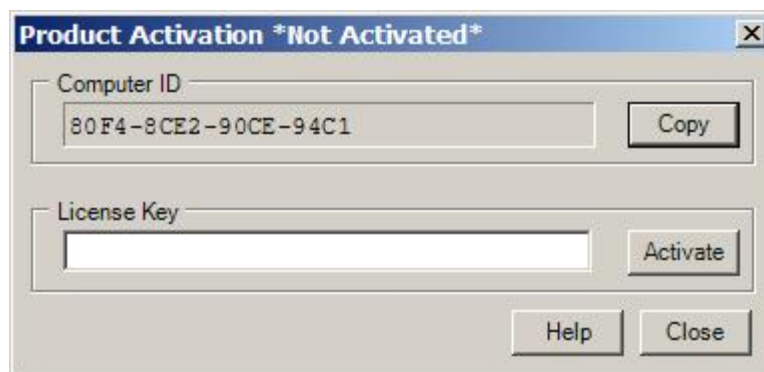
» To launch PreciseVision, click on **"Start > Programs > Precise Automation > PV xxx > PreciseVision"**. The first time PreciseVision begins execution, you will see the following popup.



The license that you purchased for PreciseVision permits you to use this software to build and execute Vision Processes on a single PC. To complete the software activation process, you must send information concerning the PC to Precise Automation. To allow time for sending the information and receiving a reply, PreciseVision is fully functional for 30 days without being activated.

If for some reason, you do not wish to initiate the activation process now, this popup will be displayed each time you start PreciseVision. To re-display the activation popup from within PreciseVision, click on **"Help > Product Activation"**.

» To initiate the activation process, click **"Yes"** in the popup above. This will display the following activation popup.



This popup displays the "Computer ID" that you need to submit to Precise as part of the activation process.

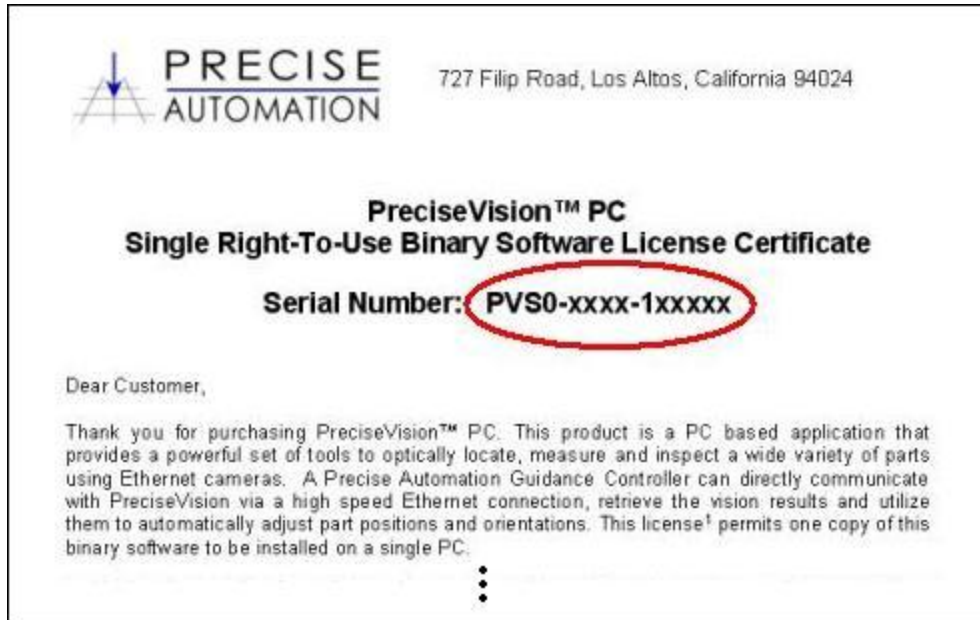
» To obtain a license key to activate PreciseVision, please send an email to Precise Automation that contains the following information:

To: sales@preciseautomation.com
Subject: PreciseVision License Key Request

Customer Name: <your name here, optional>
Customer Company: <your company name here>
Telephone Number: <your phone number here, optional>

PreciseVision Serial Number: PVS0-0xxx-xxxxxx
Computer ID Number: xxxx-xxxx-xxxx-xxxx

» You can obtain the PreciseVision Serial Number from the PreciseVision License Certificate that you received with your order. Below is a picture of the top portion of a typical PreciseVision License with the serial number circled in red.



- » The Computer ID number should be copied from the Product Activation popup.
- » As a convenience, if you are viewing this help in the *Precise Documentation Library*, you can click on the following link to get an email template: sales@preciseautomation.com.
- » Alternatively, if you do not have email access, please Fax this information to 408-516-8348 together with your own fax number.

Your name and your phone number are optional. However, we recommend that you provide this information in case there is a problem with your license and we need to get in touch with you. A sample email should look as follows.

PreciseVision License Key Request - M...

File Edit View Insert Format Tools Actions Help

To:

Cc:

Subject:

Customer Name: John Doe
Customer Company: Acme Automation
Telephone Number: 1-408-555-5555

PreciseVision Serial Number: PVS0-0604-100001
Computer ID Number: 80F4-8CE2-90CE-94C1

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In response to your request, you will receive a license key.

- » When you receive your license key, access the Product Activation popup by restarting PreciseVision or clicking in the PreciseVision menu item **"Help > Product Activation"**.
- » Enter the license key in the **"License Key"** box and press **"Activate"**.

PreciseVision is now activated.

Configuring Communication Between the PC and the Controller

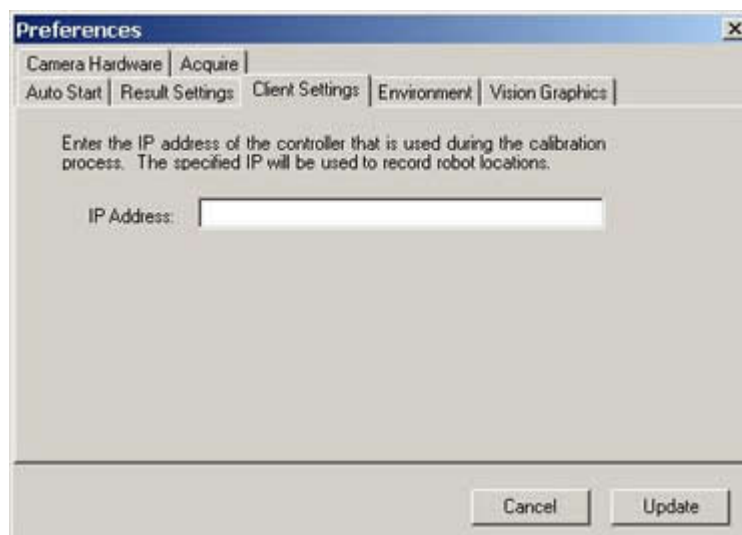
In order for PreciseVision to exchange information with a Guidance Controller, each system must know the Ethernet IP address of the other unit. During normal runtime execution, the Guidance Controller initiates all communications and so it must know where to send its commands. During the Robot Vision Camera Calibration procedure, PreciseVision needs to know where to send its commands to read the current robot position.

Configuring PreciseVision to Read Positions from a Controller

To permit PreciseVision to query a Guidance Controller for the current position of the robot, the IP address of the controller must be defined in the system Preferences.

- » Launch PreciseVision by clicking on **"Start > Programs > Precise Automation > PV xxx > PreciseVision"**.
- » Open the panel for setting the controller IP address by selecting **"File > Preferences > Client Settings"**.

The panel for setting the IP address should resemble the following:



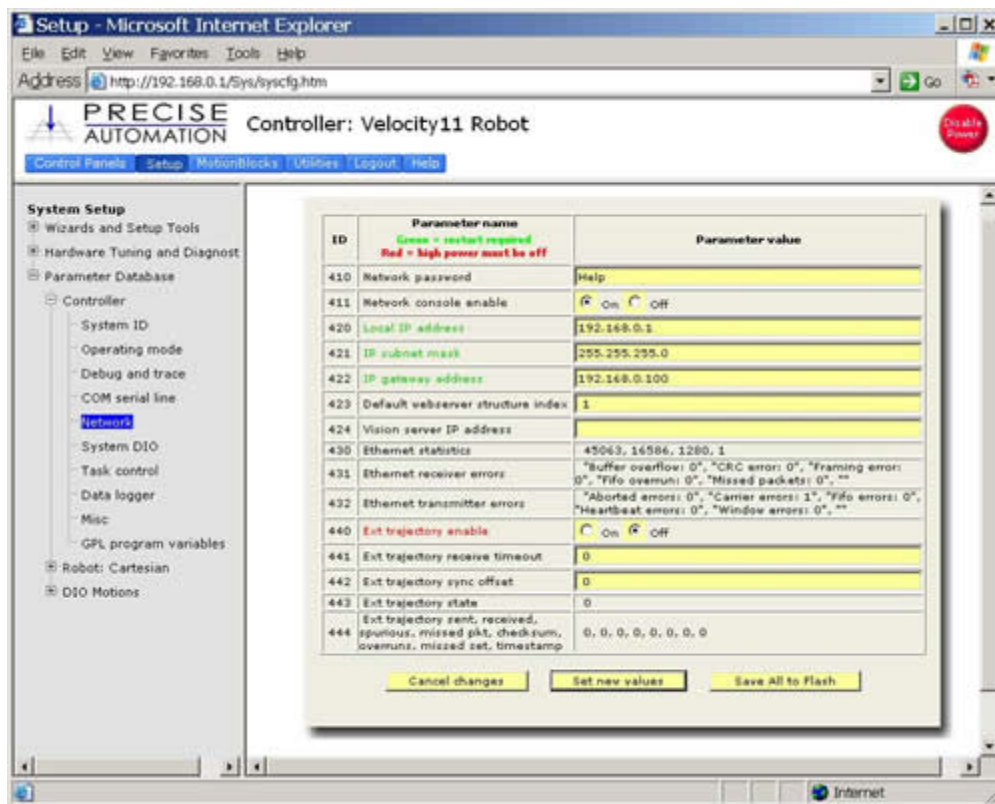
- » Enter the Guidance Controllers Ethernet IP address and press the **"Update"** button.

Configuring a Controller to Send Commands to PreciseVision

Whenever the Guidance Controller issues a command to PreciseVision, the controller automatically establishes an Ethernet connection utilizing an IP address that is specified in the controller's Parameter Database. This database is stored in the controller's flash disk and is preserved even if the controller is turned off and restarted. To modify this database value, perform the following operations.

- » Please see the *"Guidance System Setup and Operation, Quick Start Guide"* and follow the instructions for bringing up the web based Guidance Operator Interface for the controller.
- » In the web interface, open the database page for the vision IP address, **"Setup > Parameter Database > Controller > Network"**.

The web interface page should look like the following:



- » Enter the IP address of the PC executing PreciseVision into the value for the **"Vision server IP address (DataID 424)"**.
- » Press the **"Set New Values"** button to store this setting into memory.
- » Press the **"Save All to Flash"** button to store this setting in the flash disk. This ensures that

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this setting will remain in effect if the controller is restarted. The button will flash for 10-30 seconds as the data is being written. **DO NOT TURN OFF YOUR CONTROLLER WHILE THE BUTTON IS BLINKING SINCE THIS MAY CORRUPT THE FLASH DISK.**

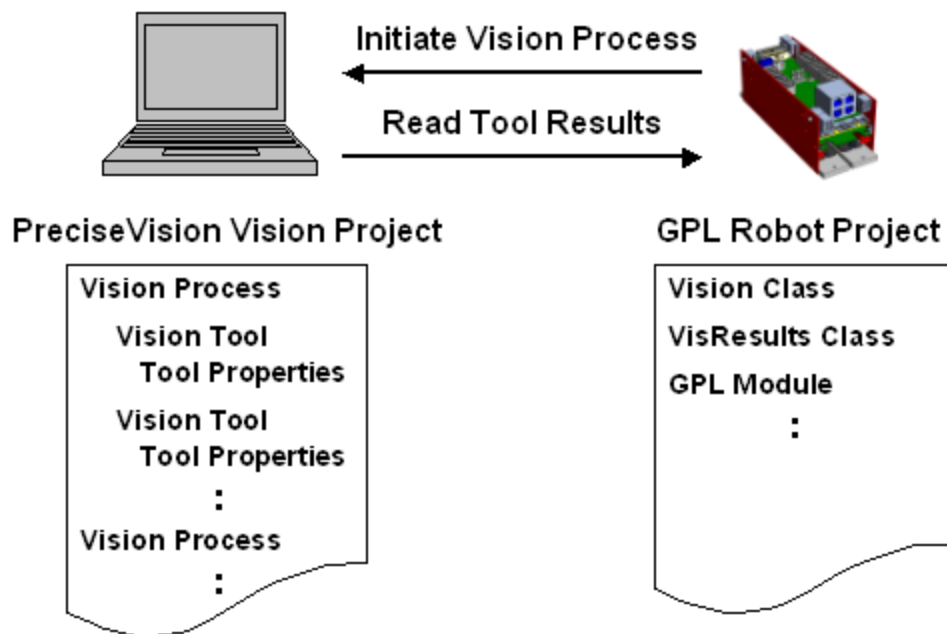
The controller is now setup to send commands to PreciseVision. It is not necessary to restart the controller.

Overview and Quick Start

PreciseVision Overview

This chapter introduces PreciseVision's principal concepts, terminology and features. For newcomers to machine vision, this chapter will provide background information prior to reading the detailed descriptions contained in the following chapters. For individuals with experience applying machine vision, the information in this chapter should be sufficient for you to start using the system.

PreciseVision has been designed to operate in combination with a Precise Guidance Controller and its embedded Guidance Programming Language (GPL) to easily produce flexible and powerful vision-guided motion applications. The following diagram illustrates the key software components in a vision guidance application.



In PreciseVision, each fundamental vision runtime function is represented as a type of "**Vision Tool**" and the collection of all possible types of tools is referred to as the "**Vision Toolkit**". For example, the function that captures a picture from a camera and stores the result in a frame buffer is the "Acquisition Tool"; the operation that fits a line to a set of edge points is the "Line Fitter Tool"; and the function that uses an advanced, patented algorithm to identify and locate parts is the "Finder Tool".

To perform an element of a vision application, any number of Vision Tools can be combined into a "**Vision Process**". Normally, an Acquisition Tool is the first tool in each Vision Process. This is followed by one or more tools to perform part location, metrology or inspection operations. Multiple copies of the same type of tool can be included within the same Vision Process. The individual characteristics of each

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tool (i.e. its size, position, algorithm parameters) are stored in Object **"Property Lists"**. After a tool is executed, its output data is stored in its Property List in a **"Tool Results"** section. To simplify their definition, tools can be positioned and sized by dragging their graphical handles on top of the display of a camera image.

A Vision Process is the basic unit of execution that can be controlled by a GPL procedure. Using a built-in **"Vision Class"**, a GPL procedure running on a Precise Guidance Controller can start the execution of a Vision Process in PreciseVision via Ethernet and monitor its progress. When the Vision Process completes execution, the GPL procedure can retrieve the Tool Results of any tool within the executed Vision Process by accessing the built-in GPL **"VisResults Class"**. In applications where PreciseVision is not connected to a Guidance Controller, another program executing in the PC or on another processor can be used to trigger a Vision Process and retrieve the results (see the appendix that describes Remote PC Control for additional information).

In most cases, only a single Vision Process is executed in order to perform the complete machine vision task. Typically, this Vision Process will take a picture and then utilize Vision Tools to locate a part and validate some key features or dimension. However, if a more complex machine vision operation is required, a GPL procedure can execute any number of Vision Processes. For convenience, multiple Vision Processes can be stored in a **"Vision Project"** in PreciseVision. At any given time, only one Vision Project can be loaded into PreciseVision and only one of its Vision Processes can be executing.

In order for PreciseVision to return Tool Results in meaningful units, e.g. millimeters, and in an appropriate coordinate system, any camera used for vision guidance must first be "Calibrated". As a convenience, PreciseVision includes a number of **"Camera Calibration"** methods that are described in a later section. Once a camera is calibrated, all data retrieved by a GPL procedure via the VisResults Class will be in millimeters and in the world coordinate system of the robot.

In a typical application, a single copy of PreciseVision will be executed on a PC and will be connected to a single robot or motion controller. If you wish to provide vision results to a number of robots or motion controllers, please see the appendix that describes Multi-Instance Execution.

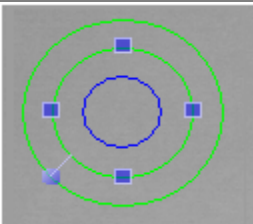
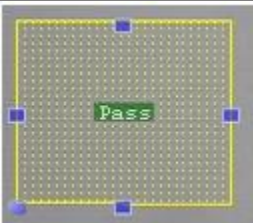
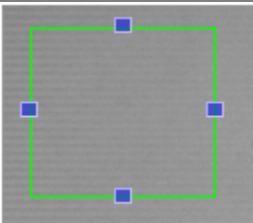
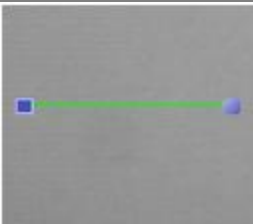
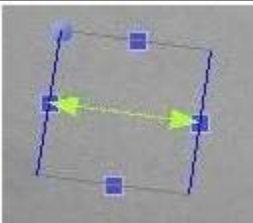
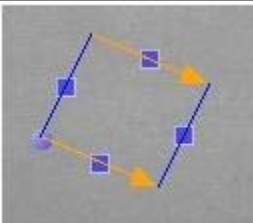
In the following sections, the Vision Tools are briefly described along with the methods for creating and editing Vision Projects, Vision Processes, and tools with their associated Property Lists.

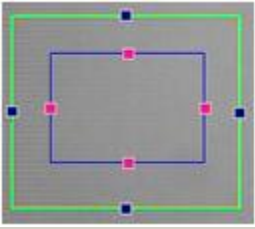

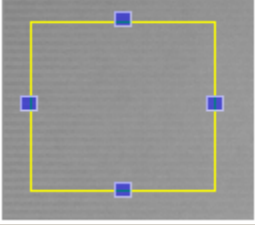
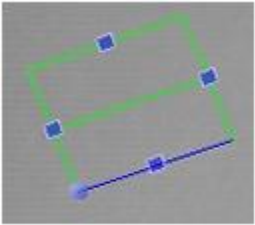
Vision Toolkit Summary

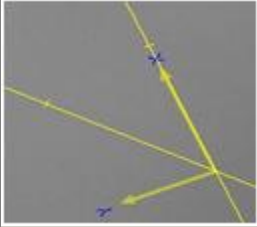
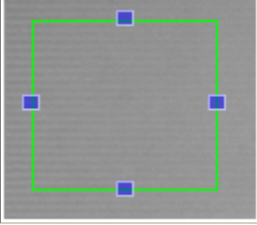
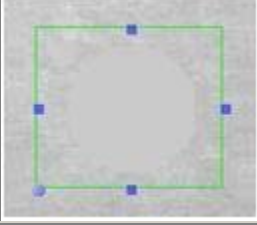
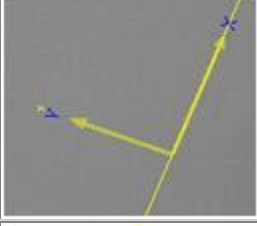
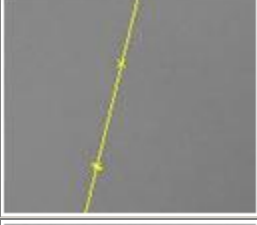
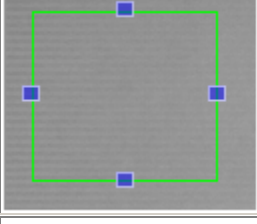
In order to effectively analyze images, PreciseVision includes a full set of vision tools for acquiring images, locating and identifying parts, performing metrology operations and executing visual inspection of key features. In this section, the function of each tool is briefly summarized and a picture displaying how the tool appears on the Camera Display Window is presented.

An important feature of PreciseVision is that the output of one tool can be easily utilized as the input for another tool. For example, after the Finder Tool locates one or more parts, a tool that measures the distance between two edges can be easily placed relative to the located part. This measurement tool can then test if a critical dimension of the part is within the desired tolerance. Since this measurement is performed relative to the output of the Finder, it will operate correctly even if the part's position or orientation changes. Furthermore, if the Finder locates more than one part, the measurement tool will be automatically applied to each located part. This ability allows complex measurements and tests to be easily built-up from the basic tools that are provided.

For a complete description of each tool, please read the "Vision Toolkit" chapter. (Note: The algorithms for the complete set of tools has been developed and will be released in future upgrades to PreciseVision during 2007. If you cannot find a tool that you require, please contact Precise Automation.)

Graphical Display	Vision Tool	Description
N/A	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.
	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.
	Connectivity 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.
	Edge Locator 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.
	Find Centerline Tool	Searches a specified region for edge points and returns the centerline between two located bounding lines.
	Find Point 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.

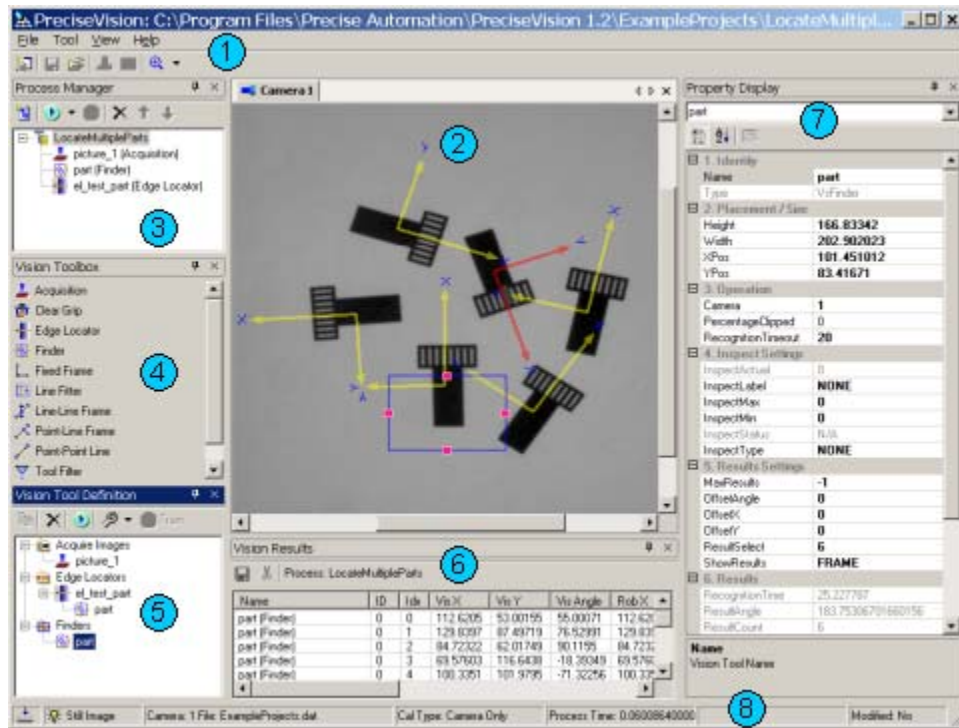
	<u>Finder Tool</u>	Most powerful vision tool that identifies randomly placed parts in a camera image and returns their position, orientation and scaling to within sub-pixel accuracy.
	<u>Fixed Frame Tool</u>	Places a reference frame at a fixed image coordinate or at a constant offset relative to another vision object. Can optionally index the frame in an X and/or Y grid pattern to repeatedly execute any linked tools.
	<u>Image Process Tool</u>	Performs image filtering, edge extraction, thresholding and morphological operations on a specified area in the camera image.
N/A	<u>Inspect Frame Tool</u>	Passes through the XPos, YPos and Angle Results of a referenced tool and optionally rotates and shifts the Results based upon an inspection. The inspection can consist of the arithmetic combination of the Results of two other tools. So, this tool also provides a means for performing simple mathematical operations on the results of two tools.
N/A	<u>Inspect List Tool</u>	Passes through the XPos, YPos and Angle Results of a referenced tool and tests up to 12 different Results from multiple tools to determine if the object is good or bad. This tool provides a convenient way to perform complex testing of a located object and generating an equivalent location with a single Pass/Fail indicator.
N/A	<u>Inspect Region Tool</u>	Inspects the perimeter and the interior of an opaque object to determine if there are any flaws in the object's outline or holes in the interior. This tool was designed to inspect wafers, where slight changes in the overall size and shape of the wafer are permitted, but chips in the perimeter or interior holes or cracks are unacceptable.
	<u>Line Fitter Tool</u>	Searches a specified region for edge points and returns the line that best fits the edges.

	<u>Line-Line Frame Tool</u>	Determines the intersection of two lines defined by vision tools and returns a reference frame.
	<u>Pixel Window Tool</u>	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.
	<u>Pixel Color Window Tool</u>	Tests if the general color of a rectangular or circular region matches a trained color within a specified tolerance.
	<u>Point-Line Frame Tool</u>	Takes a point and a line from two vision tools and returns a reference frame.
	<u>Point-Point Line Tool</u>	Computes a line given two points from two vision tools.
	<u>Sensor Window Tool</u>	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.
N/A	<u>Text Label Tool</u>	Displays string constants plus inspection and results data from a referenced tool. Text is shown relative to the position of the referenced tool.
N/A	<u>Tool Filter Tool</u>	Takes the output from another tool that generates multiple sets of results, and returns a subset of the results based upon specified criteria.

Graphical User Interface Overview

This section summarizes the purpose and use of each of the major components of the PreciseVision graphical user interface (GUI). The user interface has been designed to allow you to quickly construct a Vision Process and to easily define the properties for each of the utilized vision tools.

For detailed information on each of the components of the GUI, please read the "PreciseVision User Interface" chapter.



GUI Component	Description
1. Main Menu and Toolbar	Provides access to the major functions available within PreciseVision, e.g. loading and saving projects, selecting the camera output to view, etc. The toolbar includes buttons for putting the camera into "live video" mode, taking a single snap shot, and zooming the camera image up.
2. Vision Camera Display	Displays the output of the last selected camera. This can be either a frozen snapshot or a live camera image. When a Vision Process is being evaluated, the tool Results graphics will be overlaid on top of the camera image. When a tool is being edited, its outline will be displayed on top of the camera image. To reposition or resize a tool, simply drag its handles in this window.
3. Process Manager	Displays and permits editing of all of the Vision Processes defined within the currently loaded Vision Project. Each process can be expanded to show the sequence of Vision Tools that are executed within the process. Tools can be deleted or re-ordered within the process. To add a new tool, simply drag a defined tool from the Vision Tool Definition window and drop it on a process name. To preview how a Vision Process will perform, click on the "Test

	Process" green button in the toolbar. This will execute a process once or continuously without requiring a GPL procedure to trigger this activity.
4. Vision Toolbox	Lists all of the possible types of Vision Tools that can be created. To create a new copy of a tool, double click on the tool or right-click and select "Create tool". Each tool must be assigned a unique name. New copies of tools are automatically added to the lists in the Vision Tool Definition window.
5. Vision Tool Definition Window	Displays all of the tool that have been created. A created tool will not be utilized in a process until you drag the tool and drop it into the Process Manager window. If a tool is relative to another tool or requires other tools as inputs, they will be listed below the tool. This provides a quick visual queue as to the relationships between tools.
6. Vision Results Window	Whenever a Vision Process is executed, the output of each tool (i.e. its Vision Results) will be displayed in this window.
7. Property Display	Whenever a copy of a vision tool is selected in the Vision Tool Definition window, all of the properties of the tool will be displayed in this window. Dimmed properties are read only.
8. Status Bar	Displays status information such as the last Process execution time, live video/snapshot indicator, networking indicator, camera calibration type, etc.

Tutorial 1: Testing Processes and Editing Vision Tools

The first step in learning how to apply PreciseVision is to gain more of an understanding of how vision tools operate and how to edit tools. Fortunately, PreciseVision provides a very convenient means for experimenting with the tools without needing a camera, robot or any parts.

In the following procedure, you will be using a Sample Vision Project and camera images from disk files that are distributed with PreciseVision. One thing to note is that this Sample Project and image files were generated using standard PreciseVision facilities. So, once you are familiar with the system, you will be able to create your own Sample Projects and stored images to illustrate your work to co-workers or customers or to relay problems to Precise and our partners.

Prior to executing this tutorial, the following steps must first be performed:

- The procedure for "[Installing PreciseVision on a PC](#)" must be completed.
- No camera hardware of any sort is required.

In this first example, two Edge Locators are executed to compute a line along the side of a part.

» Start by launching PreciseVision. Click on **"Start > Programs > Precise Automation > PV xxx > PreciseVision"**.

If this is the first time PreciseVision is executed, a pop-up window will be displayed requesting the specification of the camera hardware followed by a window requesting that the software be activated. Both of these actions are good to perform and you should return to the installation chapter and follow the instructions for completing these procedures. However, if you wish, you can cancel out of these pop-up's since neither of these setup steps is required to initially execute the Sample Projects.

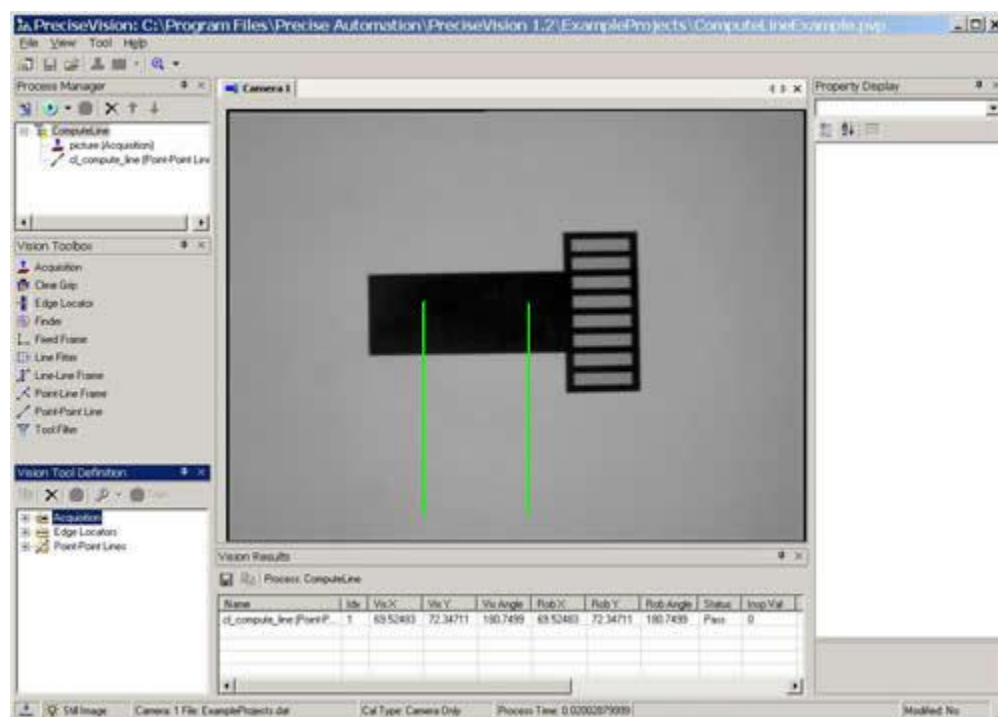
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The following "Quick Start" pop-up window should now be displayed.



If you hover the cursor over the three buttons on the left, the text in the center window panel will change to provide more information about each selection.

- » Click on the **"Samples"** button. A standard file selection pop-up window will be displayed that lists a number of Sample PreciseVision Project files (*.pvp).
- » Click on the **"ComputeLineExample.pvp"** file and press **"Open"** to load this Project.

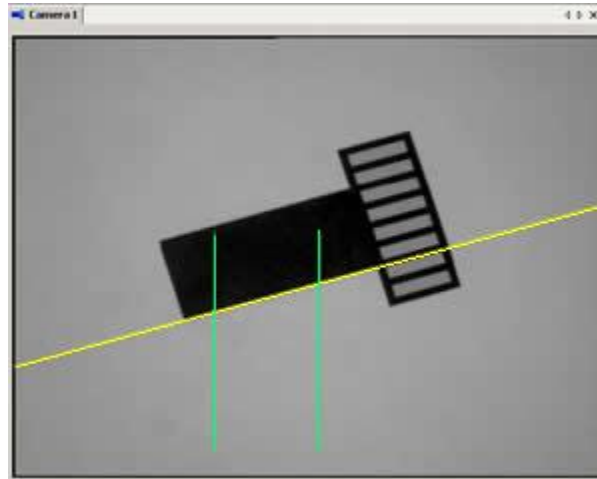


The default PreciseVision application layout should now be visible and the Camera Display should show the picture of a "T" part with two green Edge Locators as shown above.

If you examine the Process Manager, you will see that this Project has one Vision Process defined, "ComputeLine". This Process consists of an Acquisition Tool, "picture", and a Point-Point Line Tool, "cl_compute_line". The Acquisition Tool would normally be set to capture an image from a camera. In this case, it is configured to read the image from a disk file. cl_compute_line does the work of computing a line from the output of two Edge Locators. The two Edge Locators are implicitly executed and not listed in the Vision Process (more about this later).

» To test the Vision Process, click on **"ComputeLine"** in the Process Manager and then click on the circular green **"Test Selected Process"** button in the window's toolbar.

Each time that you click on the "Test Selected Process" button, the Acquisition Tool loads an image file from the disk and then the Point-Point Line Tool executes the two Edge Locators and fits a line between their first detected edges. The first time you click the test button, the Camera Display should resemble the following. You will note that the output line of the Point-Point Line Tool is indicated in yellow.

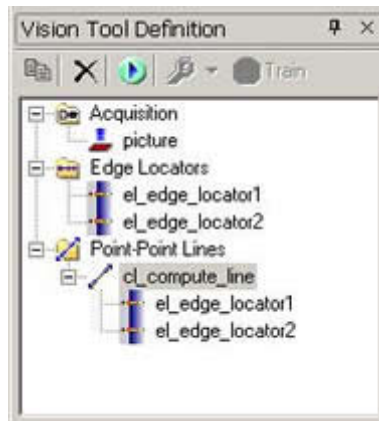


For this Sample Project, there are multiple image files and so the captured image and the results will change each time you click the test button.

» To continuously execute the Sample Project, pull down on the arrow next to the test button in the toolbar and select **"Test Loop"**.

» To stop the execution, click the **"Stop Test Loop"** button in the toolbar.

» Next, to examine the defined tools, in the Vision Tool Definition Window, click on each of the "+" boxes to expand all of the displayed items.

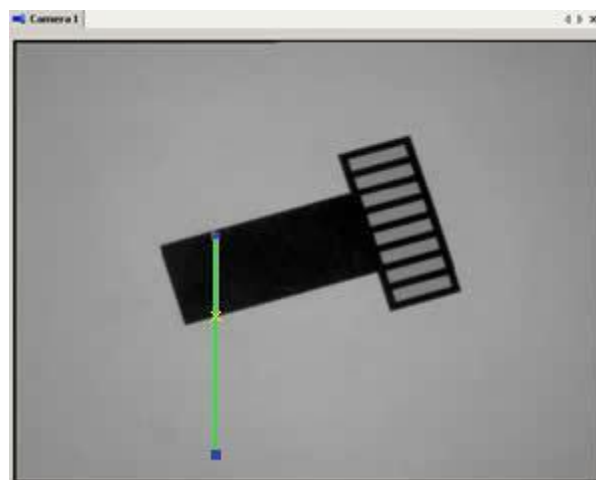


The items in the left-most column of the Vision Tool Definition Window are folders that contain all created tools of a specific type. If a type of tool has not been created, the corresponding tool folder is hidden. The top-level items listed in the tool type folders are the names of the created tools. The third and successive levels are lists of tools that are referenced by the tool above it. In this example, in addition to the "picture" and the "cl_compute_line" tools, two Edge Locators, "el_edge_locator1" and "el_edge_locator2" have been created. Note that the names of the Edge Locators appear twice, once in the top-level Edge Locator tool type list and a second time under the "cl_compute_line" tool. This second listing indicates that the output (i.e. "Results") of these two Edge Locators are referenced by and used in the computation of "cl_compute_line".

Since the system knows that the Edge Locators are needed for the computation of the Point-Point Line Tool (more about how to specify this later), the Edge Locators are automatically executed by the Point-Point Line Tool if necessary and they need not be included in the Vision Process. Including the Edge Locators in the Vision Process before the computation of the Point-Point Line Tool is a matter of personal preference and does not effect execution time.

The Vision Tool Definition Window provides a convenient means to access all created tools whether or not the tools are included in any Vision Process. This window also provides a simple graphical representation of how tools are dependent on and connected to other tools.

» In the Vision Tool Definition Window, click on either of the **"el_edge_locator1"** names to select this tool for editing.

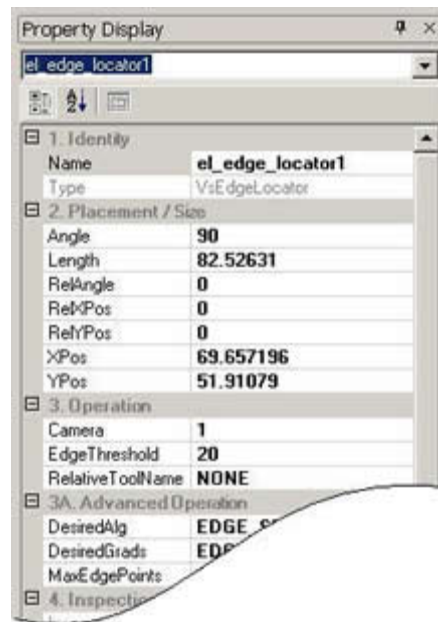


Once the Edge Locator is selected for editing, it will be displayed in the Camera Display with graphical handles (as shown above) that allow it to be repositioned and resized.

- » To practice repositioning the tool, click anywhere along the green line and drag the tool to translate it.
- » Click on the blue square that indicates the start of the Edge Locator and drag it to stretch or shrink the tool.
- » Click on the blue circle that indicates the end of the tool and drag it to rotate the tool's orientation.
- » To test the Vision Process with a new tool position and size, in the Process Manager, click on **"ComputeLine"** and then click on the circular green **"Test Selected Process"** button in the window's toolbar.

When the Edge Locator was selected for editing, you might have noticed that its properties were automatically displayed in the Property List Display as shown below. In addition to graphically positioning and sizing this tool, you can also enter new values into this panel. The properties are organized into groups based upon their function. Readonly values are displayed in dimmed characters.

For each of the tool types, all of the properties are described in detail in the Vision Toolkit Chapter of this document.



- » In the Property List Display, try editing the **"Angle"**, **"Length"**, and **"XPos"** and **"YPos"** properties and note the effect in the Camera Display.
- » If you wish to save your changes to the Sample Project, select **"File > Save Vision Project As..."** and assign a new name to your project so the original Sample is preserved.

This completes the tutorial on testing a Sample Project and editing a tool.

Tutorial 2: Adding Vision Tools

In this tutorial, we again make use of the **ComputeLineExample** Sample Project. In this case, we present the procedure for adding a Vision Tool to an existing Vision Process. For demonstration purposes, we will add an Edge Locator that measures the width of the stem of the "T" and validates if this dimension falls within an acceptable range. In an application that required high precision, you would probably use two Line Fitters for locating the edges of the "T" stem, but for training purposes, an Edge Locator will suffice.

Prior to executing this tutorial, the following steps must first be performed:

- The procedure for "[Installing PreciseVision on a PC](#)" must be completed.
- No camera hardware of any sort is required.

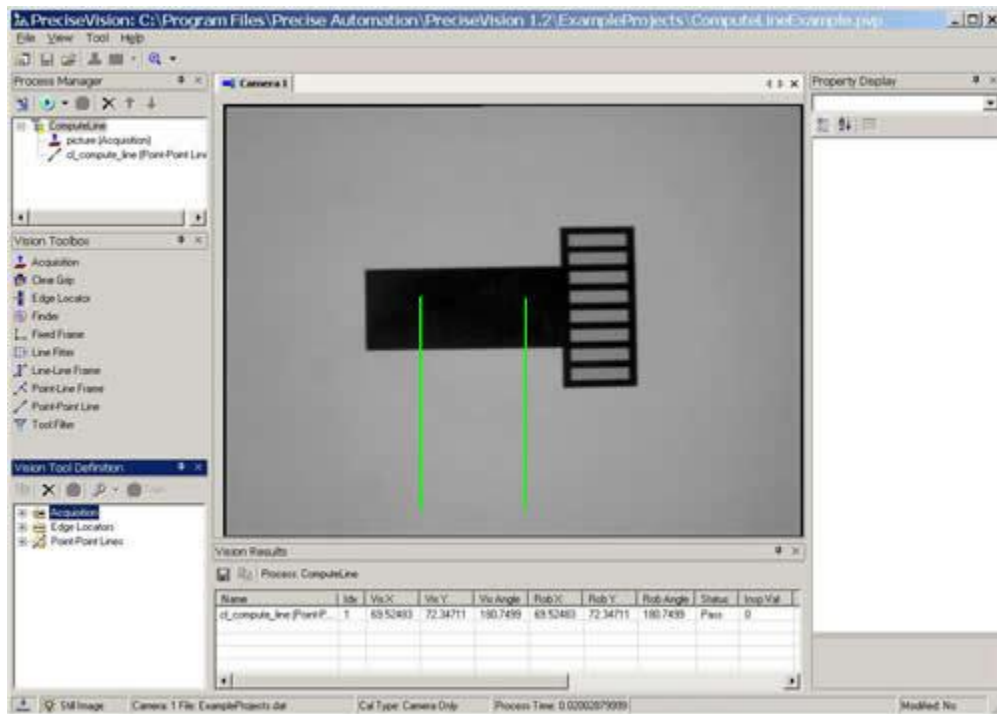
» If PreciseVision is not running, click on "**Start > Programs > Precise Automation > PV xxx > PreciseVision**".

» If PreciseVision is already running, select "**File > Quick Start**".

If a pop-up window is displayed requesting the specification of the camera hardware or a window is displayed requesting that the software be activated, you can cancel out of these pop-up's since neither of these setup steps is required to initially execute the Sample Projects.

» In the Quick Start window, click on the "**Samples**" button. A standard file selection pop-up window will be displayed that lists a number of Sample PreciseVision Project files (*.pvp).

» Click on the "**ComputeLineExample.pvp**" file and press "**Open**" to load this Project.

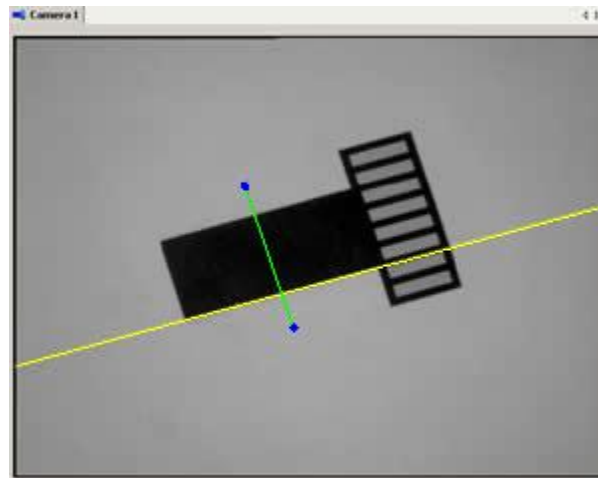


The default PreciseVision application layout should now be visible and the Camera Display should show the picture of a "T" part with two green Edge Locators as shown above.

For robustness, the visual inspection should be designed such that the measured width of the stem is accurate independent of the orientation of the "T". To achieve this, the new Edge Locator should be oriented perpendicular to the computed Point-Point Line. If the Edge Locator was just placed at a fixed position and orientation, the width measurement would return too large a value if the "T" is rotated. To create the new tool, the following should be executed.

- » Double click on the **"Edge Locator"** in the Vision Toolbox.
- » In the Name pop-up, enter **"el_measure_width"** as the name of this new tool and press **"Ok"**. The new tool will be created and will appear in the Vision Tool Definition Window.
- » Click on the new tool in the Vision Tool Definition Window and drag it to the Process Manager and drop it on **"ComputeLine"**. This will evaluate the new tool after the Results of `cl_compute_line` are computed.
- » In the Property List Display, pull down the entries for **"RelativeToolName"** and select **"cl_compute_line"**. This makes the position and orientation of the new tool relative to the computed position and orientation of the Point-Point Line Tool.
- » In the Camera Display Window, resize and position the new tool so that it is approximately perpendicular to the yellow line for `cl_compute_line` and stretched across the stem of the "T".

The Camera Display should resemble the following picture that shows the `el_measure_width` tool drawn across the stem of the "T" and approximately perpendicular to the yellow line for `cl_compute_line`.

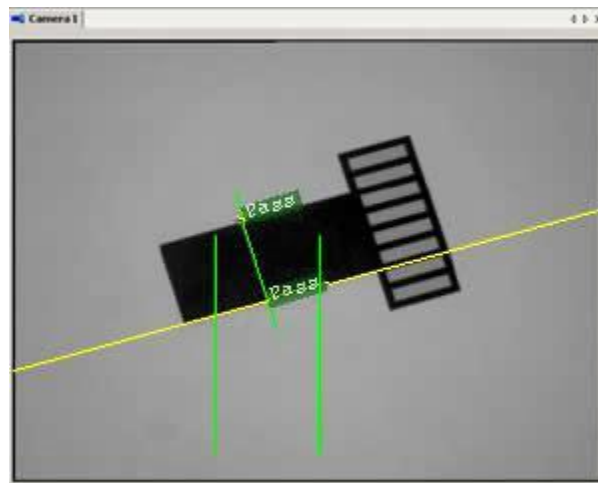


- » To ensure that `el_measure_width` is exactly perpendicular to `cl_compute_line`, in the Property display, edit **"RelAngle"** to be an even multiple of 90. For example, if it has a value of -628.2, change this to -630.
- » To automatically test the width of the stem, change **"InspectType"** to **"Distance From First To Last"**. This defines the inspected results as the computed distance between the first and last edge found by `el_measure_width`.
- » To define the width dimensions that we will accept as valid, set the **"InspectMax"** value to

"31.8" and the **"InspectMin"** value to **"31.2"**.

- » To display a pass or fail label on the tool in the Camera Display, change **"InspectLabel"** to **"Pass_and_Fail"**.
- » To test the new tool, in the Process Manager, click on **"ComputeLine"** to select it and then click on the circular green **"Test Selected Process"** button in the window's toolbar.

Each time you click the test button, you should now see the new tool in addition to the three former tools. The new tool should be drawn perpendicular to the yellow computed line and should be labeled to indicate if the width dimension is acceptable. The following illustrates a typical image in the Camera Display.



As you execute the modified Process, you should review the data displayed in the Results Window to see the numerical value of the computed width. All of the Results information is also available by selecting individual tools and viewing the data in the Properties List Display.

- » If you wish to save your changes to the Sample Project, select **"File > Save Vision Project As..."** and assign a new name to your project so the original Sample is preserved.

This completes the tutorial on adding a tool to an existing Vision Process.

Tutorial 3: Applying A Finder Tool

The Finder is the most general purpose tool available for identifying parts or sections of parts and locating their position, orientation and scale. For constrained or special situations, other tools can be combined to perform some of these functions. As an example, in the first tutorial, three tools were combined to locate a known part. But, in that case, the part was only expected to translate and rotate within a limited range. The Finder Tool utilizes an advanced patented algorithm to both identify and locate parts that are randomly positioned based upon a simple one-shot training technique.

In this tutorial, we step through the procedure for creating and teaching a Finder using a Sample Project. This tutorial also includes an example of creating a new Vision Process within an existing Vision Project.

Prior to executing this tutorial, the following steps must first be performed:

- The procedure for "[Installing PreciseVision on a PC](#)" must be completed.
- No camera hardware of any sort is required.

» If PreciseVision is not running, click on "**Start > Programs > Precise Automation > PV xxx > PreciseVision**".

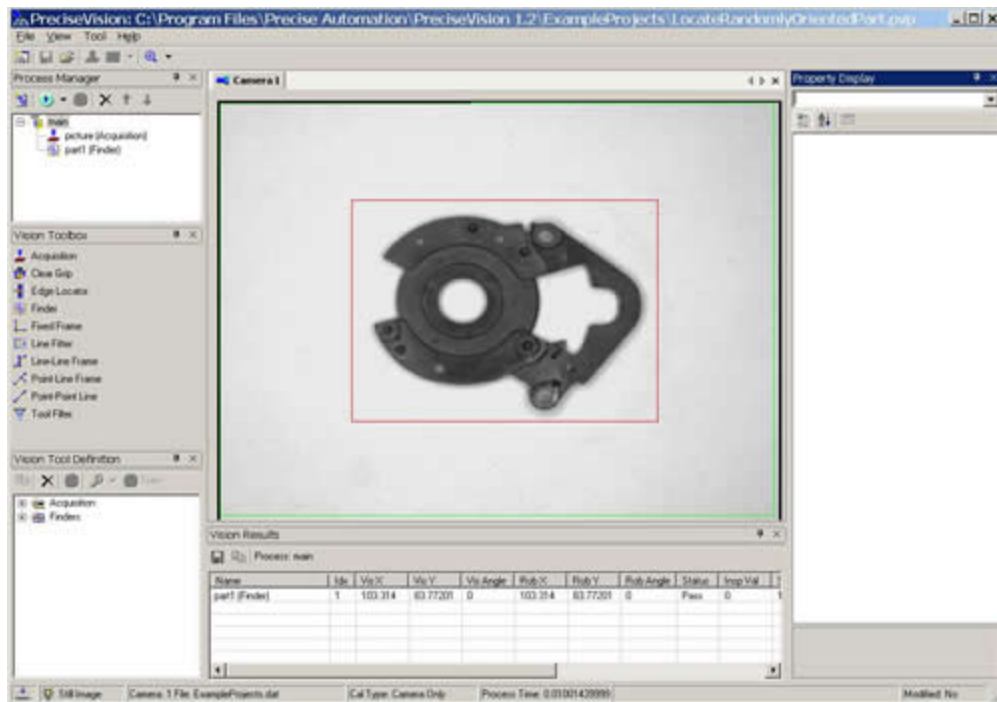
» If PreciseVision is already running, select "**File > Quick Start**".

If a pop-up window is displayed requesting the specification of the camera hardware or a window is displayed requesting that the software be activated, you can cancel out of these pop-up's since neither of these setup steps is required to initially execute the Sample Projects.

» In the Quick Start window, click on the "**Samples**" button. A standard file selection pop-up window will be displayed that lists a number of Sample PreciseVision Project files (*.pvp).

» Click on the "**LocateRandomlyOrientedPart.pvp**" file and press "**Open**" to load this Project.

The default PreciseVision application layout should now be visible and the Camera Display should show the picture of a circular plastic part with a "V" shaped attachment as shown below.



This Sample Project already includes a Finder as its principal tool. In this tutorial, we will go through the steps of re-creating this Vision Process including the Finder. Before beginning, the supplied Process should be tested to see how the Finder performs on this part.

» To see the Finder in operation, click on "**Main**" in the Process Manager and then click on

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the circular green **"Test Selected Process"** button in the window's toolbar.

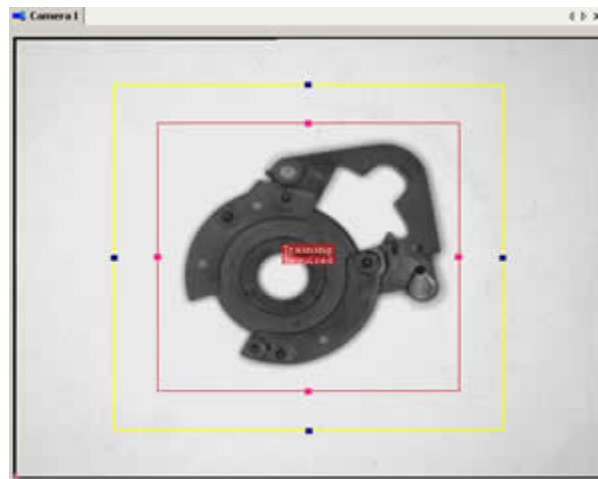
- » To continuously execute the Sample Project, pull down on the arrow next to the test button in the toolbar and select **"Test Loop"**.
- » To stop the execution, click the **"Stop Test Loop"** button in the toolbar.

We will now begin creating a new Vision Process. In order to perform the image capture, we will reuse the existing Acquisition Tool since it has already been initialized to read the desired image disk files.

- » Click on the **"Add a new Process"** button in the Process Manager toolbar.
- » In the Process Name pop-up window, fill in **"my_process"** as the name and press **"Ok"** to create the Process.
- » In the Vision Tool Definition Window, in the Acquisition folder, click on the **"picture"** tool and drag and drop it on top of the **"my_process"** in the Process Manager.

Before performing the next step of creating and training a new Finder, the following is background information and hints that will aid in applying this tool.

When you create a new Finder or re-teach ("re-train") an existing Finder, red and yellow rectangles will be drawn in the Camera Display as shown below.



The red rectangle defines the "Finder Template" for the part to be located. When PreciseVision subsequently searches for the part, it is looking for matches for the Template in the image. When the system reports the position and orientation of a matched part, it is actually stating the position of the center of the Template when the match was found and the amount by which the Template was rotated. When defining the Template, keep in mind the following guidelines.

- The Template should fully enclose the target object and should contain no other objects or parts of objects.
- The Template should include some of the background on all sides of the target object, typically at least 16 camera pixels (too many is better than too few). This allows the system to distinguish the boundary of the object from the background,

which is especially important for parts with few internal features. For a 640x480 camera, 16 pixels is 1/30th of the full height of the camera image.

- If the background varies considerably (i.e. it is dirty or has blotches), the part should be trained on a uniform neutral background.
- The target object should be oriented in the camera image in what you want to define as 'Zero' degrees. That is, when the Finder later locates a part in the trained orientation, it will return an orientation angle of 0 degrees.

The yellow outline defines the "Training rectangle". This rectangle is used to teach the system how to distinguish the Template from other objects or background clutter. When defining this rectangle, keep in mind the following guidelines.

- This rectangle must be larger than the Template and must fully enclose the Template.
- This rectangle should include one and only one complete copy of the target object. It's okay if this region includes other partial copies of the target object so long as each partial copy is less than 50% of the target object.
- This rectangle should include any other objects or clutter that are expected to be encountered during runtime to aid the system in learning to distinguish between the target object and its surroundings.
- This rectangle should be as large as possible without violating the rules above. A larger region permits the system to test more positions and orientations for the Template during the training phase and assists in optimizing the runtime search strategy.

It's now time to create the Finder and add it to the Vision Process.

- » Double click on the **"Finder"** in the Vision Toolbox.
- » In the Name pop-up, enter **"my_finder"** as the name of this new tool and press **"Ok"**. The new tool will be created and will appear in the Vision Tool Definition Window.
- » Follow the step-by-step instructions within the "Finder training" Application Wizard that is displayed to setup the Finder keeping in mind the hints above.
- » Click on **"my_finder"** in the Vision Tool Definition Window and drag it to the Process Manager and drop it on **"my_process"**. This will evaluate the Finder after the camera acquisition is executed.
- » To test the new tool, in the Process Manager, click on **"my_process"** to select it and then click on the circular green **"Test Selected Process"** button in the window's toolbar.

Congratulations, you just created your first Vision Process that identifies and locates randomly parts! You can continue to click on the test button or execute your process in a continuous loop.

- » If you wish to retrain the Template at anytime, click on **"my_finder"** in the Vision Tool Definition Window to select it. Then click on the arrow to the right of **"Finder Operation Mode"** icon on the window toolbar and select **"Train Mode"**. You can also restart the Finder Training Wizard in this same pull-down if you wish.
- » If you wish to save your changes to the Sample Project, select **"File > Save Vision Project As..."** and assign a new file name to your project so the original Sample is preserved.

» At this time, we highly recommend that you execute each of the distributed Sample Vision Projects, review their Vision Processes and edit the Tool Properties to get an understanding of more of the vision tools.

This completes the tutorial on creating a Vision Process and applying the Finder Tool.

Tutorial 4: Developing a Robot Vision Application

This tutorial illustrates how to develop a simple, but complete, robot vision guidance application. It presents both the PreciseVision Project and the GPL software that must be executed on a Guidance Controller. This tutorial requires that your robot and Guidance controller be operational and interfaced to the PC executing PreciseVision.

Prior to executing this tutorial, the following steps must first be performed:

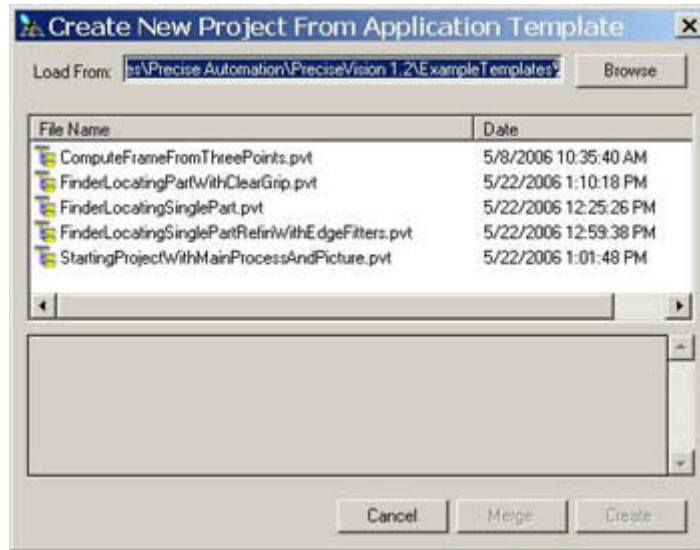
- The procedure for "[Installing PreciseVision on a PC](#)" must be completed.
- A camera must be rigidly mounted over a region that can be reached by the robot.
- The camera interface must be installed and interfaced to PreciseVision using one of the procedures in the "[Hardware Installation](#)" section of this manual.
- The robot must be fully operational and interfaced to the PC via Ethernet.
- The procedures outlined in "[Configuring Communication Between the PC and the Controller](#)" that permit the two systems to exchange data must have been performed.
- The "[Robot Vision Area Camera Calibration](#)" must have been executed to define the camera's pixel-to-millimeter conversion and the transformation from the camera's frame of reference to the robot's frame of reference.
- The Guidance Development Suite must be installed on the PC and you should have a modest ability to develop and execute GPL programs.

» If PreciseVision is not running, click on **"Start > Programs > Precise Automation > PV xxx > PreciseVision"**.

» If PreciseVision is already running, select **"File > Quick Start"**.

» In the Quick Start window, click on the **"New Project"** button.

You should now see the "Create New Project From Application Template" pop-up window that resembles the following.



The "Create New Project From Application Template" is a wizard that builds a complete Vision Project for a number of common tasks. For example, the "FinderLocatingPartWithClearGrip" constructs a Project that uses a Finder Tool to locate an object and then executes two ClearGrip Tools to verify that the parts can be grasped without hitting an obstruction. In particular, this wizard deletes the current Vision Project (after confirmation if the Project should be saved), creates a new Project, and automatically creates the Vision Tools and Vision Processes for the selected task. The wizard then walks you through the steps to position, size and train each of the tools for your parts. Over time, we will be adding additional templates to address even more common tasks and we will be adding the ability for you to add your own templates to simplify the use of the system by your co-workers or customers. Of course, you can always create your own Vision Projects, Processes and Tools using the basic methods described in the other tutorials. The Application Wizard is just a convenience for people learning about the system or it can serve as a starting point for those already familiar with the system.

For this exercise, we will be selecting the "FinderLocatingSinglePart" template. This takes a single picture and then employs a single Finder Tool to locate your part.

- » Click on the **"FinderLocatingSinglePart.pvt"** file, click on **"Create"** and then follow all of the instructions of the wizard to create your Vision Project. At the conclusion of the wizard, the Project, Process and Tools should all be created and the Finder should be trained on your object.
- » Save your Project by selecting **"File > Save Vision Project As..."** and assigning a file for your Project.
- » To test your Project, place your object in the camera's field-of-view, click on **"Main"** in the Process Manager and then click on the circular green **"Test Selected Process"** button in the window's toolbar.
- » To validate that the Vision Project and the camera calibration are working properly, using the same robot pointer you used during the camera calibration process, manually move the robot to the X/Y position indicated in the Results Window **"RobX"** and **"RobY"** values and verify that the tool is at the center of your part's Finder Template.

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PreciseVision is now setup and ready to receive commands. It is not necessary to place PreciseVision in a special mode to work with the robot, it is always listening for commands from a GPL system. So, there is no further development to be done in PreciseVision.

The next step is to develop a GPL project that will execute the Vision Process "Main", retrieve the "part1" Finder Results and move the robot to the specified position. A simplified version of the required program is presented in the *"Guidance Programming Language, Introduction to GPL"* manual in the Vision section and is repeated below.

» Within GDE, the Guidance Development Environment, in the Project Manager, create a new GPL Project named **"Robot_vision"**.

» In the new **"Robot_vision"** Project, double click on the **"Main.gpl"** file to begin editing.

» In the editor window, below the "Public Sub Main" statement, insert the following lines of text. If you are reading this exercise in the *Precise Documentation Library* (the online help file), this can be accomplished by copying and pasting if you wish to save yourself some typing.

```
Dim vis As New Vision
Dim vResult As New VisResult

Robot.Attached = 1
Move.Loc(safe, vsProfile)

vis.Process("Main") ' Run vision process "Main"
If vis.ResultCount("part1") = 0 Then
    Console.WriteLine("Vision object not found")
    Goto done
End If
vResult = vis.Result("part1", 1) ' Get results

' Create a reference frame object and set it
' equal to the returned vision location
Dim vsRefFrame As New RefFrame
vsRefFrame.Loc.PosWrtRef = vResult.Loc

' Pickup point is relative to new frame
vsRelPoint.RefFrame = vsRefFrame

Move.Approach(vsRelPoint, vsProfile)
Move.Loc(vsRelPoint, vsProfile)
Move.Approach(vsRelPoint, vsProfile)

' Move back to safe location
Move.Loc(safe, vsProfile)

done:
```

» In the the **"Robot_vision"** Project, double click on the **"GModule.gpo"** file to access the global Motion Objects panel.

» Create and teach a Location named **"safe"** that positions the robot so it is not obstructing the camera's view of the part. Also, create a Motion Profile named **"vsProfile"** that will be used to slowly move the robot to the part.

» Create a Location named **"vsRelPoint"**. This will define the robot's pickup position relative to the Location returned from PreciseVision. Normally, it would be best to manually define this Location relative to the actual value returned from the vision system. But for demonstration purposes, set its properties to the following where the Z value is a safe world coordinate value

above the part.

$X = 0$
 $Y = 0$
 $Z = Z_safe$
 $Yaw = 0$
 $Pitch = 180$
 $Roll = 0$

- » Press the **"Save Document"** icon on the main tool bar to save your changes.
- » To load your application, in the Project Manager, drag the **"Robot_vision"** Project from the PC to the top **"Loaded Projects"** panel and drop it.

You have now completed the development of the GPL Project and we are ready to execute the complete vision guided robot application.



DANGER: Before proceeding with this procedure, please ensure that the robot has been properly mounted, all required safety interlocks have been installed and tested, and power has been connected. For the PrecisePlace robots, this information is provided in the *"PrecisePlace 2300/2400 Robot, Hardware Introduction and Reference Manual"*.

- » In the GDE Robot Control Window, set the **"Robot Speed"** to approximately 5%. This will force your Project to move the robot at 1/20th of its normal speed.
- » **This next action will move the robot automatically to a position computed by PreciseVision, so be prepared to hit the E-Stop button or disable power if any problem occurs!**
- » With your part placed in the camera's field-of-view, execute the GPL Project. When you run a GPL program for the first time, it is advisable to start the project in debug mode. This can be done by selecting **"Debug > Start with break"** or pressing **"Shift-F5"**. Single step through the program one line at a time by pressing **"F10"**.

Congratulations, you just created your first full vision guided robot application!

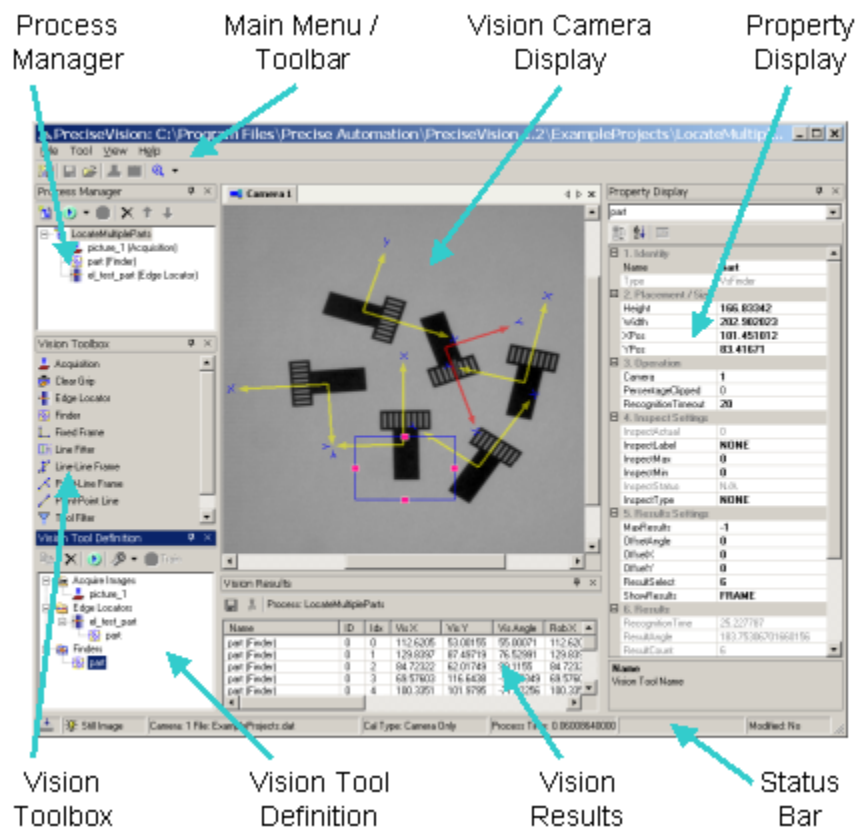
For more information on the GPL vision interface, please read the Vision Guidance chapter of the *"Guidance Programming Language, Introduction to GPL"* manual. This contains an overview of the built-in GPL vision classes, methods and properties. For more detailed information, please see the *"Guidance Programming Language, GPL Dictionary Pages"*.

Graphical User Interface

PreciseVision User Interface

The PreciseVision Graphical User Interface (GUI) consists of a title bar that displays the name of the opened project, a top menu bar, a main toolbar, and a variety of dockable windows. Each of the dockable windows can be displayed or hidden, resized and repositioned into the arrangement that is most efficient for your use.

When PreciseVision is started for the first time, the following default arrangement of the various elements of the GUI is presented.



To reposition a window, you simply click in its title bar and drag it to its new location. If you drag a window on to another window, they can split the space or share the space using tab controls. If you click on the close icon (x) in the top right of a window's title bar, you can use the "View" top-level menu to redisplay the window. If you click on the "push pin" in the top right of a window's title bar, you will either "pin" a window and fix its location or "un-pin" a window so it can share its space with another window.

Windows can be resized by grabbing a border and stretching or shrinking it to the desired dimension.

In the following sections, the functions supported by each of the major elements of the PreciseVision GUI (i.e. main menu bar, tool bars, and windows) will be described. In addition, the [Preferences Panel](#) for specifying system configuration information is also described. The graphical components are presented in order of importance rather than alphabetically. To jump to a specific description, click on a label in the picture above or on a window.

Main Menu and Toolbar

The Main Menu and the Main Toolbar provide access to general functions such as displaying the dockable windows, saving and loading Vision Projects and launching the camera calibration operations. This menu and toolbar appear as follows.



The following tables describe the operation of each of the selections within the Main Menu and are organized by the name of the top-level menu. These tables are followed by a description of each of the Toolbar buttons.

File	Description
Quick Start	Displays the pop-up Quick Start window that is shown each time PreciseVision is started. This window allows an existing Project to be loaded, sample canned Projects to be loaded, or a new Project to be constructed by a step-by-step wizard that supports many common procedures. The latter two options are very instructive for individuals who wish to learn about machine vision or PreciseVision.
New Vision Project	Displays a sub-menu with selections that create either an empty unnamed Vision Project or a new Project constructed by a step-by-step wizard that supports many common procedures. An additional sub-menu selection permits the last executed wizard to be re-executed to allow editing of the previously generated Vision Process.
Open Vision Project	Opens a new Vision Project from the disk and loads it into memory replacing the current Vision Project. The standard file pop-up window is displayed to allow browsing to the desired folder. PreciseVision project files have a ".PVP" file extension.
Import Vision Project	Loads in the Vision Project contained in a file and merges its contents with the currently loaded project. If the new project contains any processes or tools whose names conflict with items that are already loaded, "_r" is appended to the name of the new item. Also, any camera calibration information that is contained in the new project is ignored.
Save Vision Project	Either saves the loaded Vision Project to its associated disk file or displays a pop-up file window to allow the operator to browse to the desired disk folder and assign a disk file name.
Save Vision Project As ...	
Close Project	Closes the loaded Vision Project after prompting if any changes should be saved to the Project's disk file. The close operation deletes all defined tools and Vision Processes resulting in an empty un-titled Project.
Preferences	Displays the PreciseVision Preferences panel. This panel contains a

PreciseVision





	number of application setup parameters that customize the operation and appearance of PreciseVision, e.g. enable/disable the display of the Main Toolbar or tool graphics.
Acquire New Image	Takes a single snap shot from the currently selected camera and loads the image into the Camera Display window.
Reinitialize Camera Connections	Reinitializes Dalsa cameras that have stopped operating after being disconnected and reconnected or due to network connectivity disruptions. PreciseVision normally tries several times to reconnect to cameras that are no longer operating, but will eventually stop retrying. This function forces the system to perform additional retries.
Image Load / Save	Diagnostic and debugging aid that loads a camera image from a disk file into the Camera Display window or saves the currently displayed image to a disk file.
Lock / Unlock Application	Locking an application prohibits users from modifying the loaded project. This is useful for avoiding situations where a user might inadvertently change a parameter or tool and cause a vision project to no longer operate correctly. Locking dims out all menu items, removes most toolbar items, and inhibits closing PreciseVision. Unlocking requires a password if a password has been defined in the Preferences panel.
Exit	Terminates execution of PreciseVision







View	Description
Layouts	Provides "Load Default", "Load Layout" and "Save Layout" selections for permitting custom desktop layouts to be preserved, reloaded or set back to the normal default. Also provides "Load Runtime Layout", "Load Edit Layout" and "Load Calibration Layout" for putting standard layouts into effect. These standard layouts can also be accessed from the main toolbar.
Select Camera	Selects the camera whose image is to be presented in the Camera Display window. This also specifies the camera that is utilized in the Camera Calibration methods and other functions.
Debug	Provides access to a sub-menu that launches a number of diagnostic functions.
Process Manager	Permits any dockable window that has been closed to be re-displayed.
Vision Tool Definition	
Vision Toolbox	
Property Display	
Results Display	
Guidance Web Panels	Opens up to three web panels specified in the 'Preferences -> Web Interface' tab. This provides convenient access to the Precise Guidance Controller web interface.

Tool	Description
Calibrate Vision	Initiates the execution of the camera calibration wizard. This procedure determines the pixel-to-millimeter conversion for the

	selected camera and also the conversion from the camera's frame of reference to that of the robot.
Camera Calibration Configuration	Displays a pop-up window that associates a camera calibration file with a specific camera in the current Vision Project. The information in this pop-up is saved and reloaded with the Vision Project.
Show Camera Information	Displays a pop-up window that shows which camera is selected and the camera calibration data that is in effect.
Camera Video Properties	Displays a pop-up window that permits the brightness range and offset for the currently selected camera to be set. This is helpful during the setup procedures for the Camera Calibration methods and other functions.
Show Vision Tool Cross Reference Information	Displays a pop-up window that either: (1) lists the vision processes and vision tools that reference each defined tool or (2) lists the defined vision tools that are not referenced by any vision process or any vision tool. This function is useful for understanding the relationship between vision tools in complex applications.

Help	Description
Contents	Opens the <i>Precise Documentation Library</i> in a separate window and jumps to the specified section that is relevant to PreciseVision.
PreciseVision GUI	
Vision Tools Overview	
GPL Programming	
Product Activation	Displays the pop-up window used for activating this product.
Camera Driver Info	Presents the version and identification information for installed camera drivers.
About PreciseVision	Generates a popup window that displays the PreciseVision version and ID information along with build information for key components of this application package.

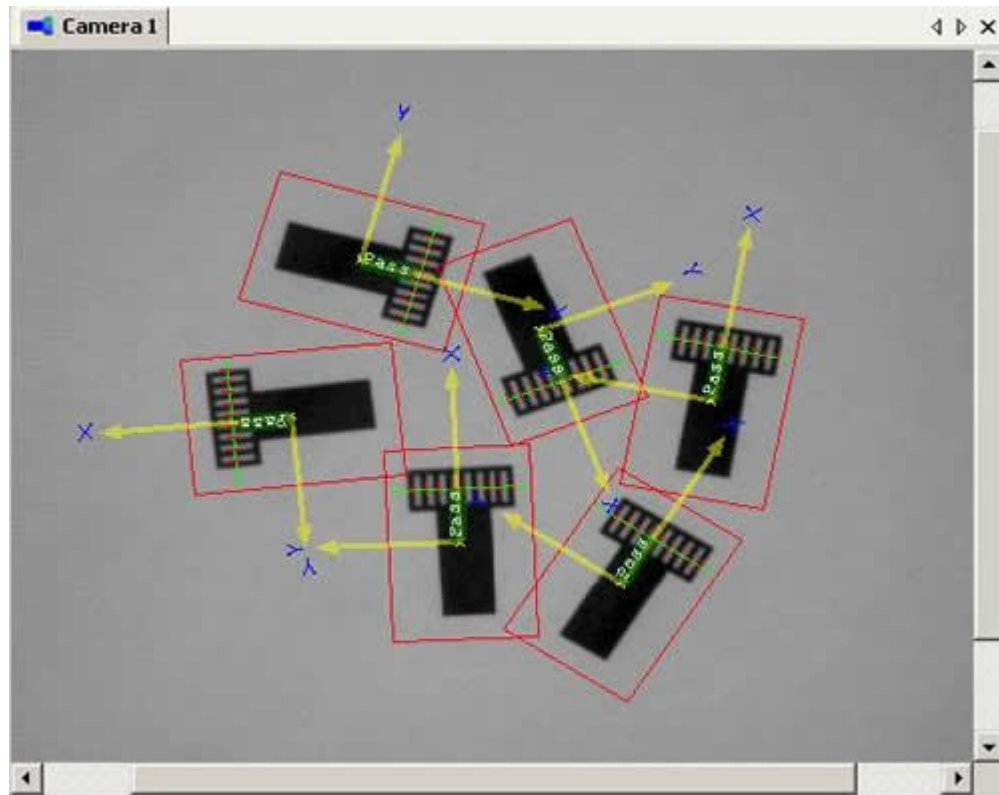
Icon	Tool Tip Title	Description
	Create new Vision Project	A new empty un-named Vision Project is created by deleting all of the tools and existing Vision Processes. If the current Project has been changed and needs to be saved to the disk, a pop-up is first presented that permits the operator to save the modifications.
	Save current Vision Project to disk	Saves the loaded Vision Project back into its disk file. If the current project has never been saved to the disk, a file pop-up window is displayed to allow the operator to browse to the desired disk folder and assign a disk file name.
	Open a Vision Project	Opens a new Vision Project from the disk and loads it into memory, replacing the currently loaded Project. The standard file pop-up window is displayed to allow browsing to the desired folder. PreciseVision project files have a ".PVP" file extension.
	Display live video	Places the currently selected camera into "Live Video"

	camera image	mode. Pictures will be taken continuously and displayed in the Camera Display window. This mode is very convenient for setting up the focus, f-stop, gain, and offset of a camera. If the camera is already in live video mode, pressing this button will terminate this mode.
	Take a single snap shot	Takes a single snap shot (i.e. picture) using the currently selected camera and displays the results in the Camera Display window.
	Toggle Color Display Mode	For color cameras only, toggles the Camera Display window display between color and grayscale mode. Set to color display mode by default.
	Zoom the Camera Display window	Zooms the Camera Display window view in or out. Pressing the button zooms in. A pulldown menu tied to this button zooms out or resets the window to its un-zoomed state. If "Zoom Auto" is selected, the active vision window is automatically scaled so as to best fit within the display window. The zoom factors range from 0.2 to 4 in steps of 0.1.
	Refresh Camera Display window graphics	Redraws any graphics generated by vision tools in the Camera Display window. This is convenient because the graphics can sometimes be lost when PreciseVision is minimized or if you click on certain panels.
	Switch display layout	Switches between three predefined display layouts: Edit, Run and Calibration. This icon makes changing the display layout very easy.
	Lock / Unlock Application	Locking an application prohibits users from modifying the loaded project. This is useful for avoiding situations where a user might inadvertently change a parameter or tool and cause a vision project to no longer operate correctly. Locking dims out all menu items, removes most toolbar items, and inhibits closing PreciseVision. Unlocking requires a password if a password has been defined in the Preferences panel.

Vision Camera Display

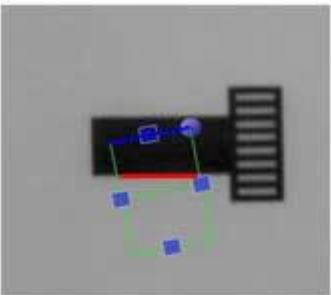
The Camera Display window shows the captured image from a selected camera with graphics to illustrate applicable vision tools. The camera image can be a "live video" display, which means that the captured image is continuously updated, or a single snap shot. The vision tool graphics illustrate the placement of tools and their computed results. When a tool is selected for editing, the graphics also include handles that permit the tool to be easily re-positioned, re-oriented and re-sized using a mouse.

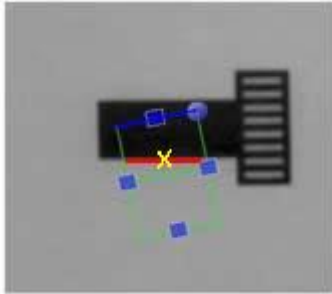
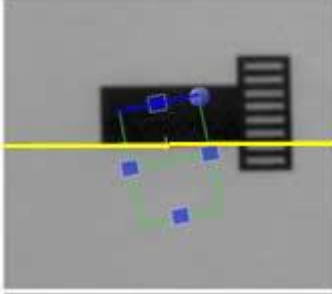
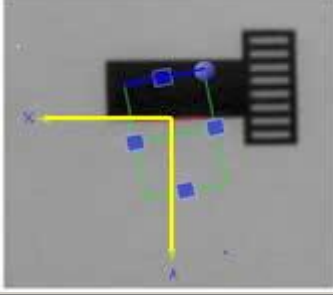
The following picture is a typical camera image with overlaid tool graphics. For all cameras, the X-axis of the camera coordinate system points from left to right and the Y-axis points from the bottom of the display to the top. The origin (0,0) of the camera coordinate system is in the lower-left corner of the camera image. If the camera is not calibrated, X/Y positions in the camera image are returned in units of raw pixels relative to the lower-left corner of the camera image. If the camera is calibration, X/Y positions are typically in units of millimeters relative to the origin.



To accommodate large or small images (those with many or few pixels), the camera display can be zoomed out or zoomed in. The control for this operation is provided on the Main Toolbar along with icons for manually placing a camera into live video mode and taking a snapshot. The Main Menu contains other commands for changing the selected camera and adjusting their gain and offset.

The following images describe how to utilize the graphical handles to place and size a typical vision tool and options for controlling how the results of a tool are illustrated in the Camera Display Window.

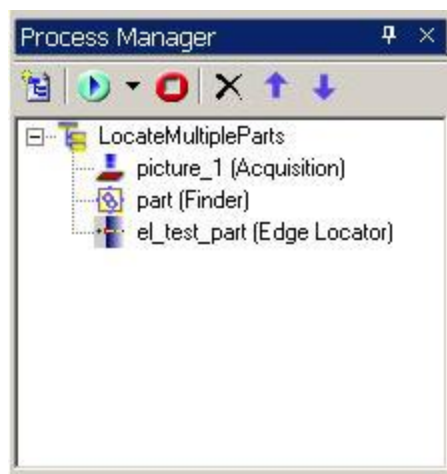
Graphical Display	Description
	<p>This is a snap shot of a Line Fitter Tool placed over one edge of a part. The green and blue perimeter lines indicate the tool's search area. The blue edge marks the side of the search region that should be positioned on the dark side of the edge. The red line illustrates the results of the tool and marks the best fit line.</p> <p>To position the tool, click anywhere in the search region and drag the rectangle. To resize the tool, click one of the four blue squares and drag. To rotate the search region, click the blue circle and drag.</p>

	<p>If the output of a tool is to be utilized as an input (X, Y) point for another tool, it is informative to display the result as a single position. In this picture, the ShowResults property for the Line Fitter has been set to "POINT". This places a yellow "X" at the origin of the output of the Line Fitter. Note, setting ShowResults only affects the graphical display and does not alter the results computed by the tool.</p>
	<p>In this example, if the output of the Line Fitter is to be interpreted as a line, the ShowResults property for the Line Fitter can be set to "LINE".</p>
	<p>In this final example, the output of the Line Fitter is to be interpreted as a reference frame, so the ShowResults property for the Line Fitter has been set to "FRAME".</p>

Process Manager Window

The Process Manager Window displays the list of all of the Vision Processes that are contained in the currently loaded Vision Project. If a Vision Process is expanded, all of the Vision Tools for the Process are displayed in the order in which they are evaluated. This window is the primary means for managing Vision Processes including their creation, renaming, deletion, modification and test execution. Any Process that is displayed in this window is eligible for execution by a GPL procedure running on a Precise Guidance Controller.

A typical Process Manager Window is shown below.



In this example, a single Vision Process "LocateMultipleParts" is contained in the currently loaded Vision Project. This Vision Process has three tools. The Process begins with the standard Acquisition Tool that takes a picture. After the picture is captured, the system evaluates a Finder Tool named "part". The final operation is an Edge Locator "el_test_part".



It should be noted that if the Edge Locator is defined relative to the Results of the Finder Tool, the Process could have been written without the explicit execution of the Finder. When the system encounters the Edge Locator, it would automatically execute the Finder if the Finder had not been evaluated. The decision of whether to include the Finder in the Vision Process is entirely a matter of personal preference. Whether or not the Finder is included, the Results of the Process would be identical as well as the execution time.





To add a new Vision Process to a Project, click the toolbar icon to "Add a new process". Once the new Process is assigned a unique name, it will appear as a top-level (i.e. left-most) item in the window. To specify the sequence of tools to be executed in the process, simply drag Vision Tools from the Vision Tool Definition Window and drop them on the Process. New tools are automatically added to the end of the Process and can be re-ordered by using the up and down arrows in the toolbar. The order of appearance of the tools is important since the tools are evaluated top to bottom in the displayed list.

After a Vision Process has been created, it can be renamed by right-clicking on its name within the Process Manager window and selecting "Rename Process."

Once a Vision Process has been created, it can be triggered from GPL or can be manually tested using an icon on the toolbar. The manual test can be executed a single time or the process can be executed continuously. The continuous test mode is intended for demonstration purposes since the execution of the Process will not be synchronized with the GPL robot program and therefore not of very much practical use.

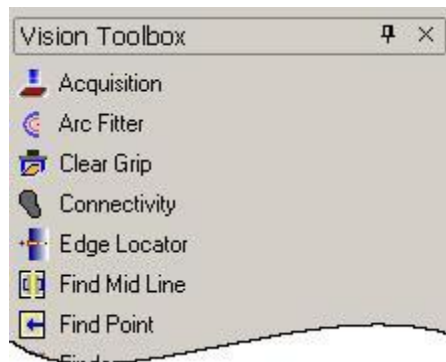
The following tables provide additional information on each of the window toolbar options.

Icon	Tool Tip Title	Description
	Add new process	Creates a new Vision Process and adds it to the Process Manager Window after it has been assigned a unique name via a pop-up window. The Process names are very important since they are used by GPL procedures to initiate the execution of a Process.
	Test selected process	Test executes the selected Process once or

		continuously. This is useful for debugging a Process and examining its computed results. However, in a robot guidance application, Processes are always initiated from a GPL procedure to ensure that the picture taking and evaluation are coordinated with the robot motions.
	Stop test loop	If a process is running in a continuous test mode, this button will stop the Process. This is only used while manually test executing a Process.
	Remove selected item	Removes a Process from a Project or a tool from a Process. In both cases, any referenced tools are not deleted from the Project, only the reference to the tool is removed. To delete a tool, you must use the Vision Tool Definition Window.
	Move tool up	Moves a vision tool up or down one line in a Vision Process list. The order in which the tools are listed in a Process is important because this is the order in which the tools are evaluated. If a Vision Process is selected, these button will change the order of the Processes within this window. This is a convenience feature and does not alter how Vision Processes are executed.
	Move tool down	

Vision Toolbox Window

The Vision Toolbox Window displays a list of all of the vision tool types that can be employed to construct a Vision Process. The top of this list currently looks as shown below.

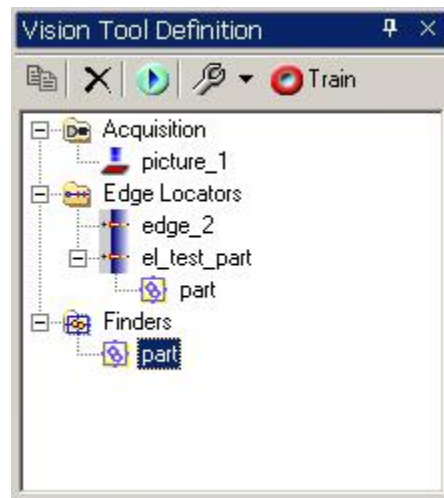


To add a new tool to an application, double click on a tool type in this list or right-click and select **"Create Tool"**. A pop-up will be displayed for assigning a unique name to the new copy of the tool. Once a name has been assigned, the new tool will appear in the Vision Tool Definition Window. Once there, the tool can be edited or dragged into the Process Manager to add the execution of the tool to a specific Vision Process.

Vision Tool Definition Window

The Vision Tool Definition Window displays all of the tools that have been created in the currently loaded Vision Project, even those that are not referenced in any Vision Process. This window provides the primary means for adding tools to a Vision Process and for selecting tools to be edited. As a convenience, this window graphically indicates when tools are dependent upon the results of other tools.

A typical Vision Tool Definition Window will appear as shown below.



To simplify accessing tools, all of the defined tools are grouped according to their tool type and only tool types that have one or more tools defined are visible. In the example above, there is one Acquisition Tool named "picture_1", two Edge Locators named "edge_2" and "el_test_part" and one Finder Tool named "part". The second Edge Locator has been defined with respect to the results of the Finder, so the Finder "part" appears below "el_test_part" to indicate this relationship.

There are a number of ways that a new tool can be added to the Vision Project and the Vision Tool Definition Window:

- Double click on a tool type in the Vision Toolbox Window.
- Right-click a tool or tool type in the Vision Tool Definition Window and select "New Vision Tool".
- Drag a tool type from the Vision Tool Definition Window and drop it into the Camera Display Window.
- Right-click in the Camera Display Window and select "New Vision Tool".

To copy an existing tool while maintaining its dependencies to other tools, highlight the tool in this window and click the "Copy" icon in the toolbar or drag the existing tool and drop it into the Camera Display Window.






To edit a tool, simply click on the name of the tool. This will automatically display the properties of the tool in the Property Display Window and will highlight the editing graphics and the handles for the tool within the Camera Display Window.

To test the operation of a tool without executing a Vision Process, click on the tool and click the "Play" button in the toolbar. This only executes the selected tool and any tools on which it is dependent. If the

PreciseVision

tool on which it is dependent returns multiple results, e.g. a Finder, only the first set of results is processed by the tool being executed. This is done to permit you to easily reposition the executed tool.

The following tables provide additional information on each of the window toolbar options.

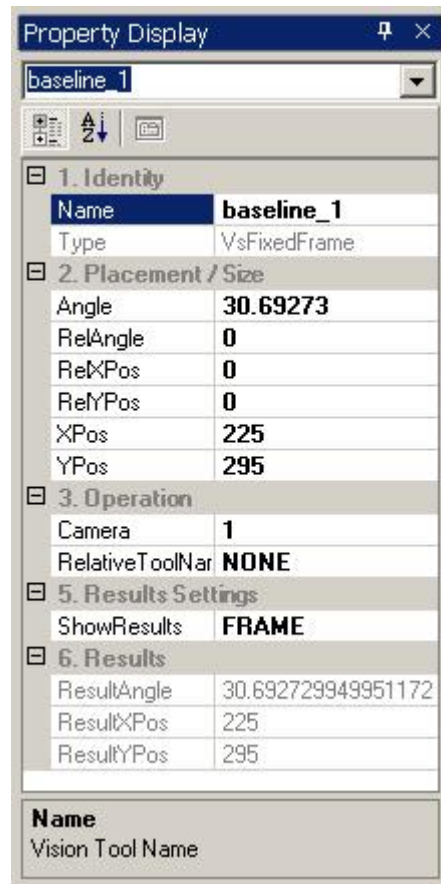
Icon	Tool Tip Title	Description
	Create copy	Copies the selected tool along with its relationships to other tools.
	Remove selected tool	Deletes the selected tool after confirmation but does not effect any tools that it references.
	Execute selected tool	Executes the selected tool and all of the tools on which it is dependent without executing a Vision Process. See above for further information.
	Finder operation mode	For Finder Tools, switches between "Find" and "Train" mode. Can also launch the Training Wizard to assist in teaching a Finder Tool and can display a trained Finder template at various resolutions as a diagnostic aid.
	Perform training operation	For tools that require training, executes the training process. In the case of the Finder Tool, this records the Finder Template and performs the analysis to determine distinctive features and the maximum levels of the search pyramid.

Property List Display

In PreciseVision, each Vision Tool is internally represented as a software "Object". The parameters for each tool are referred to as its "Properties". The properties include both the values that specify how a tool operates (e.g. its tool type, tool name, position, size, operating characteristics, etc.) as well as the values that indicate the results of executing the tool (e.g. number of objects found, number of edges located, etc.). For a given type of Vision Tool, the list of properties is always the same, but the list will vary from one type of tool to the next.

Some Vision Tools provide special buttons that are displayed between the tool name and the property grid. These buttons provide access to tool specific operations during the editing process (e.g. automatically snapping a tool into position).

The Property List Display provides a very convenient means for both viewing and editing the property values of a tool. As an example, the Property List Display for a typical Fixed Frame Tool is shown below.



The pull-down list at the top of the window selects the tool to be displayed. The displayed tool will also be automatically changed whenever a new tool is created or a tool is selected in the Vision Tool Definition Window.

Once a tool has been selected, any of its writable values can be modified by clicking on a cell and entering a new value. When a property is selected, a short description of the property is displayed at the bottom of the window. Properties that are readonly are indicated by dimmed text.

To assist in accessing these parameters, the properties are group according to their use. A description of each of the groups is presented in the following table. For detailed information on the properties for each of the tool types please see the chapter on the "Vision Toolkit".

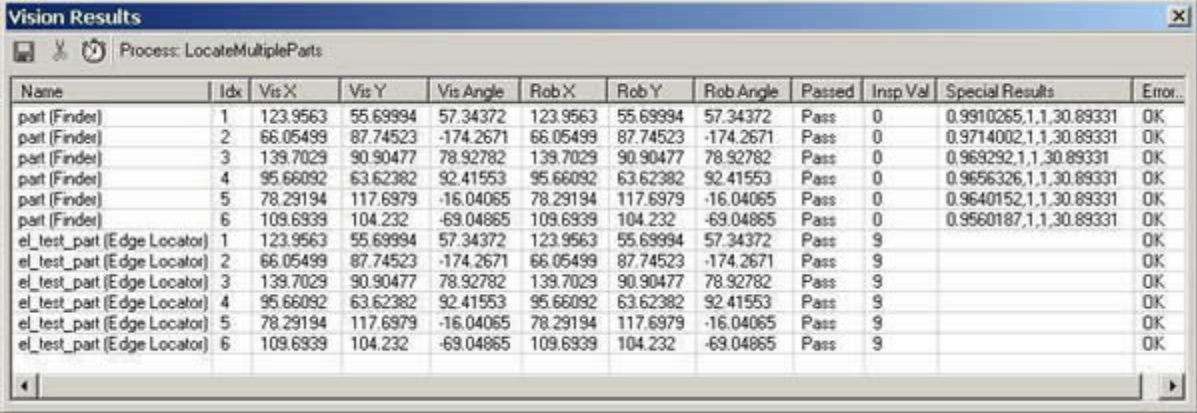
Property Group	Description
1. Identity Properties	Specifies the name of the tool and its basic tool type.
2. Placement / Size Properties	Defines the position, orientation and size of the tool in the coordinate system of the camera. In addition, if the tool is defined relative to another tool, the relative position and orientation can also be specified. Normally, it is easiest to graphically position and size each tool by dragging on the tool's handles displayed in the Camera Display Window.
3. Operation Properties	Defines 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.
3A. Advanced Operation Properties	Contains Operation Properties that are not normally modified and generally require a bit more experience to utilize. For these properties, their default settings will yield good tool performance for typical applications.
4. Inspection Settings Properties	Permits 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.
5. Results Settings Properties	Controls 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 .
6. Results Properties	Displays a single set of results for the vision tool. In general, the results returned varies from tool to tool. Many tools return a vision reference frame. However, some tools return additional results items such as statistical information on how well the answer fits the actual data.

Vision Results Display

The Vision Results Window displays the "Results" properties for all of the tools evaluated in the previously executed Vision Process. For position and orientation data, the results are displayed in both the vision coordinate system and the robot coordinate system utilizing the applicable camera calibration data. The information contained in this display is automatically updated each time a Vision Process completes execution.




A typical display that illustrates the results of a Vision Process that contains both a Finder and a Edge Locator Tool is shown in the following picture. For tools that return multiple sets of results (e.g. the Finder or Connectivity), if you click on a line in the Results display, the corresponding object will be highlighted with a blue coordinate frame in the Camera Display.



The screenshot shows a window titled "Vision Results" with a toolbar and a table of results. The process name is "LocateMultipleParts". The table has 12 columns: Name, Idx, Vis X, Vis Y, Vis Angle, Rob X, Rob Y, Rob Angle, Passed, Insp Val, Special Results, and Error.. The results are grouped by tool type: "part (Finder)" and "el_test_part (Edge Locator)". Each tool has 6 rows of data, all of which are "Pass".

Name	Idx	Vis X	Vis Y	Vis Angle	Rob X	Rob Y	Rob Angle	Passed	Insp Val	Special Results	Error..
part (Finder)	1	123.9563	55.69994	57.34372	123.9563	55.69994	57.34372	Pass	0	0.9910265,1,1,30.89331	OK
part (Finder)	2	66.05499	87.74523	-174.2671	66.05499	87.74523	-174.2671	Pass	0	0.9714002,1,1,30.89331	OK
part (Finder)	3	139.7029	90.90477	78.92782	139.7029	90.90477	78.92782	Pass	0	0.969292,1,1,30.89331	OK
part (Finder)	4	95.66092	63.62382	92.41553	95.66092	63.62382	92.41553	Pass	0	0.9656326,1,1,30.89331	OK
part (Finder)	5	78.29194	117.6979	-16.04065	78.29194	117.6979	-16.04065	Pass	0	0.9640152,1,1,30.89331	OK
part (Finder)	6	109.6939	104.232	-69.04865	109.6939	104.232	-69.04865	Pass	0	0.9560187,1,1,30.89331	OK
el_test_part (Edge Locator)	1	123.9563	55.69994	57.34372	123.9563	55.69994	57.34372	Pass	9		OK
el_test_part (Edge Locator)	2	66.05499	87.74523	-174.2671	66.05499	87.74523	-174.2671	Pass	9		OK
el_test_part (Edge Locator)	3	139.7029	90.90477	78.92782	139.7029	90.90477	78.92782	Pass	9		OK
el_test_part (Edge Locator)	4	95.66092	63.62382	92.41553	95.66092	63.62382	92.41553	Pass	9		OK
el_test_part (Edge Locator)	5	78.29194	117.6979	-16.04065	78.29194	117.6979	-16.04065	Pass	9		OK
el_test_part (Edge Locator)	6	109.6939	104.232	-69.04865	109.6939	104.232	-69.04865	Pass	9		OK

The following tables provide additional information on the window toolbar options and the data provided in each column of the results table.

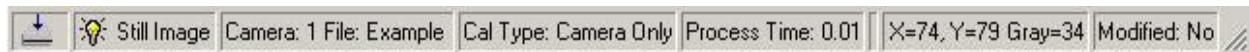
Icon	Tool Tip Title	Description
	Save	Stores the results data in a comma delimited file (*.CSV) that can be read into a spreadsheet application for further processing. A standard popup file window is displayed to allow the file name and disk directory path to be specified.
	Copy to clipboard	Copies the contents of the results table to the system clipboard in a comma delimited (*.CSV) format. This information can then be pasted into another application.
	Timer	Displays the execution time for each tool in the previously executed vision process instead of the tool results. The incremental time for each tool is displayed as well as the cumulative execution time for all tools in the process, in milliseconds.

Data Column	Description
Name	Specifies the name of the vision tool that generated the results.
Idx	For tools that return multiple sets of results, this is the index for the set of results that is displayed on a line. The index value goes from 1-n.
Vis X	For tools that return a position and orientation, this is the X & Y position in millimeters and the angle in degrees. These values are in the coordinate system of the camera's field-of-view.
Vis Y	
Vis Angle	
Rob X	For tools that return a position and orientation, this is the X & Y position in millimeters and the angle in degrees. These values are in the robot's world coordinate system and are the values that are transferred to a GPL program in a vision guidance application.
Rob Y	
Rob Angle	
Passed	Pass / Fail results of the tool Inspection. This is the same value as the InspectPassed property.
Insp Val	Actual property value that was tested by the tool Inspection. This is the same value as the InspectActual property.
Special Results	Each vision tool may have additional results that are unique to the tool type. This column provides a place for up to 20 special results per vision tool.
Errors and Warnings	Specifies if an error or warning condition occurred when the tool was executed. This is the same value as the ResultErrorCode property.

Application Status Bar

The bottom of the PreciseVision application window contains the Status Bar. This area continuously displays status information on the execution of the application. The Status Bar typically resembles the following.

PreciseVision



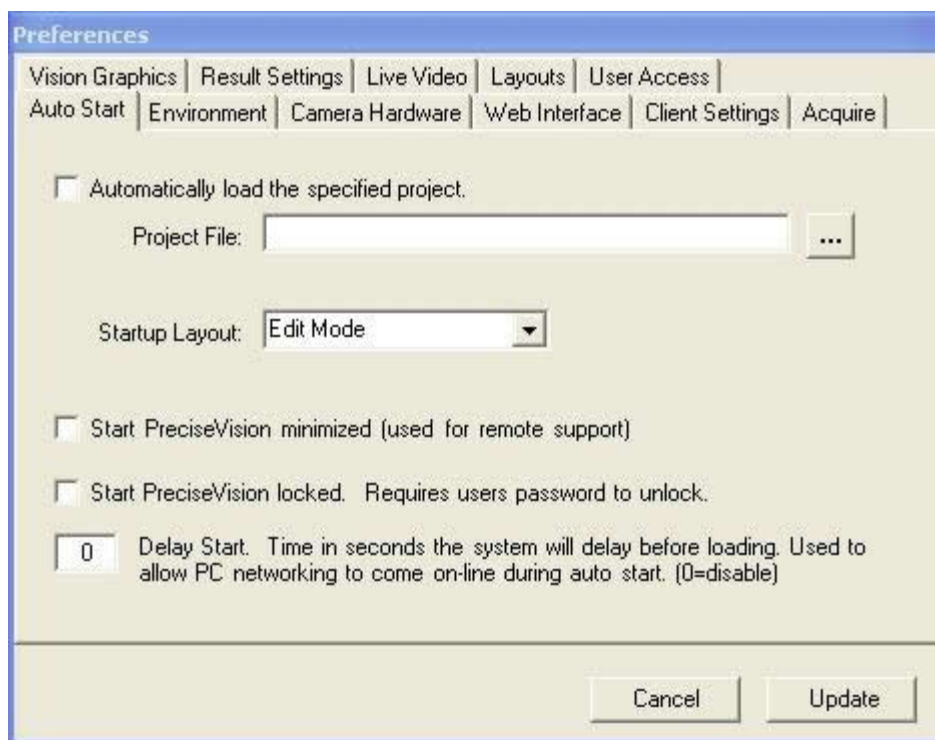
The information contained in each of the columns of the Status Bar is described in the following table.

Col #	Data	Description
1	Server status	Indicates Ethernet traffic between PreciseVision and a Guidance Controller. Each time a message is received, the icon will flicker.
2	Image status	Indicates if the selected camera is in "live video" mode (bright light bulb) or a single still image has been captured.
3	Camera calibration file	Displays the name of the camera calibration file for the currently selected camera.
4	Camera calibration type	Displays the type of camera calibration that is in effect for the currently selected camera, e.g. Camera Only, Robot Vision, etc.
5	Process execution time	Indicates the total time required to execute the last Vision Process in seconds.
7	Camera coordinates and intensity reading	Shows the X/Y position of the mouse cursor in calibrated camera coordinates and the gray-level intensity value of the associated camera image pixel. This is useful for setting threshold and edge level values.
8	Project modified flag	Indicates if the currently loaded Vision Project has been modified in any way and must be saved to the disk in order to preserve the changes.

Preferences Panel

The Preferences Panel contains a number of application setup parameters that customize the operation and appearance of PreciseVision. Once saved, these preferences are automatically reloaded and put into effect each time the application is restarted.

The Preference Panels appears as shown below.



When any data in the Preferences has been modified, the **"Update"** button must be pressed before the change will take effect and be preserved.

In the following table, the configuration information presented on each tab of this panel is briefly described.

Tab	Description
Acquire	Defines the default disk file path for storing camera images when an Acquisition Tool is executed. This is a debugging and diagnostics convenience for logging images.
Auto Start	<p>Specifies a Vision Project that will be automatically loaded each time PreciseVision is restarted. Once a Project is loaded, its Vision Processes are immediately available for execution by a GPL procedure executing on a Guidance Controller.</p> <p>This tab also contains the 'Startup Layout' specification. The specified layout will be automatically loaded each time PreciseVision is started. For production systems this would normally be set to the 'Run Mode' layout.</p> <p>Options are also provided to start up PreciseVision minimized and / or in a locked mode that prevents operators from making changes to the loaded processes. To set the lock password, see the User Access tab.</p> <p>A parameter is provided that will delay PreciseVision from starting execution for a specified number of seconds. This is beneficial if PreciseVision is automatically started when the PC boots up, but the PC requires time to initialize its network cards and camera</p>

	interfaces.
Camera Hardware	Specifies the type of camera hardware to be used to capture images, e.g. Ethernet or USB, and defines each camera's logical number. Some of the data specified on this panel and its sub-panels are specific to the type of camera being employed. Normally, these parameters are defined during the software and camera installation process. For more information on this panel, please see the Camera Installation sections of this manual for detailed information on configuring each type of supported camera.
Client Settings	Defines the Ethernet IP address for the Guidance Controller that is accessed during the camera calibration process. For normal operations, the controller IP address is automatically deduced from the commands that GPL sends to PreciseVision.
Environment	<p>Controls whether the Main Toolbar and the Status Bar are displayed. Also permits adjustment of some diagnostic and demonstration parameters.</p> <p>In addition, a checkbox is provided to permit PreciseVision to be minimized to an icon in the System Tray as opposed to an item on the Windows Start Bar.</p> <p>An "Auto Zoom" feature is also provided that automatically scales the active camera image to best fit within the camera display window.</p>
Layouts	<p>Defines three user-interface layouts of the dockable panels. These layouts provide an easy way to quickly switch between several display formats that are appropriate for different operating needs: production systems, editing sessions and calibration processes.</p> <p>If the "Layout Filename" is left blank, PreciseVision will automatically use a predefined default layout stored in the "Layout" folder of the installation directory. If the field contains a valid layout file, it will override these defaults.</p> <p>Click the "Current" button in each selection to record the size of the window (width and height) automatically.</p>
Live Video	<p>Controls the rate at which the camera image is updated in Live Video mode. This permits the Ethernet network traffic to be balanced when using PreciseVision.</p> <p>The update rate ranges from 1 to 30 frames per second (fps) with a default setting of 10. For cameras interfaced at 100Mb Ethernet, a rate of 1 to 15 fps is typical. For cameras interfaced at 1000Mb Ethernet, the refresh rate can be as high as 30 fps.</p> <p>This mode is NOT available for USB cameras. The frame rate is set to the maximum defined by the camera. Some USB cameras do not operate properly if the live frame rate is set to certain values.</p>
Result Settings	Enables the logging of Vision Tool Results to a disk log file for diagnostic purposes. Each time a tool is executed, its Results are time stamped and stored in a specified file in a comma delimited text format (*.csv). This file can be easily imported to Excel or another spreadsheet application for analysis.
User Access	Defines the password used to unlock access to PreciseVision.
Vision Graphics	Enables and disables the display of Vision Tools and their Results in

	the Camera Display Window. Drawing these graphics has relatively little impact on the performance of the system, so the graphics are normally displayed.
Web Interface	<p>Enables up to 3 web panels to be configured into the PV user interface as dockable controls. These panels can be utilized to integrate web pages of the Guidance Controller into the PV environment.</p> <p>Either the complete path for each web must be specified, e.g. "http://192.168.0.1/ROMDISK/web/Opr/master/masterfs.html" or just the path with the Client Guidance Controller without the Client's IP address, e.g. 'ROMDISK/web/Opr/master/masterfs.html'. In the latter case, the IP address of the Client Guidance Controller will be automatically assumed when displaying the panel.</p>

Vision Toolkit Description

Vision Toolkit Introduction

This chapter provides detailed information on each of the tools in the PreciseVision vision toolkit. These tools perform all of the runtime operations that are needed to acquire and process an image captured from a camera.

Each instance of a tool is a vision object with a graphical front-end, a property list for configuring the tool for your desired operation, and a read-only list of results properties that can be used by other vision objects to create more complex machine vision and logical operations. The graphical front-ends allow the vision tools to be easily positioned over a captured image and greatly simplifies their training.

ToolKit Summary

The following table briefly summarizes the primary function of each of the vision tools. The "Type" broadly categories each tool as to whether it "Acquires" an image, "Finds" an object, "Measures" features, "Inspects" a region, "Computes" additional information, "Filters" image or object data or serves as a "Motion Sensor". Please see the detailed descriptions on the following pages for more ways in which these tools can be utilized.

Vision Tool	Type	Description
Acquisition Tool	Acquires	Captures an image from a camera or loads it from a disk file, and stores the image into a frame buffer.
Arc Fitter Tool	Measures	Searches a specified region for arc edges and returns the arc that best fits the edges. Returns both the arc center point and radius.
Clear Grip Tool	Inspects	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.
Connectivity Tool	Finds	Searches a 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.
Edge Locator Tool	Measures	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.
Find Centerline Tool	Measures	Searches a specified region for edge points and returns the centerline between two located bounding lines.

<u>Find Point Tool</u>	Measures	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.
<u>Finder Tool</u>	Finds	Most powerful vision tool that identifies randomly placed parts in a camera image and returns their position, orientation and scaling to within sub-pixel accuracy.
<u>Fixed Frame Tool</u>	Computes	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.
<u>Image Process Tool</u>	Enhances image	Performs image filtering, edge extraction, thresholding and morphological operations on a specified area in the camera image.
<u>Inspect Frame Tool</u>	Computes	Passes through the XPos, YPos and Angle Results of a referenced tool and optionally rotates and shifts the Results based upon an inspection. The inspection can consist of the arithmetic combination of the Results of two other tools. So, this tool also provides a means for performing simple mathematical operations on the results of two tools.
<u>Inspect List Tool</u>	Computes	Passes through the XPos, YPos and Angle Results of a referenced tool and tests up to 12 different Results from multiple tools to determine if the object is good or bad. This tool provides a convenient way to perform complex testing of a located object and generating an equivalent location with a single Pass/Fail indicator.
<u>Inspect Region Tool</u>	Computes	Inspects the perimeter and the interior of an opaque object to determine if there are any flaws in the object's outline or holes in the interior. This tool was designed to inspect wafers, where slight changes in the overall size and shape of the wafer are permitted, but chips in the perimeter or interior holes or cracks are unacceptable.
<u>Line Fitter Tool</u>	Measures	Searches a specified region for edge points and returns the line that best fits the edges.
<u>Line-Line Frame Tool</u>	Computes	Determines the intersection of two lines defined by vision objects and returns a reference frame.
<u>Pixel Window Tool</u>	Inspects	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.
<u>Pixel Color Window Tool</u>	Inspects	Tests if the general color of a rectangular or circular region matches a trained color within a specified tolerance.
<u>Point-Line Frame Tool</u>	Computes	Takes a point and a line from two vision objects and returns a reference frame.

Point-Point Line Tool	Computes	Computes a line given two points from vision objects.
Sensor Window Tool	Motion sensor	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.
Text Label Tool	Labels	Displays string constants plus inspection and results data from a referenced tool. Text is shown relative to the position of the referenced tool.
Tool Filter Tool	Filters	Takes the output from another tool that generates multiple sets of results, and returns a subset of the results based upon specified criteria.

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 **Identity Properties** specify the name of the tool and its basic tool type.

1. Standard Identity Properties			
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. <i>In GPL, this is the name by which a tool is referenced.</i>
Type	String	n/a	This read-only property displays the basic type for the tool, e.g. VsLineFitter.

The **Placement / Size Properties** define the position, orientation and size of the tool in the coordinate system of the camera. In addition, if the tool is defined relative to another tool, the relative position and orientation can also be specified. 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 refers to the size of the portion of the camera image that is being analyzed.

2. Standard Placement/Size Properties			
Property Name	Data Type	Range	Description
Angle	Single	-360 to 360	These values specify the orientation (in degrees) and the position (in calibrated units, mm) 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.
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
Height	Single	0 - AOI (mm)	These values define the height and width of the vision tool in calibrated units (mm). 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 (mm)	
RelAngle	Single	-360 to 360	These values specify the orientation (in degrees) and the position (in calibrated units, mm) of the center of the vision tool relative to the vision object specified by RelativeToolName . If the vision tool is not relative to another vision object, these values are zero.
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	

The **Operation Properties** 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.

3. Standard Operation Properties			
Property Name	Data Type	Range	Description
Camera	Integer	1 - 6	Defines the number of the camera (and its associated frame buffer) on which the tool operates.
Relative-ToolName	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.
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The **Advanced Operation Properties** contain Operation Properties that are not normally modified and generally require a bit more experience to utilize. For these properties, their default settings will yield good tool performance for typical applications.

3A. Standard Advanced Operation Properties			
Property Name	Data Type	Range	Description

The **Inspection Settings Properties** permits 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.

4. Standard Inspection Settings Properties			
Property Name	Data Type	Range	Description
InspectType	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.
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	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.
InspectMax	Single		Maximum and minimum values permitted for the item specified in InspectType to "Pass" the inspection. Values outside of this range are marked as "Failed".
InspectMin	Single		
InspectActual	Single		This is a read-only property that indicates the value of the result specified by InspectType that was tested during the inspection. <u>[GPL: VisResult.InspectActual]</u>
InspectPassed	List	Pass / Fail	Indicates if the inspection criteria was satisfied (Pass) or was not (Fail). Set to 'Pass' if no inspection is selected. If the inspection fails, any tool that

			references this tool, for example via the RelativeToolName property, will also have a failed <code>InspectPassed</code> although that tool will still be evaluated. <i>[GPL: VisResult.InspectPassed]</i>
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The **Results Settings Properties** 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**.

5. Standard Results Settings Properties			
Property Name	Data Type	Range	Description
MaxResults	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.
OffsetAngle	Single	degrees	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). See the Fixed Frame Tool for an alternate method for implementing this offset.
OffsetX	Single	mm	
OffsetY	Single	mm	
ResultSelect	Integer	1 - n	For tools that return more than one set of results, this property selects the set of results that is displayed in the Results Properties . This does not affect the actual results of the tool.
ShowResults	List	NONE / POINT / LINE / FRAME	Alters how the results of a tool is 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.

The **Results Properties** display a single set of results for the vision tool. In general, the results returned varies from tool to tool. Many tools return a vision reference frame. However, some tools return additional results items such as statistical information on how well the answer fits the actual data. If the tool computes more than one set of results and

MaxResults is set to greater than 1, the displayed set of results will correspond to the setting of the **ResultSelect** property.

6. Results Properties			
Property Name	Data Type	Range	Description
ResultCount	Integer	0 - n	Number of sets of results the vision tool has returned. <i>[GPL: Vision.ResultCount]</i>
ResultErrorCode	Integer		Standard error code that indicates if the tool executed without an error. This is different from the InspectPassed , which indicates if the result was computed properly but its value was inside or outside of a specified limit. If ResultErrorCode is non-zero, any tool that references this tool, for example via the RelativeToolName property, will also fail with this same error code and will not be evaluated. <i>[GPL: VisResult.ErrorCode]</i>
ResultAngle	Single	-360 to 360	Orientation (in degrees) and position (in calibrated units, mm) of the center of the results computed by the vision tool in the coordinates of the vision image taking into consideration the value of the Offset's in the Results Settings Properties . For robot guidance applications, these values are transformed by the vision-to-robot calibration conversion routines and then presented as <i>[GPL: VisResult.Loc.X, VisResult.Loc.Y and VisResult.Loc.Roll]</i> .
ResultXPos	Single	mm	
ResultYPos	Single	mm	

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.

Prerequisites

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
GainBlue	Single	0-12 (set to -1 if not a color camera)	These properties scale the intensity values for each of the three color layers as they are read from the camera. This permits the color intensities to be balanced.
GainGreen	Single		
GainRed	Single		
3A. Advanced Operation			
AcquireBufferImage	Boolean	True / False	If True, a copy of the image is stored into a secondary buffer when the image is acquired. This must be set True if the original image is to be restored by a subsequent Acquisition tool that has its AcquireMode set to "RESTORE_ORIGINAL". For resolutions greater than 640x480, setting this value to False, if not needed, can save a few milliseconds of execution time. Set False by default.
AcquireMode	List	NORMAL_ACQUIRE / ACQUIRE_AND_SAVE / PLAY_FROM_DISK / LIVE_VIDEO / SAVE_ONLY / RESTORE_ORIGINAL	"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

			<p>saves the image to a disk file.</p> <p>"PLAY_FROM_DISK" - restores an image from a disk file. The disk file is specified by the AcquirePath and AcquirePrefix (see below). If there are multiple numbered image files with the same prefix, each time the Vision Process is executed, the contents of the next sequential file will be copied to the image buffer.</p> <p>"LIVE_VIDEO" - continuously updates the vision display with the latest image from the camera. This is a system setup mode that facilitates setting the camera f-stop, focus, VideoGain, and VideoOffset.</p> <p>"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 access.</p> <p>"RESTORE_ORIGINAL" - restores the contents of the current frame buffer to its original value at the time that the image was first captured. Requires that AcquireBufferImage is set to True when the image is first captured.</p>
AcquirePath	String	n/a	<p>String that defines the path to the disk file when AcquireMode is set to "ACQUIRE_AND_SAVE" or "PLAY_FROM_DISK". If blank (""), the path defined in the Preferences will be used. If the path does not contain a ':' (i.e. C:\...), AcquirePath will be appended to the path where the PreciseVision application is stored, e.g. "C:\Program Files\Precise Automation\PreciseVision #.#"</p>
AcquirePrefix	String	n/a	<p>String that defines the disk file name (excluding the required .BMP extension) when AcquireMode is set to "ACQUIRE_AND_SAVE" or "PLAY_FROM_DISK". If blank</p>

			(""), the file name defined in the Preferences will be used. This string is combined with AcquirePath, a numerical index, and the ".BMP" file extension to generate the disk file name for saving or loading vision images.
ActiveLayer	List	Monochrome / RedLayer / GreenLayer / BlueLayer	<p>Specifies the type of data to be loaded into the image frame buffer for processing by subsequent vision tools.</p> <p>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.</p> <p>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 "RedLayer" 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 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 ActiveLayer property.</p>
ImageFile	String	n/a	Read-only string that displays the currently selected vision image file. This value is only displayed when the AcquireMode is set to "PLAY_FROM_DISK".
LoadFirstImage	Boolean	True / False	This is a convenience feature for setting the display of a sequence of images back to the first image and is only valid during the "PLAY_FROM_DISK" mode. That is, when this property is set

			to TRUE, the disk file that satisfies AcquirePath and AcquirePrefix and has the lowest index values will be loaded into the image buffer.
4A. Dalsa Genie Camera			
ExposureTime	Single		Time, in milliseconds, that the camera will integrate light on its imaging sensor. The longer the time, the more light is collected and the brighter the image. However, this will also lengthen the time required for the image acquisition. This parameter may not be supported on all hardware configurations.
TriggerEnable	Boolean	True / False	If this property is True, the image capture is delayed until a digital input signal is received by the camera.
TriggerTimeout	Integer	1 - 30	If TriggerEnable is True, this property specifies the time in seconds that the system will wait for the trigger to occur before an error is generated (-4019 Vision Process Failed).
VideoGain	Integer	0.5 - 2.0	The VideoGain and VideoOffset scale and shift the grayscale value of each pixel as it is read in from the camera. This allows a narrow range of brightness values to be expanded to span the entire 256 grayscale value range.
VideoOffset	Integer	-127 - 127	

Remarks

This tool performs the basic image capture operation from a color or monochrome camera and stores the image in a frame buffer. Consequently, this tool is normally the first tool in each Vision Process.

Multiple cameras can be accessed by this tool and their gains and offsets can be controlled to optimize the brightness range for the field of view. To facilitate setting up a camera's gain, offset, focus, and f-stop, the camera image can also be continuously acquired and displayed in the Camera Display Window.

Normally, when this tool is executed, a camera image is immediately captured. However, if **TriggerEnable** is True, executing this tool primes an image capture, but the picture is not immediately taken. The image capture is delayed until a digital signal, which is directly connected to the camera, is asserted. For applications where the timing of the image capture relative to an external event is critical, trigger mode can significantly reduce latency and jitter. As a debugging convenience, if a Vision Process is manually executed using the PreciseVision GUI and the process contains an **Acquisition** that has triggering enabled, a pop-up is display to confirm if the camera should wait for an external

trigger or if the picture should be taken immediately. This pop-up is not displayed if the Vision Process is remotely initiated from a Guidance Controller.

Camera triggering is not supported on all cameras. Please consult your camera's hardware documentation for specific information on whether it supports external triggering and how this is implemented. For example, with Dalsa cameras, hardware signal #1 is a sinking input that must be pulled low to the camera's ground to trigger a frame capture.

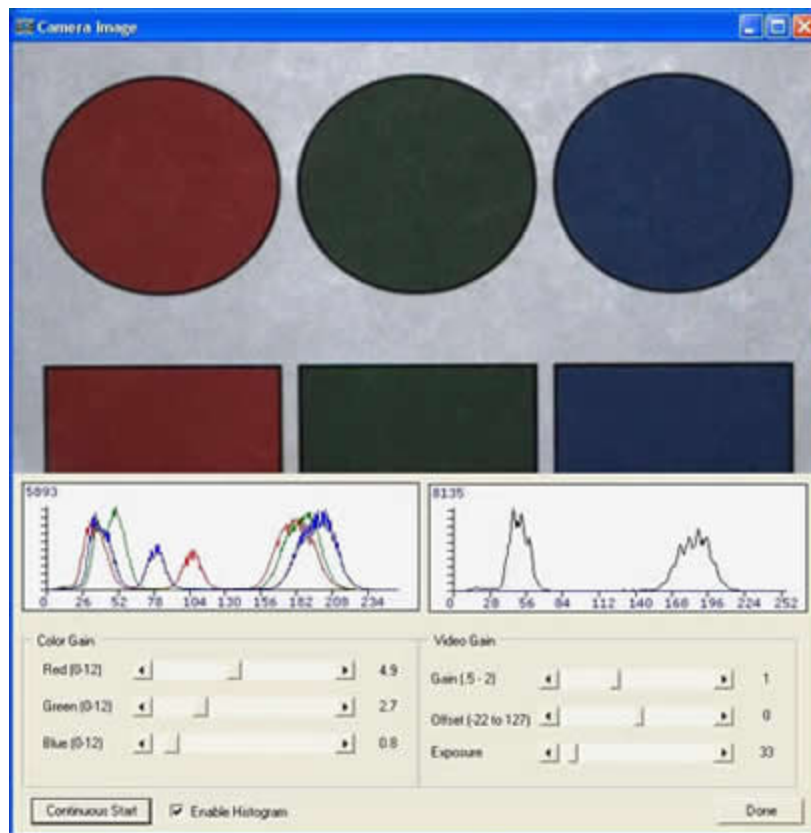
Most vision tools analyze the data that is stored in a frame buffer by an Acquisition tool, generate results, and leave the frame buffer unmodified. However, if an "Image Process" tool is executed (e.g. a low pass filter), the data stored in the frame buffer is altered so that all subsequent tools operate on the modified image data. In these cases, it is sometimes convenient to restore the original contents of the frame buffer. This can be done by executing an Acquisition Tool with the **AcquireMode** set to "RESTORE_ORIGINAL". This operation restores the original image data from an in-memory buffer, and is therefore much faster than storing an image to a file and then reloading. In order for this mode to operate properly, the original Acquisition tool must have its **AcquireBufferImage** property set to True. When this property is true, a copy of the camera image is generated in memory when the acquisition is performed.

As both a demonstration feature and as 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 **AcquireMode** 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 **AcquirePath** with the **AcquirePrefix** and an optional numerical index followed by the .BMP 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.

Special Feature Buttons (located above the property editor)

Adjust Video Properties

Pressing this button displays a pop-up window that permits the property values for the monochrome image (**VideoGain**, **VideoOffset**, **ExposureTime**) and the color image (**GainRed**, **GainGreen**, **GainBlue**) to be manually adjusted while dynamically viewing the effect of the new settings. In addition, histograms of the various values can be simultaneously displayed.



Select Acquire Path

Pressing this button displays a pop-up window that permits you to browse the PC's file structure to select the **AcquirePath** that specifies where image disk files are to be stored and retrieved.

Examples

If the **AcquireMode** is set to "PLAY_FROM_DISK", and the **AcquirePath** is set to "ExampleProjects", and the **AcquirePrefix** is set to "part2", and the folder that contains the PreciseVision application contains a folder "ExampleProjects" that has the following files:

part2_0001.bmp, part2_0002.bmp, part2_0003.bmp

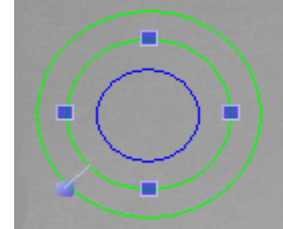
Then, each time that the **Acquisition Tool** is executed, it will load the next successive file in the list above and will restart when it encounters the end of the list.

See Also

[Vision Toolkit](#) | [Sensor Window Tool](#)

Arc Fitter Tool

Vision tool that searches a specified region for arc edge points and returns the circle or arc that best fits the edges.



Prerequisites

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	-360 to 360	Standard Placement / Size properties. The X and Y values define the center of the tool and the center of the search region.
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	-360 to 360	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
Radius	Single	mm	Specifies the nominal radius of the arc or circle to be located. This defines the mid-range value for the radius search.
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
AngularSize	Integer	0-360	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.
DarkOutside	Boolean	True / False	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.
EdgeThreshold	Integer	0 - 254	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 Locator for more information on edge gradients. The default value is 30.
FindWhat	List	FITARC_FIND_CENTER / FITARC_FIND_RADIUS / FITARC_FIND_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.
SearchRadiusRange	Single	mm	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.
UseWhichEdge	List	FITARC_MIDDLE_EDGES / FITARC_INNER_EDGES / FITARC_OUTER_EDGES / FITARC_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).
3A. Advanced Operation			

DrawEdgePoints	List	..._NO_EDGE_POINTS / ..._ALL_EDGE_POINTS / ..._USED_EDGE_POINTS	If set, draws yellow dots to indicate ALL edge points that are selected after the EdgeMode is applied or only those edges that are USED to fit arcs after the EdgeMode is applied and all outliers are eliminated. This is very helpful for understanding the effect of changing various property settings. This value is NO_EDGE_POINTS by default.
MaxEdgePoints	Integer	3 - n	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. The default value is 30.
MaxIterations	Integer	0 - n	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. The default value is 5.
MinFilterDistance	Single	0 - n.nn	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. The default value is 1.
SigmaFilter	Single	0 - n.nn	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. The default value is 1.5.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	
InspectType	List	NONE / ..._RMS / ..._RADIUS / ..._NUM_EDGES_FOUND / ...NUM_EDGES_USED	
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
OffsetAngle	Single	degrees	Standard Results Settings properties
OffsetX	Single	mm	
OffsetY	Single	mm	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultErrorCode	Integer		Standard Results properties
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	
ResultNum-EdgesFound	Integer		Number of edge points found. <i>[GPL: VisResult.Info(1)]</i>
ResultNum-EdgesUsed	Integer		Number of edge points remaining after the filtering process. <i>[GPL: VisResult.Info(2)]</i>
ResultRadiusFound	Single		Radius of the located arc in mm. <i>[GPL: VisResult.Info(4)]</i>
ResultRMS	Single		Root mean square of the arc fit. <i>[GPL: VisResult.Info(0)]</i>

Remarks

The Arc Fitter searches the region defined by its green and blue outlined arc 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.

In order to make this tool more discriminating, the Arc Fitter only utilizes edges whose dark and light sides have roughly the same orientation as the dark (blue) and light (green) sides of the search area. 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 blue side on the anticipated dark side of the object. To aid in this operation, there is an 'Auto Size / Position' feature button above the property editor. This button will analyze the coarse position of the tool and snap it to the nearest arc/circle. The radius search range is automatically adjusted as well.

The operation of this tool is basically 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 **MaxEdgePoints**. 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 **MaxEdgePoints**. On the other hand, the accuracy of the tools increases approximately as the square root of **MaxEdgePoints**. That is, if you increase **MaxEdgePoints** 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. **MaxIterations** specifies the maximum number of fits to perform. After each arc fit, edges that are beyond **SigmaFilter** standard deviations are rejected, unless the edge is within **MinFilterDistance** pixels of the fit arc. The iterative process stops if (1) **MaxIterations** 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.

Special Feature Buttons (located above the property editor)

Adjust Edge Threshold

Pressing this button displays a pop-up window that permits the value of the **Edge Threshold** property to be manually adjusted while dynamically viewing the effect of the new setting in the Camera Display. The display indicates the edges that satisfy the threshold criterion in white.

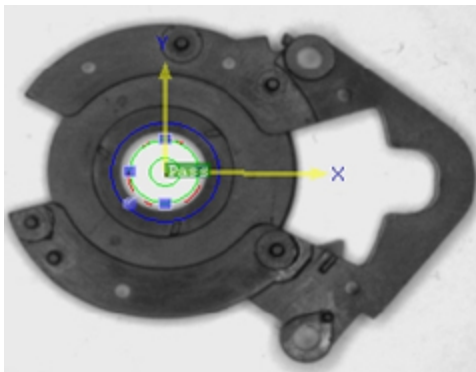
PreciseVision

Auto Size / Position

Provides an easy way to position the tool. This button will compute the currently found arc/circle and automatically snap the tool to the exact coordinates of the found arc/circle. In addition the radius search range is adjusted proportionally to the arc/circle size.

Examples

In the following example, an Arc Fitter is utilized to accurately determine the position of a hole within an object. The best fit radius of the hole is computed and the resultant is compared to the acceptable range of values to generate a pass/fail inspection result.

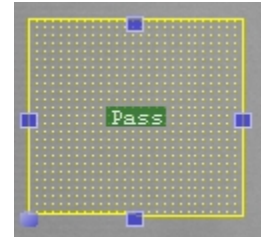


See Also

[Vision Toolkit](#) | [Edge Locator](#) | [Line Fitter](#)

Clear Grip Tool

Vision tool that verifies that there is no obstruction within the bounds of a defined window. This tool is typically used to confirm that gripping a part will not result in a collision.



Prerequisites

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	-360 to 360	Standard Placement / Size properties. The X and Y values define the center of the verification window. The Height and Width define the dimensions of the window.
Height	Single	0 - AOI (mm)	
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	-360 to 360	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
EdgeThreshold	Integer	0 - 254	Specifies the threshold below which weak (low contrast) gradients edges are ignored. The smaller the number, the more sensitive the system is in locating edges. Please see the description of the Edge Locator for more information on edge gradients. The default value is 30.
4. Inspection Settings			

InspectActual	Single		Standard Inspection Settings properties
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	
InspectType	List	NONE / EDGE_COUNT	
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
ShowResults	List	NONE / FRAME / LINE / POINT	Standard Results Settings properties
6. Results			
ResultErrorCode	Integer		Standard Results properties
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	
ResultEdgeCount	Integer		Number of edge pixels found. <i>[GPL: VisResult.Info(0)]</i>
ResultTotalArea	Integer		Total number of pixels in the tested rectangular region. <i>[GPL: VisResult.Info(1)]</i>

Remarks

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. a 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 **InspectType** to EdgeCount, if the number of edges falls outside of the **InspectMax** and **InspectMin** limits, this tool will signal a failure.

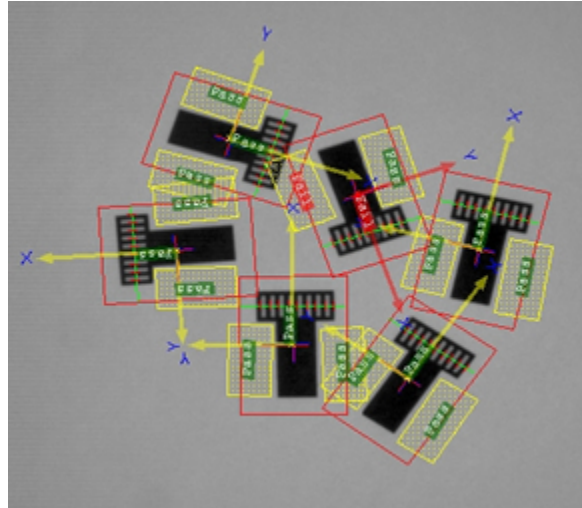
Special Feature Buttons (located above the property editor)

Adjust Edge Threshold

Pressing this button displays a pop-up window that permits the value of the **Edge Threshold** property to be manually adjusted while dynamically viewing the effect of the new setting in the Camera Display. The display indicates the edges that satisfy the threshold criterion in white.

Examples

In the following example, the Clear Grip tool is used to test if randomly oriented and positioned parts can be safely grasped. As each part is located by a Finder, two Clear Grips tools are tested, one on each side of the part. If the grip zone does not contain a portion of another part, the zone is marked as passed. However, in the sample picture, one zone in the center of the image is partially occluded by another part and that zone is marked as failed. This would prevent the robot from attempting to pick up the part in the center and potentially damaging the adjacent part or the gripper.

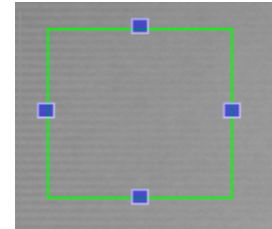


See Also

[Vision Toolkit](#) | [Finder Tool](#)

Connectivity (Blob) Tool

Vision tool that 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 a located blob.



Prerequisites

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	0 (<i>non-rotating</i>)	Standard Placement / Size properties . The X and Y values define the center of the tool and the center of the search region. The Height and Width specify the size of the search region.
Height	Single	0 - AOI (mm)	
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	0	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
MaxArea	Integer	0 - n	Specifies the maximum number of pixels that a valid blob can contain. Any blob that consists of a greater number of pixels will be ignored.
MinArea	Integer	0 - n	Specifies the minimum number of pixels that a valid blob must contain.

			Any blob that consists of a smaller number of pixels will be ignored.
ObjectColor	List	DARK_OBJECT / LIGHT_OBJECT	After the image area is converted to binary, defines whether connected groups of black or white pixels should be considered as blobs.
Threshold	Integer	0 - 254	Specifies the threshold below which gray-scale pixels will be set to black and above which pixels will be set to white. When this tool is created, the system will automatically set this property to a reasonable value for the full vision window. This value can also be updated using the special feature button described below.
3A. Advanced Operation			
MinHoleArea	Integer	0 - n	Minimum number of pixels required before a hole in a blob is retained and not filled in. If this property is set to 1 (default), all holes are included in blobs regardless of their size. If this value is set to the total area of the image, holes will always be deleted.
SampleRate	Integer	0 - n	When the tool is set to return PERIMETER information, this property 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.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	

InspectType	List	NONE / ..._RMS / ..._ANGLE / ..._NUM_EDGES_FOUND / ..._NUM_EDGES_USED	
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
MaxResults	Integer	-1 or 1 to n	Standard Results Settings properties. MaxResults defines the number of blobs or perimeter points to find each time this tool is executed. By default, this property is set to -1, find all possible blobs or perimeter points. See below for a description of ResultMode .
OffsetAngle	Single	degrees	
OffsetX	Single	mm	
OffsetY	Single	mm	
ResultMode	List	BLOB_CENTER / MIN_RADIUS / MAX_RADIUS / MAJOR_AXIS / MINOR_AXIS / PERIMETER	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultCount	Integer	0 - n	Standard Results properties ResultCount indicates the number of blobs located in non-PERIMETER mode. In PERIMETER mode, this is sum of all perimeter points found for all blobs.
ResultErrorCode	Integer		
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	
ResultBlobArea	Integer	pixels	Total area of the blob in pixels excluding any holes within the blob. <i>[GPL: VisResult.Info(3)]</i>
ResultNumPerBlobs	Integer	0 - n	For PERIMETER mode, this is the total number of blobs located and ResultCount indicates the sum of all perimeter points available. For non-PERIMETER mode, this value is undefined and ResultCount indicates the total number of blobs located. <i>[GPL: VisResult.Info(2)]</i>
ResultObjectIdx	Integer		Each blob in a region is assigned an index. In PERIMETER mode, each

			returned <i>VisResult</i> represents a single perimeter point. If multiple blobs are located, this property can be monitored to determine when the perimeter points pertain to the next blob. <u>[GPL: <i>VisResult.Info(0)</i>]</u>
ResultMajorAxisAngle	Single	-360 to 360	Angle <u>[GPL: <i>VisResult.Info(8)</i>]</u> and Length <u>[GPL: <i>VisResult.Info(9)</i>]</u> of the major axis of the best fit ellipse for the blob. This axis provides a means for characterizing the orientation of an arbitrary shape unambiguously within +90 degrees. By definition, this ellipse has the same 2nd moments of inertia as the blob.
ResultMajorAxisLength	Single	mm	
ResultMinorAxisAngle	Single	-360 to 360	Angle <u>[GPL: <i>VisResult.Info(10)</i>]</u> and Length <u>[GPL: <i>VisResult.Info(11)</i>]</u> of the minor axis of the best fit ellipse for the blob. This axis provides a means for characterizing the orientation of an arbitrary shape unambiguously within +90 degrees. By definition, this ellipse has the same 2nd moments of inertia as the blob.
ResultMinorAxisLength	Single	mm	
ResultMaxRadiusAngle	Single	-360 to 360	Angle <u>[GPL: <i>VisResult.Info(6)</i>]</u> and Length <u>[GPL: <i>VisResult.Info(7)</i>]</u> 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. This provides a means for characterizing the orientation of an arbitrary shape. However, the uniqueness of this radial line is a function of the shape.
ResultMaxRadiusLength	Single	mm	

ResultMinRadiusAngle	Single	-360 to 360	Angle [GPL: VisResult.Info(4)] and Length [GPL: VisResult.Info(5)] 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. This provides a means for characterizing the orientation of an arbitrary shape. However, the uniqueness of this radial line is a function of the shape.
ResultMinRadiusLength	Single	mm	

Remarks

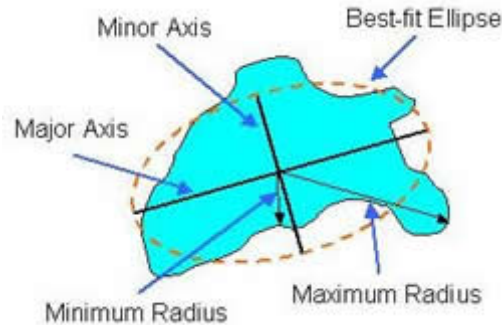
The Connectivity tool converts the region defined by its green outlined rectangle to a binary image and groups adjacent ("connected") pixels with the correct **ObjectColor** into blobs. Any blobs that do not satisfy the specified size limits as well as any interior blobs (i.e. blobs within blobs) are 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 is similar to the Finder Tool in that multiple objects can be identified and located. However, this is a less discriminating and less powerful tool than the Finder, but it is nonetheless very useful. In particular, Connectivity 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. This perimeter retrieval feature allows an application to easily trace an object, which is useful in the textile or automated cutting industries.

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 Finder Tool should be utilized in place of Connectivity.

With regard to the performance of the Connectivity 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.



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 **ResultMaxRadiusAngle** 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 (**ResultMajorAxisAngle**) can provide a very good orientation estimation. But, it should be kept in mind that this parameter always has a 180 degree ambiguity due to the symmetry of an ellipse.

The **ResultMode** 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 **ResultMode** 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 & 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 **SampleRate** specifies if some pixels on the perimeter are to be skipped. For example, if the **SampleRate** 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 **ResultObjectIdx** 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 **ResultObjectIdx** set to a value of 2.

Special Feature Buttons (located above the property editor)

Automatic Threshold

The Connectivity tool operates on a thresholded binary image. This requires a specific gray level to be entered in the **Threshold** property to define which pixels are to be converted to black (below the **Threshold**) and white (above the **Threshold**). To help set this value, there is an "Automatic Threshold" button available above the property editor. When this button is pressed, the **Threshold** property is automatically set to the system's best estimate for the tool's search region.

If the **Threshold** is properly set, a thin red boundary should will be drawn along the perimeter of each located object. If required, manually adjust the **Threshold** value to ensure the displayed red boundary is properly aligned with the object boundary.

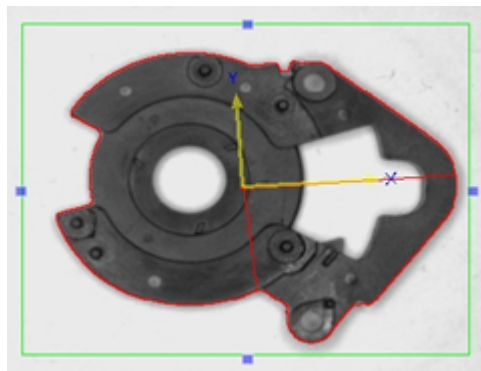
Adjust Threshold

PreciseVision

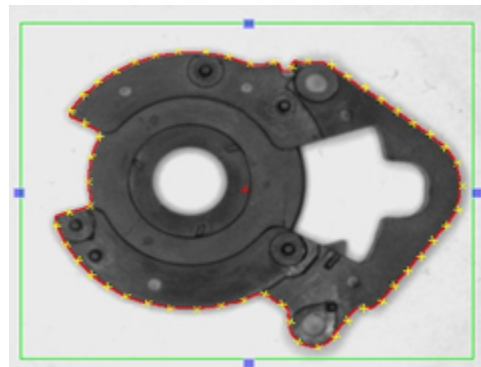
Pressing this button displays a pop-up window that permits the value of the **Threshold** property to be manually adjusted while dynamically viewing the effect of the new setting in the Camera Display. The displayed image shows all pixels converted to black or white, where the white pixels are the ones that are above the threshold.

Examples

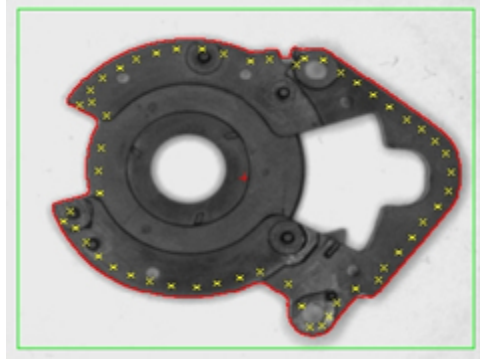
In the following example, a single part is located using a Connectivity (blob) tool. The maximum radius is used to determine the orientation of the part (**ResultMode** set to MAX_RADIUS). The red outline illustrates the perimeter of the object as computed by the tool. The intersection of the X and Y axes denotes the computed centroid of the blob. The X-axis is aligned with the radial line to the perimeter point that is furthest away from the centroid. For this part, the maximum radius point yields a unique orientation angle for the object.



In the following example, the **ResultMode** is set to PERIMETER and the Connectivity tool returns the locations of the points along the perimeter of the object. In this example, the **SampleRate** has been set to 20, so a yellow "X" is drawn every 20 pixels along the perimeter representing each of the returned values.



In this following example, a Fixed Frame tool has been added to the vision process. The Fixed Frame has its **RelativeToolName** set to the name of the Connectivity tool. The Connectivity tool is once again set into PERIMETER mode. Since the orientation of each of the perimeter results is perpendicular to the perimeter of the blob, the Fixed Frame can be used to create a series of points that are a fixed distance inside of the boundary of the blob. In the picture below, the display of the blob perimeter points has been turned off and the position of each Fixed Frame is being displayed as a yellow "X".

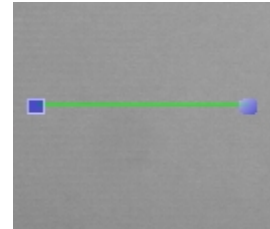


See Also

[Vision Toolkit](#) | [Finder](#)

Edge Locator Tool

Vision tool that 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

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	-360 to 360	Standard Placement / Size properties. The X and Y values define the center of the tool.
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	-360 to 360	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
Length	Single	0 - AOI (mm)	Defines the length of the linear path that is tested for edges.
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
EdgeThreshold	Integer	0 - 254	Specifies the gray scale threshold value used to detect edges or (in the case of gradient values) the threshold for the rate of change of the gray scale values. The smaller the number, the more sensitive the system is in locating edges. The default value is 30.
3A. Advanced Operation			

DesiredAlg	List	EDGE_BINARY / EDGE_GRAYTHRES / EDGE_SUBPIX / EDGE_HIGH- PRECISION_SUBPIX	<p>EDGE_BINARY: identifies edge transitions in a binary image.</p> <p>EDGE_GRAYTHRESH: identifies an edge position whenever the gray scale value crosses a specified threshold value.</p> <p>EDGE_SUBPIX: 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.</p> <p>EDGE_HIGH_PRECISION_SUBPIX: 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.</p>
DesiredGrads	List	EDGE_ALLGRADS / EDGE_POSGRADS / EDGE_NEGGRADS	This parameter specifies whether all edges are to be detected (EDGE_ALLGRADS) or only edges that occur when the gray scale value goes from dark-to-light (EDGE_POSGRADS) or only edges when the gray scale value goes from light-to-dark (EDGE_NEGGRADS). 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.
MaxEdgePoints	Integer	1 - n	Maximum number of edge points to return.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties.
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	All of the inspected results should be self explanatory except perhaps the "GRAY_...", which test the average or

InspectType	List	NONE / NUMBER_OF_POINTS / DISTANCE_TO_- FIRST_POINT / DISTANCE_TO_- LAST_POINT / DISTANCE_TO_- MID_POINT / DISTANCE_FROM_- FIRST_TO_LAST / GRAY_AVERAGE / GRAY_MIN / GRAY_MAX	min/max grayscale values along the length of the entire tool.
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
MaxResults	Integer	-1 or 1 to n	Standard Results Settings properties
OffsetAngle	Single	degrees	
OffsetX	Single	mm	
OffsetY	Single	mm	
ResultSelect	Integer	1 - n	
ShowResults	List	NONE / FRAME / LINE / POINT	
ResultMode	List	RESULT_EDGE_POINTS / RESULT_FIRST_POINT / RESULT_LAST_POINT / RESULT_MID_POINT / RESULT_PASS_- THRU_SOURCE / RESULT_HISTOGRAM / RESULT_GRAYLEVEL	<p>Defines whether all edge points or selected edge points are to be returned in the results.</p> <p>The "RESULT_PASS_THRU_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 Locators after it has computed the position of a part and use the Locators to perform additional visual verification tests, but still have the process return the "Results" location of the parent tool. Please see the "PassFailEdgeCount" demonstration program that was shipped with PreciseVision for an example of the use of this feature.</p> <p>The "RESULT_GRAYLEVEL" and "RESULT_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.</p>

6. Results			
ResultCount	Integer	0 - n	Standard Results properties
ResultErrorCode	Integer		
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	

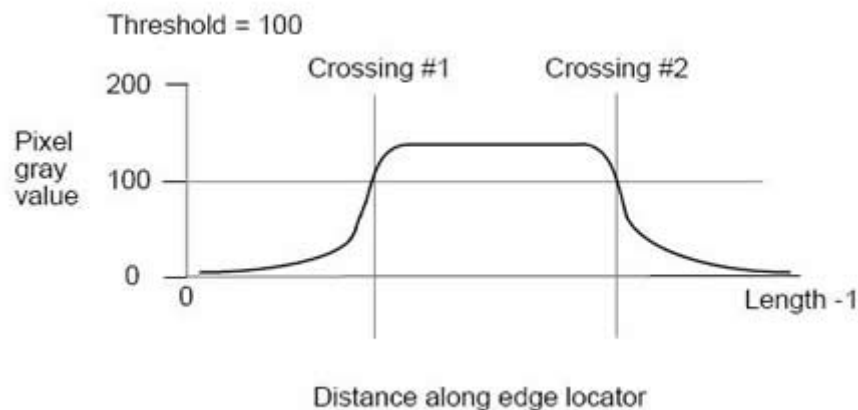
Remarks

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

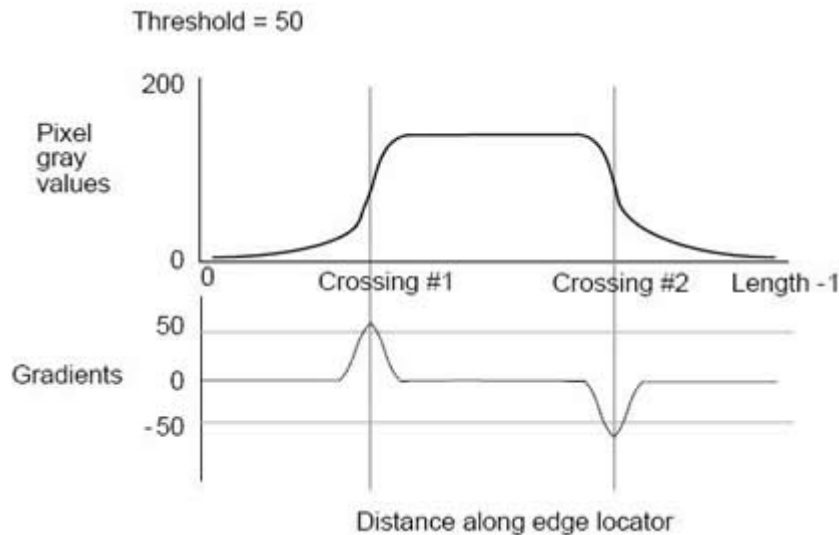
When locating edge points, this tool operates by analyzing pixels along the specified line. Processing starts at the square resizing handle and ends at the round rotation handle. In cases where you wish to compute the position of a single straight or smoothly curved edge, the Line Fitter and Arc Fitter tools will yield more accurate results because they compute an edge position utilizing many more pixel values.

The primary mode of operation for this tool is specified by the **Desired Alg** property. If this parameter is set to "EDGE_GRAYTHRESH", an edge is detected whenever the gray scale value crosses the threshold specified by **EdgeThreshold**. The graph below shows a typical example of how the gray scale values might appear along the length of an Edge Locator. 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 Alg** property is set to "EDGE_SUBPIX", 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 Locator. 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 Alg** is set to "EDGE_HIGH_PRECISION_SUBPIX", a higher-resolution sub-pixel position is computed than the "EDGE_SUBPIX" method 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 Locator.

Finally, if **Desired Alg** is set to "EDGE_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 **ResultMode** 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 **ResultMode** is set to "RESULT_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. This array of results is also displayed in the Vision Results panel of the PV user interface in the "Special Results" section and can be recorded if "logging" is enabled.

Whenever this mode is selected, the **ResultXPos** and **ResultYPos** properties represent the center of the specified line and can be used to further propagate the vision tree.

Returning Grayscale Values

If the **ResultMode** is set to "RESULT_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. This array of results is also displayed in the Vision Results panel of the PV user interface in the "Special Results" section and can be recorded if "logging" is enabled.

Whenever this mode is selected, the **ResultXPos** and **ResultYPos** properties represent the center of the specified line and can be used to further propagate the vision tree.

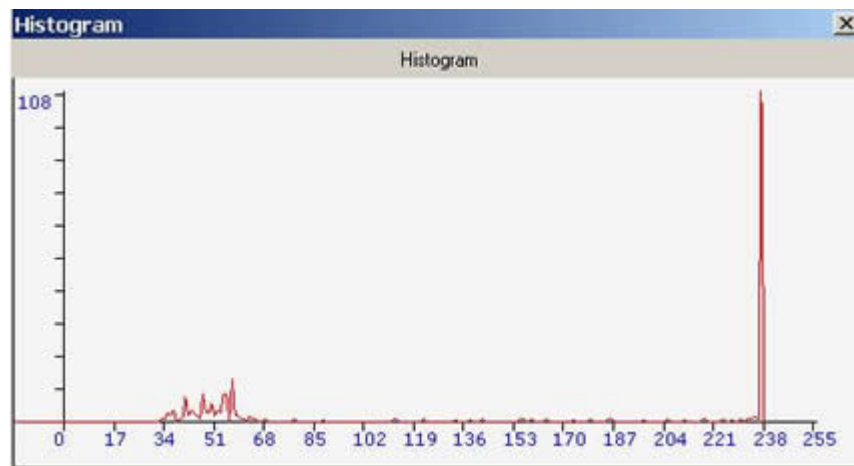
Special Feature Buttons (located above the property editor)

Adjust Threshold

Pressing this button displays a pop-up window that permits the value of the **Edge Threshold** property to be manually adjusted while dynamically viewing the effect of the new setting in the Camera Display. If the **DesiredAlg** mode is "EDGE_BINARY", the display illustrates the pixels above the threshold as white. Otherwise, for the grayscale modes, the display indicates the edges that satisfy the threshold criterion in white.

Show Histogram

If "RESULT_HISTOGRAM" mode is selected, this button will pop-up a window that displays the histogram for the specified line in the current image. A sample graph is shown below. This graph corresponds to the tool placement described in the Example below. You will note the large number of white pixels with grayscale values around 238 and a distribution of dark pixels with grayscale values between 34 and 68.

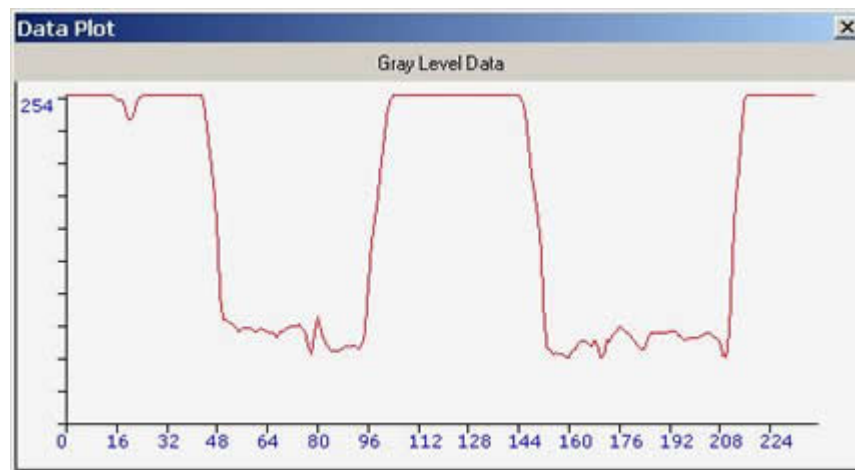


Show Gray Level

If "RESULT_GRAYLEVEL" mode is selected, this button will pop-up a window that displays the grayscale levels for each pixel along the specified line in the current image. A sample graph is shown below. This graph corresponds to the tool placement described in the Example

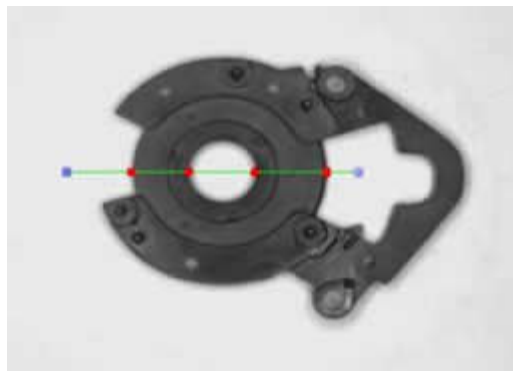
PreciseVision

below. Note the low intensity values for the pixels that correspond to the black sections of the object.



Examples

In the following example, an edge locator starts on the left of the image (at the square resizing handle) and processes moving to the right (towards the round rotation handle). In this case, four edges are detected and can be utilized to measure the diameter of the center hole and the thickness of the two sides. (Note, an Arc Fitter could have been used to determine the diameter of the center hole and would have resulted in a more accurate measurement.)

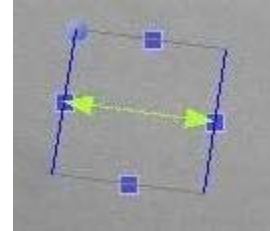


See Also

[Vision Toolkit](#) | [Arc Fitter](#) | [Find Point](#) | [Line Fitter](#)

Find Centerline Tool

Vision tool that searches a specified region for edge points and returns the centerline between two located bounding lines.



Prerequisites

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	-360 to 360	Standard Placement / Size properties. The X and Y values define the center of the tool and the center of the search region. The Height and Width specify the size of the search region.
Height	Single	0 - AOI (mm)	
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	-360 to 360	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
EdgeMode	List	..._NEAREST_DARK / ..._NEAREST_NOMINAL / ..._NEAREST_LIGHT / ..._MAX_GRADIENTS / ..._MAX_CONCENTRATION	If several possible lines exist within the search region, this parameter helps to distinguish which two are selected as the bounding lines. In addition to selecting the lines closest to the dark sides, light sides, nominal (center line), or greatest concentration of

			<p>edges, you can also select the lines with the highest contrast.</p> <p>The concentration mode is particularly useful if there are two or more distinct non-collinear groups of edges per possible boundary line and a boundary line is attempting to span multiple groups. If concentration mode is specified, for each bounding line, this tool will select the largest cohesive group of edges as the basis for fitting the line.</p>
EdgeThreshold	Integer	0 - 254	<p>Specifies the threshold below which weak (low contrast) gradients edges are ignored. The smaller the number, the more sensitive the system is in locating edges. Please see the description of the Edge Locator for more information on edge gradients. The default value is 30.</p>
3A. Advanced Operation			
BiasFilter	List	..._BIAS_NONE / ..._BIAS_TO_LIGHT / ..._BIAS_TO_DARK	<p>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.</p>
DrawEdgePoints	List	..._NO_EDGE_POINTS / ..._ALL_EDGE_POINTS / ..._USED_EDGE_POINTS	<p>If set, draws yellow dots to indicate ALL edge points that are selected after the EdgeMode is applied or only those edges that are USED to fit boundary lines after the EdgeMode is applied and all outliers are eliminated. This is very helpful for understanding the effect of changing various property settings. This value is NO_EDGE_POINTS by default.</p>
MaxEdgePoints	Integer	2 - n	<p>Maximum number of edge point searches to perform across the</p>

			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.
MaxIterations	Integer	0 - n	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 zero disables filtering. The default value is 5.
MinFilterDistance	Single	0 - n.nn	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.
SigmaFilter	Single	0 - n.nn	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.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties The LINE_THICKNESS is the average distance between the two bounding lines measured at the center of the tool.
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	
InspectType	List	NONE / ..._RMS / ..._ANGLE / ..._NUM_EDGES_FOUND / ..._NUM_EDGES_USED / ..._LINE_THICKNESS	

InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
OffsetAngle	Single	degrees	Standard Results Settings properties
OffsetX	Single	mm	
OffsetY	Single	mm	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultErrorCode	Integer		Standard Results properties
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	
ResultLine-Thickness	Single		Average distance between the two bounding lines measured at the center of the tool. <i>[GPL: VisResult.Info(3)]</i>
ResultNum-EdgesFound	Integer		Number of edge points found during the boundary line fitting. <i>[GPL: VisResult.Info(1)]</i>
ResultNum-EdgesUsed	Integer		Number of edge points remaining after the filtering process for the boundary lines. <i>[GPL: VisResult.Info(2)]</i>
ResultRMS	Single		Root mean square of the boundary line fits. <i>[GPL: VisResult.Info(0)]</i>

Remarks

This tool searches the region defined by its gray and blue outlined rectangle 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 degrees. 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 (nominal) line of the search region (as indicated by the green double headed arrow) 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, please 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.

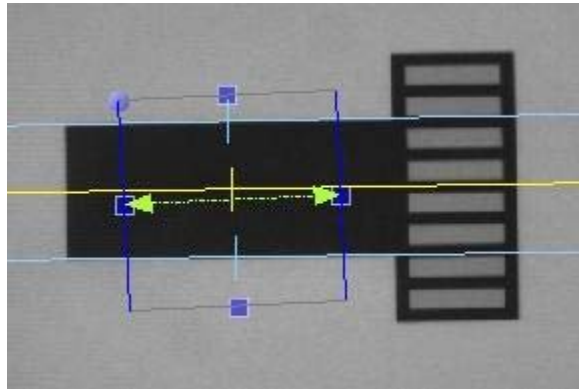
Special Feature Buttons (located above the property editor)

Adjust Threshold

Pressing this button displays a pop-up window that permits the value of the **Edge Threshold** property to be manually adjusted while dynamically viewing the effect of the new setting in the Camera Display. The edges that satisfy the threshold criterion are displayed in white.

Examples

In the following example, a single **Find Centerline** tool is utilized to accurately determine the orientation of the primary axis of an object.

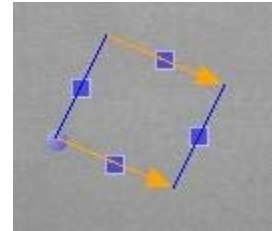


See Also

[Vision Toolkit](#) | [Line Fitter](#) | [Edge Locator](#)

Find Point Tool

Vision tool that 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

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	-360 to 360	Standard Placement / Size properties. The X and Y values define the center of the tool and the center of the search region. The Width defines the distance that is searched looking for the first edge point. The Height defines the length of the reference search line.
Height	Single	0 - AOI (mm)	
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	-360 to 360	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
Threshold	Integer	0 - 254	Specifies the threshold below which weak (low contrast) gradients edges are ignored. The smaller the number, the more sensitive the system is in locating edge points. Please see the description of the Edge Locator for more information on edge gradients. The default value is 30.
3A. Advanced Operation			

ToolDisplayMode	List	NoDisplay / DisplaySearch	DisplaySearch illustrates all of the edges that were located within the search region.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties.
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	
InspectType	List	NONE (reserved for future use)	
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
OffsetAngle	Single	degrees	Standard Results Settings properties
OffsetX	Single	mm	
OffsetY	Single	mm	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultErrorCode	Integer		Standard Results properties
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	

Remarks

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. The direction of search is indicated by two arrows that mark the boundary of the search region.

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.

Candidate edge points are located using the same method as the sub-pixel mode of the [Edge Locator](#). So, the XY position of the located edge point is computed with sub-pixel accuracy along the direction of search and to within a pixel perpendicular to the direction of the search. The position of the returned point can be used in combination with other tools to establish the position or thickness of an object.

Special Feature Buttons (located above the property editor)

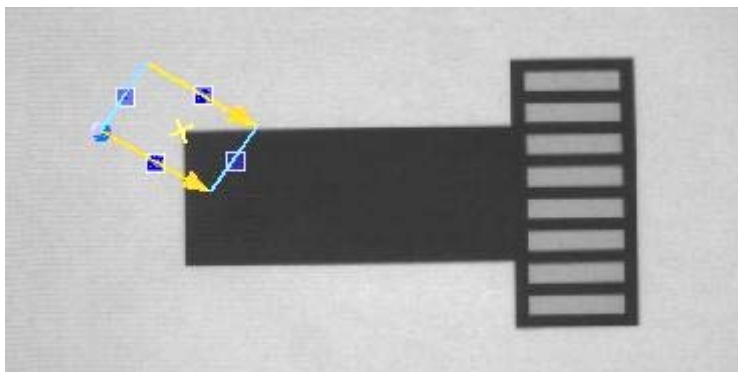
Adjust Threshold

PreciseVision

Pressing this button displays a pop-up window that permits the value of the **Threshold** property to be manually adjusted while dynamically viewing the effect of the new setting in the Camera Display. The display indicates the edges that satisfy the threshold criterion in white.

Examples

In the following example, this tool locates the edge point of the black object that is closest to the reference line that defines the start of the rectangular search region. The search is performed in the direction indicated by the tool's arrows. In this case, the closest edge is a corner point.

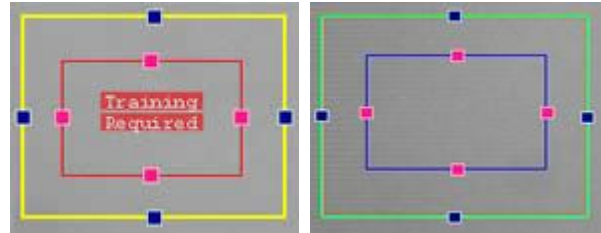


See Also

[Vision Toolkit](#) | [Edge Locator](#)

Finder Tool

Most powerful vision tool that identifies randomly placed parts in a camera image and returns their position, orientation and scaling to within sub-pixel accuracy.



Prerequisites

None

Properties: Template "Training" Mode

Property Name	Data Type	Range	Description
1. Identity			
Type	String	n/a	Standard Identity properties
2. Placement/Size			
Height	Single	0 - AOI (mm)	Standard Placement / Size properties. The X and Y values define the center of the rectangular template and the Height and Width define its dimensions.
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
HiResMinScore	Single	0 - 1	When a template is compared against a

LoResMinScore	Single	0 - 1	<p>region in a camera image, the "recognition score" indicates how well the two match. A value of 0 represents a total mismatch and a value of 1 represents a perfect match. The HiResMinScore and LoResMinScore properties dictate when a comparison is considered to represent a good match. The LoResMinScore is utilized at the lowest resolution (highest level of the search pyramid) to determine if a possible match is good enough to be further analyzed at the levels with higher resolution. The HiResMinScore dictates if a match is acceptable at the full camera image resolution and is acceptable as a final, good match.</p> <p>These values are set automatically during training and can be manually adjusted after training is completed.</p> <p>In general, the LoResMinScore is set equal to or lower than HiResMinScore. In fact, LoResMinScore can be set very low or even to 0. Since the Finder sorts all of the candidate matches at the lowest resolution and pursues best candidates first, setting LoResMinScore low just results in more candidates being pursued to the full resolution level. If a specific number of parts is being located, having additional candidates is not a problem since the finder will stop when the desired number of parts is located. However, if an unknown number of parts is being searched for, having this property set too low can result in excessive execution time.</p> <p>On the other hand, the setting for HiResMinScore is very important in terms of the quality of the Finders results. As soon as the system identifies the number of parts that you request whose recognition score satisfies this criterion, the Finder stops and returns these candidate matches. Setting this property higher results in higher quality matches being returned at the risk of rejecting acceptable matches.</p>
MaxAngle	Single	-360 to 360	These properties dictate the range of

MinAngle	Single	-360 to 360	<p>orientations that are tested relative to the trained orientation of the template. Normally, these properties are set to +/- 180 degrees to detect parts in any orientation. However, if a part can only rotate a limited amount relative to its taught orientation, reducing these values to reflect the smaller range of orientations will speed up processing.</p> <p>In addition, if the part has some type of orientation symmetry (e.g. a circle or a square), these values should be set to restrict the range of orientations. This speeds processing and prevents the robot from making unnecessary changes in orientation to grasp the part. These properties should be set as follows for the common types of symmetries:</p> <p>Circle: +/- 0 deg Square: +/- 45 deg Rectangle: +/- 90 deg Equilateral triangle: +/- 60 deg Hexagon: +/- 30 deg</p> <p>By default, these properties are set to +/- 180 degrees.</p>
3A. Advanced Operation			
Accuracy	Integer	1 - 100	<p>This property controls the amount of effort and time that is spent on performing the final refinement of the location and orientation of a matched template. Smaller values result in less accuracy but faster execution times. Values above 10 provide higher sub-pixel accuracy at the expense of execution times. By default, this property is set to 10.</p>
Depth	Integer	1 - n	<p>This is the maximum pyramid search level to build and use. At runtime, to optimize its execution, the Finder initially searches for matches between the template model and the camera image at reduced resolutions. Each level of reduced resolution is a factor of 2 smaller in width and height. During training, PreciseVision automatically computes the maximum number of levels to use based upon the loss of distinctive features and other criterion and sets this property value. After training, the Depth can be reduced to limit the number of reduced resolution levels considered. This is beneficial if the system is too aggressive and selects too many levels. The number of levels does not affect the accuracy of the final results of the Finder since the last match is always performed at</p>

			the full image resolution.
GainLimit	Single		Each time the template is compared to a region of a camera image by the Finder Tool , to enhance robustness, the comparison is automatically normalized to eliminate differences due to the overall brightness of the image. In particular, each pixel value is effectively adjusted as follows: $\text{New_value} = \text{Gain} * \text{image_pixel} + \text{Offset}$ This normalization process is controlled by the following properties: GainLimit restricts the range of the Gain. If non-zero, the "Gain" will be restricted to fall between $1/\text{GainLimit}$ and GainLimit . By default, this property is set to 4. OffsetLimit restricts the amount by which the overall brightness is adjusted up or down, i.e. this property specifies the maximum absolute value of the "Offset". By default, this property is set to 64.
OffsetLimit	Integer	0 - n	
MaxScale	Double Array		These properties can be set to locate parts that have a variable scaling (size). This can occur if the part can be at different distances from the camera while still in acceptable focus. Allowing scaling variations can be very useful, but it does require additional execution time. The first value in each of these arrays is for the X scaling and the second is for Y. The X and Y values should be set equal to other. By default, all four values are set to 1.0, which indicates no scaling is permitted. In general, these values should not be greater than 1.2 or less than 0.8.
MinScale	Double Array		
Speed	Single	-1 or 1 to 100	This property controls how quickly the tool executes at runtime versus how meticulously it attempts to find matches. If this value is set to 1, the Finder executes more slowly but with the highest reliability. If it is set to 100, it executes at the fastest speed but may fail under non-ideal conditions. During training, the value of this property is automatically set to a conservative value that achieves a good balance of speed and reliability. After training, the value can be modified.

Properties: Runtime "Find" Mode

Property Name	Data Type	Range	Description
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1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Height	Single	0 - AOI (mm)	Standard Placement / Size properties. The X and Y values define the center of the rectangular search region and the Height and Width define its dimensions.
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	-360 to 360	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
PrecentClipped	Integer	0 - 50	This property allows parts to be recognized even if the matching template area is partially outside of the search region. Normally, this property is set to 0 and the Finder only searches for X/Y template center positions that have the template fully within the search area. In this case, this tool will not return a match position where the center of the template is closer than 1/2 the template's width or height to a side of the search region. If the PercentClipped is set to 50%, all template center positions within the search area will be considered. As this property value is increased, the recognition match score that is compared to HiResMinScore and LoResMinScore will be reduced somewhat, but not in proportion to the value of this property. Also, this property only applies to template matches that protrude beyond the search space and does not deal with occlusion due to overlapping parts. To allow for overlapping parts, the HiResMinScore and LoResMinScore should be reduced. By default, this property is set to 0.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings

InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	properties
InspectType	List	NONE / RESULT_ANGLE / RESULT_SCORE / RESULT_ID	
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
MaxResults	Integer	-1 or 1 to n	Standard Results Settings properties . MaxResults defines the number of matches to find each time that this tool is executed. This tool will execute more quickly if a known number of matches are expected and this property is set accordingly. This is due to the fact that execution terminates as soon as the expected number of successful matches is found. Until all expected matches are found, this tool will continue to exhaustively test all possible matches. By default, this property is set to -1, exhaustive matching.
OffsetAngle	Single	degrees	
OffsetX	Single	mm	
OffsetY	Single	mm	
ResultSelect	Integer	1 - n	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultCount	Integer	0 - n	Standard Results properties
ResultErrorCode	Integer		
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	
ResultScaleX	Single		These values indicate the X and Y scale factors that were computed when matching the template to the camera image. If scaling was not enabled, these values will be set to 1. [GPL: VisResult.Info(1), VisResult.Info(2)]
ResultScaleY	Single		
Recognition Time	Single	msec	Total time required for the last execution of this tool in milliseconds. [GPL: VisResult.Info(3)]
ResultScore	Single	0 - 1	This is the "recognition score" that indicates how well the template matched the located part. A value of 0 represents a total mismatch and a value of 1 represents a

			perfect match. Accepted scores will all be greater than or equal to the HiResMinScore property value for the associated template. <u>[GPL: VisResult.Info(0)]</u>
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Remarks

The **Finder** is the most powerful tool in the toolkit and provides the most general method for identifying and locating parts in grayscale images. It can locate randomly placed parts with both simple and complex shapes and will return their part type, position, orientation and scale. There are other tools in the toolkit that are appropriate for specialized situations such as binary images or non-rotated parts. Also, for some simplified or constrained cases, it is relatively easy to combine **Line Fitters** and other tools to locate parts. However, the **Finder** can handle the widest range of parts and situations, has a very simple one-shot teaching method, and returns accurate sub-pixel results.

To address applications like locating a secondary object with a primary object, the **Finder** can be placed relative to the results of any other tool including another **Finder**. The one restriction is that the **Finder** search window is always orthogonally aligned with the camera frame of reference.

Typical uses for this tool include: finding fiducial marks on a printed circuit board, locating parts randomly placed on a conveyor belt and refining the position and orientation of sample trays.

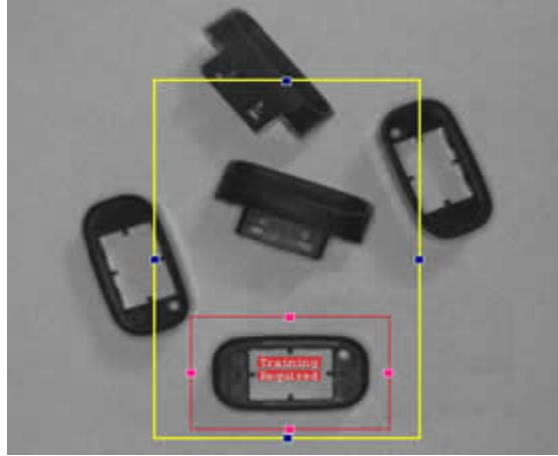
Finders and Finder Templates

To teach the **Finder** the visual characteristics of a part, a single image of the part must be "trained". The training process consists of bounding the entire part plus some of the adjacent background with a red "Template rectangle". This red rectangle defines the "**Finder Template**" for the part. When PreciseVision subsequently searches for the part during runtime, it is looking for matches for the Template in the image. When the system reports the position and orientation of a matched part, it is actually stating the position of the center of the Template when the match was found and the amount by which the Template was rotated.

During the training process, a yellow "Training rectangle" must also be positioned around the Template. This yellow rectangle is used to teach the system how to distinguish the Template from other objects or background clutter that might be encountered at runtime.

If different types of parts or clutter are expected to be present, the system will work best if one and only one full copy of the desired target part plus the other objects and the clutter are enclosed by the yellow rectangle. In general, the larger the yellow rectangle, the better the Finder will operate since this allows the Finder to try more positions and orientations for the template as it optimizes its search parameters. Please note that since PreciseVision is a 2D vision system, different poses (stable states) of the same part that produce different 2D images are considered different parts.

The following picture illustrates how the training rectangles should be positioned to teach the **Finder** how to locate one orientation of a part while ignoring a second stable state.



If two or more types of parts are to be identified and located in the same image, multiple **Finders** and their Templates should be trained and included in the Vision Process.

After the Template and Training rectangles have been properly positioned, the **Finder** can be taught by pressing the Train icon on the Vision Tool Definition tool bar. To simplify the training and setup process, when you create a new **Finder**, a wizard is automatically displayed that walks you through the training steps. Using this wizard, performing the training and setting up the key **Finder** properties is extremely simple.

Training and Finding Modes

The **Finder** is always in one of two modes: "Training" or "Finding". When this tool is first created, it is automatically placed into the Training mode. In this mode, the property list displays the size and the position of the Template and other properties that are specific to the type of part being taught, e.g. parameters for part symmetries, expected scale variations, etc. In the Vision Camera Display window, the yellow Training rectangle and the red Template rectangle are displayed.

After a Template has been trained, the tool will be in Find mode and an alternate property list is displayed. This property list presents the size and position of a green "Search rectangle". This rectangle defines the camera image area that the **Finder** will search for matches to the Template. The alternate property list also contains parameters that control the search, e.g. the maximum search time, number of parts to find, etc. In the Vision Camera Display Window, the green Search rectangle and the blue "taught Template rectangle" will be displayed.

To switch between Training and Finding modes, select a **Finder** and right click in the Vision Tool Definition Window or the Camera Display Window or select the appropriate icon in the Vision Tool Definition tool bar.

The Finder Search Algorithm

The heart of the **Finder Tool** is a new patented algorithm that combines an intelligent search technique with the robustness of normalized correlation to match the Template with regions in the search region. The intelligent search technique avoids the computational requirements of applying correlation to a multi-dimensional search that accommodates concurrent changes in position, orientation and scale. Also, this technique does not introduce the problems encountered with correlation optimization

methods such as skipping pixels, while still retaining the important benefits of a normalized correlation match.

Like most search methods, this tool employs reduced resolution images for the initial search passes in order to quickly identify candidate positions. This method is often called a pyramid search since each successive search level has half as many pixels in each row and column. During the training process, this tool automatically computes the maximum number of levels that can be utilized while still retaining sufficient distinctive features to differentiate the target object from the background and other objects.

At each position where the template (or a reduced resolution template) is compared to the image (or a reduced resolution image), a normalized comparison operation produces a "recognition match score". This score ranges from 0, which indicates no match, to 1, which indicates a perfect match. At the reduced resolutions, all of the locations whose score exceeds a minimum value are retained and ordered according to their score value. The tool then pursues each of these candidate locations and validates whether the location also satisfies a minimum match score when tested at the full camera resolution. When the system finds the requested number of successful results or all of the candidate locations have been exhausted, execution is terminated.

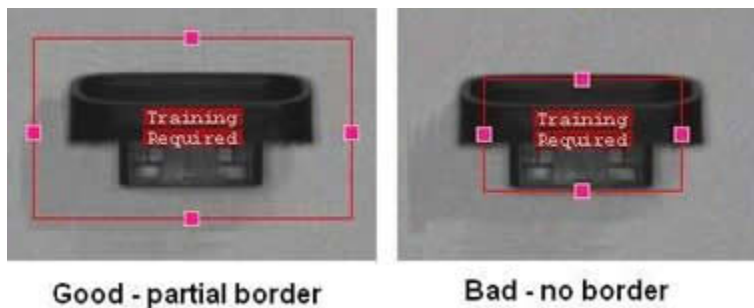
As a final step, if the Inspection Setting has been defined, each of the successful results will be tested against the Inspection criteria and will be tagged as to whether it "Passes" or "Fails".

Optimizing The Finder And Templates

The following are a number of guidelines for optimizing the performance of the **Finder** and **Finder Templates**.

Template (Red) Rectangle Guidelines

- The Template should fully enclose the target object and should contain no other objects or parts of objects.
- In general, the Template rectangle should be larger than the target object. It is best to have a boundary of at least 16 camera pixels all around the target object (more pixels are better than fewer pixels). For a 640x480 camera, 16 pixels is 1/30th of the full height of the camera image. This permits the system to capture the edges between the object and the background. This is especially important if the object does not have many internal features.

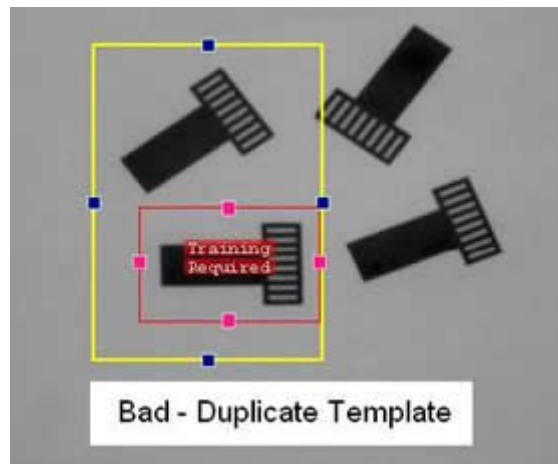


- If the background varies significantly (e.g., there is dirt and paint blotches on a conveyor belt), then the part should be placed on a uniform, neutral background to teach the Template.

- The target object should be oriented in the camera image in what you want to define as 'Zero' degrees. That is, when the Finder later locates a part is in the trained orientation, it will return an orientation angle of 0 degrees.

Training (Yellow) Rectangle Guidelines

- The Training rectangle must be larger than the Template and must fully enclose the Template.
- The Training rectangle should include one and only one full image of the target object. Since the Finder uses the contents of the Training rectangle to determine distinguishing features of the Template, a second complete copy of the Template will confuse the system and will generate an error. It is acceptable to have additional partial images of the target object in the Training rectangle so long as each is less than 50% of the target object (see picture above in the Template discussion for an example).



- This rectangle should include any other objects or clutter that are expected to be encountered during runtime to aid the system in learning to distinguish between the target object and its surroundings.
- This rectangle should be as large as possible without violating the rules above. A larger region permits the system to test more positions and orientations for the Template during the training phase and assists in optimizing the runtime search strategy.

Finder Properties

- If your part is symmetric, e.g. a circle, a square, a rectangle, set the **MinAngle** and **MaxAngle** properties to limit the rotation of the results.
- If any portion of the part might extend beyond the search window, set the **PrecentClipped** property appropriately.

System and Camera Setup

- Prior to training or executing this tool, calibrate the camera's pixel to millimeter relationship. Failure to do so may result in parts not being located. This is due to the fact that many cameras do not have square pixels, i.e. their X and Y scaling factors are different. If this difference in scaling is not accounted for properly, as parts are rotated, their shape will be distorted and their size will be incorrect.

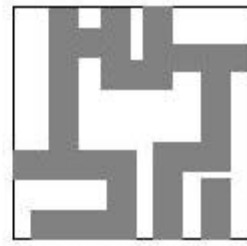
- Larger target objects (and therefore larger templates) generally perform better than small templates for various reasons: finding a very small template in a large search space is comparable to finding a needle in a haystack; larger templates usually have more image features; larger templates usually can be found with higher accuracy particularly in orientation; and larger templates containing some big features can be searched using taller search pyramids thereby accelerating the search.

Optimal Target Objects

- Target objects that contain corners that form a 90-degree angle result in more reliable recognitions and higher accuracy.
- Sharp features in focus provide more accurate results than smooth or blurred features.
- If the template has many edges in one direction but only a few in the orthogonal direction, matched locations will have greater accuracy in the direction perpendicular to the majority of the edges. In the figures below, templates "A" and "B" contain many vertical edges so both can be located with high accuracy in the horizontal direction. But template "A" has very few horizontal edges compared to "B", so along the vertical direction, "B" will be found with higher accuracy than template "A".



Template A (poor)



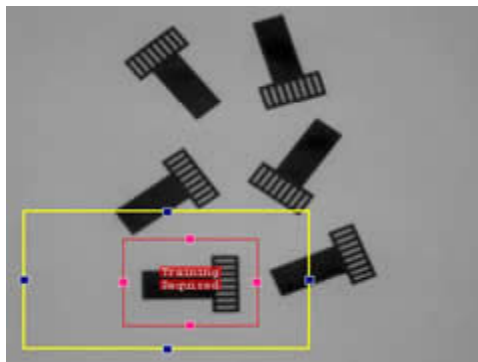
Template B (good)

- A wide dynamic range of brightness in the template provides more accurate results than an image with a narrow range. However, avoid saturation. Image information is lost when pixels are clipped at the two ends of the brightness range.
- Fine details in the image enhance the overall accuracy of the position calculations, but large features enhance the speed of search. Large features enable use of taller search pyramids.

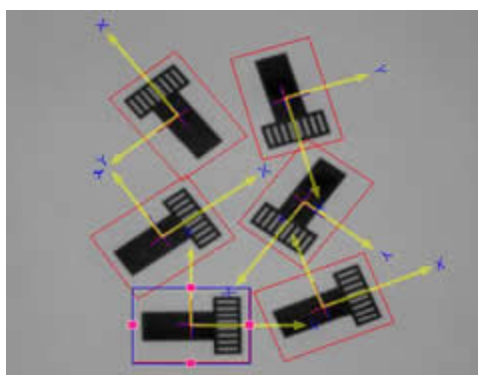
Examples

In the following example, a **Finder Template** is trained on one of six identical parts. Since the parts are all the same, the yellow Training rectangle is only placed around one complete part although other partial parts (each less than 50% of the full object) are included in order to enlarge the Training rectangle. Also, for a reasonable template boundary and for an intuitive orientation angle, the horizontal part is trained rather than the parts at a skewed angle. After the Training and the Template rectangles are positioned, the Train icon can be pressed.

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For this simple part, training completes in approximately one second after which the tool is automatically placed into Find mode and the search operation is executed once. At the conclusion of the search, all six parts will be identified and each of the part's position and orientation will be indicated by yellow coordinate axes as illustrated in the following picture.



Once in Find mode, the "Execute Selected Tool" green circular icon is enabled on the Vision Tool Definition tool bar. For testing purposes, the **Finder** can be repeatedly executed by clicking this icon.

See Also

[Vision Toolkit](#) | [Connectivity](#)

Fixed Frame Tool

Computational tool that 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

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	-360 to 360	Standard Placement / Size properties. The X and Y values define the origin of the reference frame and the Angle specifies its rotation.
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	-360 to 360	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
3A. Advanced Operation			
FramePatternXIndex	Integer	1 - n	If the X and/or Y index values are greater than 1, the position of the Fixed Frame is indexed in a grid pattern the number of X and/or Y steps by the appropriate Pitch values. This permits any linked tools to be automatically and repeatedly executed in a grid pattern.
FramePatternYIndex	Integer	1 - n	
FramePatternXPitch	Single	mm	
FramePatternYPitch	Single	mm	
5. Results Settings			

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ShowResults	List	NONE / FRAME / LINE / POINT	The frame can be graphically represented as a coordinate frame, line or a point.
6. Results			
ResultAngle	Single	-360 to 360	Standard Results properties
ResultXPos	Single	mm	
ResultYPos	Single	mm	

Remarks

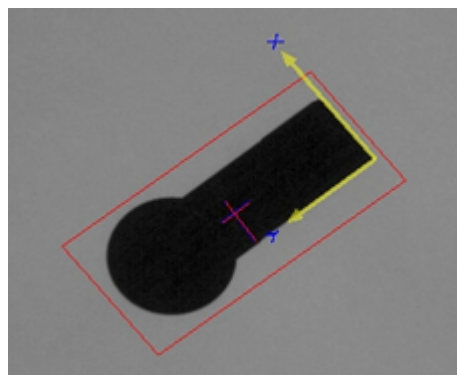
A Fixed Frame can be used in several different ways. It can be defined relative to another vision object with a fixed position and angular offset. This is an alternative to directly setting an offset in the Results Settings of most tools and has the advantage of allowing the offset to be graphically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

Examples

Below is an example of a Finder that returns a frame that is at the center of the part. A Fixed Frame is placed relative to the finder and used to effectively re-define the part's frame of reference. Additional vision tools can now be placed relative to the Fixed Frame. The advantage of doing this is that if the Finder template is re-trained it may not be placed in exactly the same position and orientation relative to the part. The Fixed Frame can then be adjusted to account for any difference in the Finder position and orientation. By using this relative reference frame, we can easily ensure that all subsequent tools will maintain their positional relationship with respect to key features of the part.

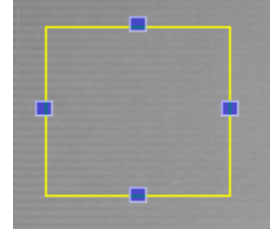


See Also

[Vision Toolkit](#) | [Line-Line Frame Tool](#) | [Point-Line Frame Tool](#) | [Point-Point Line Tool](#)

Image Process Tool

Vision tool that performs image filtering, edge extraction, thresholding and morphological operations on a specified area in the camera image.



Prerequisites

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	0 (<i>non-rotating</i>)	Standard Placement / Size properties . The X and Y values define the center of the region to be processed. The Height and Width define the dimensions of the region.
Height	Single	0 - AOI (mm)	
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	0	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
InvertBinary	Boolean	TRUE / FALSE	(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.
Iteration	Integer	1 - n	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.
ProcessMode	LIST	CONV_* / BINARY_*	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. See the Remarks for an illustration of each of the supported operations.
Threshold	Integer	0 - 254	(BINARY_*) This is the value used to convert gray scale 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 Locator for more information on edge gradients. The default value is 30.
3A. Advanced Operation			
ConvolutionSize	List	SIZE_3X3 / SIZE_5X5	Specifies whether the convolution kernel is a 3x3 or a 5x5 matrix. The size of the kernel determines how many neighboring pixels are consider in the computation of each new pixel value.
5. Results Settings			
OffsetAngle	Single	degrees	Standard Results Settings properties
OffsetX	Single	mm	
OffsetY	Single	mm	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultErrorCode	Integer		Standard Results properties X and Y position for the centroid of the processed area-of-interest.
ResultAngle	Single	0 (non-rotating)	
ResultXPos	Single	mm	
ResultYPos	Single	mm	

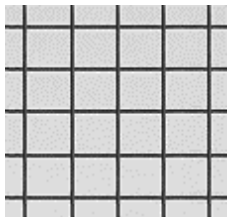
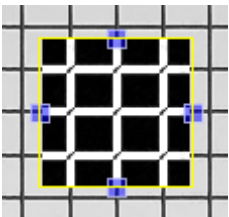
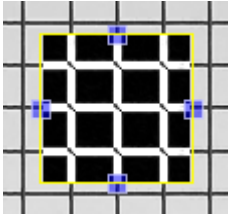
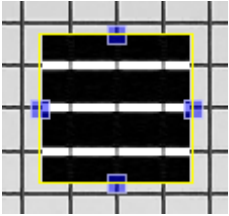
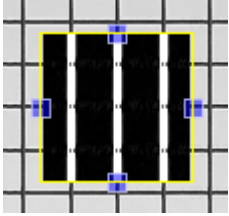
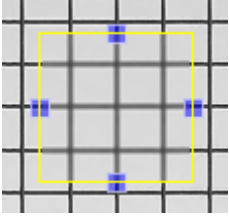
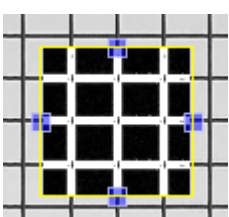
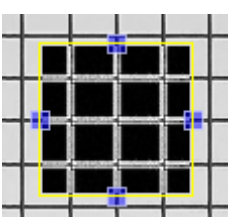
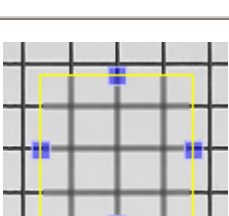
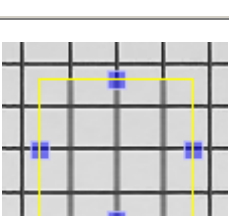
Remarks

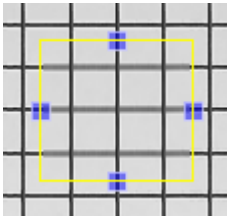
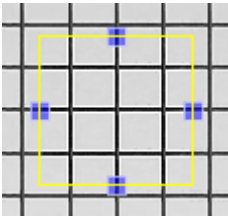
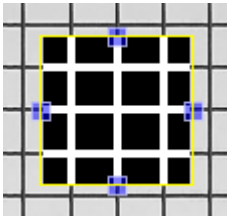
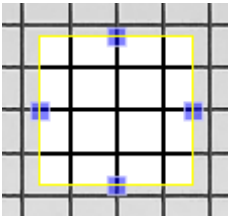
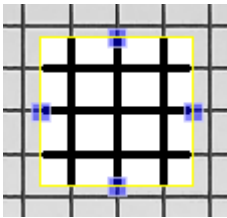
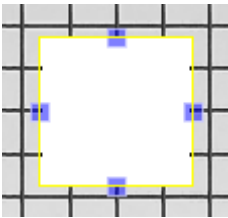
This tool performs an image filtering, edge extraction, thresholding or morphological operation on a specified area in the camera image. For example, an operator can be applied to smooth a region to eliminate noise due to poor lighting. Conversely, the image can be sharpened to highlight features.

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.

If you wish to revert back to the original raw captured image data, special properties must be set in the [Acquisition Tool](#) at the time that the picture is first taken.

The following table illustrates each of the image processing operations.

	Raw, unprocessed camera image.		CONV_FILTER_EDGE_DL Extracts edges with a bias for edges that slope down from the left.
	CONV_FILTER_EDGE_DR Extracts edges with a bias for edges that slope down from the right.		CONV_FILTER_EDGE_H Extracts edges with a bias for horizontal edges.
	CONV_FILTER_EDGE_V Extracts edges with a bias for vertical edges.		CONV_FILTER_GAUSSIAN Reduces image noise by blurring the region. This is a smoothing operator.
	CONV_FILTER_LAPLACIAN Extracts edges using a Laplacian operator.		CONV_FILTER_LAPLACIAN_GAUSSIAN Extracts edges after smoothing with a Gaussian to reduce noise.
	CONV_FILTER_LOWPASS Reduces image noise by eliminating high frequency changes. This is a smoothing operator.		CONV_FILTER_LOWPASS_H Reduces image noise by eliminating high frequency changes but only in the horizontal

			direction. This is a 1D smoothing operator.
	CONV_FILTER_LOWPASS_V Reduces image noise by eliminating high frequency changes but only in the vertical direction. This is a 1D smoothing operator.		CONV_FILTER_SHARP Accentuates or enhances edges in the image.
	EDGE_THRESH Computes each pixel's edge strength and sets all strong edges to white and all weak edges to black.		BINARY_THRESH Converts all pixels to white or 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.

Special Feature Buttons (located above the property editor)

Adjust Threshold

Pressing this button displays a pop-up window that permits the value of the **Threshold** property to be easily adjusted while dynamically viewing the effect of the new setting in the Camera Display. In a **BINARY_*** mode, the displayed image shows all pixels converted to black or white. In an **EDGE_*** mode, the edge pixels are extracted and displayed in white.

See Also

[Vision Toolkit](#) | [Acquisition Tool](#)

Inspect Frame Tool

Inspection tool that passes through the XPos, YPos and Angle Results of a referenced tool and optionally rotates and shifts the Results based upon an inspection. The inspection can consist of the arithmetic combination of the Results of two other tools. So, this tool also provides a means for performing simple mathematical operations on the results of two tools.

Prerequisites

FrameSource must be defined for this tool to execute.

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
ApplyFrameOffset	List	NONE / OFFSET_ON_PASS / OFFSET_ON_FAIL / OFFSET_ALWAYS	The nominal Results of this tool are equal to the Results of the specified FrameSource . This property specifies when the OffsetX , OffsetY , and OffsetAngle are added to the nominal Results. For example, this tool can rotate the orientation of the output of the FrameSource by 180 degrees based upon the pass/fail outcome of a specified inspection operation.
FrameSource	List	n/a	Name of the <u>required</u> tool whose ResultsXPos , YPos and Angle are taken as the nominal Results of this tool.
InspectTool1	List	n/a	If the InspectType

InspectTool2	List	n/a	specifies an arithmetic computation that operates on the Results of two tools, these two optional properties specify the tools that are the sources for the Results.
3A. Advanced Operation			
SortResults	List	NONE / SORTFROMLEFT / SORTFROMRIGHT / SORTFROMTOP / SORTFROMBOTTOM	If the FrameSource generates multiple Results, this property automatically sorts the Results as specified. This is useful for items on a conveyor belt that may need to be picked in order from the front to back.
ZeroAngle	Boolean	TRUE / FALSE	If True, will force the ResultAngle to ZERO. This is useful for randomly oriented parts that require the angle to be removed for picking. This operation does NOT change the sorting operation.
4. Inspection Settings			
InspectType	List	NONE / INSP1_MINUS_INSP2 / INSP1_PLUS_INSP2 / INSPECTIONS_PASS / INSPECTIONS_FAIL / INSPECT_XY_DISTANCE / INSPECT_X1_MINUS_X2 / INSPECT_Y1_MINUS_Y2 / INSPECT_X1_PLUS_X2 / INSPECT_Y1_PLUS_Y2 / INSPECT_X1_MULT_X2 / INSPECT_Y2_MULT_Y2 / INSPECT_X1_DIV_X2 / INSPECT_Y1_DIV_Y2 / INSPECT_ANG1_MINUS_ANG2 / INSPECT_ANG1_PLUS_ANG2 / INSPECT_ANG1_DIV_ANG2 / INSPECT_ANG1_MULT_ANG2	Standard Inspection Settings properties. The InspectType can specify a simple arithmetic operation that is to be performed on the Results obtained from InspectTool1 and InspectTool2 . The InspectActual returns the result of the arithmetic operation and the InspectPassed is set according to whether the result falls within the specified Min and Max values.
InspectMax	Single		
InspectMin	Single		
InspectActual	Single		
InspectPassed	List	Pass / Fail	
InspectEval	String		Displays the arithmetic expression that is

			evaluated to compute the InspectActual results. This expression is a function of the InspectType .
InspectString	String	n/a	Optional label that is displayed in the camera window. This provides a convenient way to display part ID or other information.
5. Results Settings			
MaxResults	Integer	-1 or 1 to n	Standard Results Settings properties . The Offsets are conditionally added to the nominal ResultsXPos , YPos and Angle depending upon the setting of ApplyFrameOffset and the pass / fail status of the inspection operation.
OffsetAngle	Single	degrees	
OffsetX	Single	mm	
OffsetY	Single	mm	
ResultSelect	Integer	1 - n	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultCount	Integer	0 - n	Standard Results properties . The ResultsXPos , Ypos and Angle are equal to the Results of the FrameSource , optionally adjusted by the OffsetX , OffsetY , OffsetAngle .
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	

Remarks

This tool passes through the **ResultXPos**, **ResultYPos**, and **ResultAngle** from a referenced **FrameSource** tool and optionally shifts and rotates the Results based upon a pass/fail test. This function can be used to correct the position and/or the orientation of an object based upon an additional inspection operation. If the referenced tool produces multiple Results, the test and correction will be applied to each generated Result.

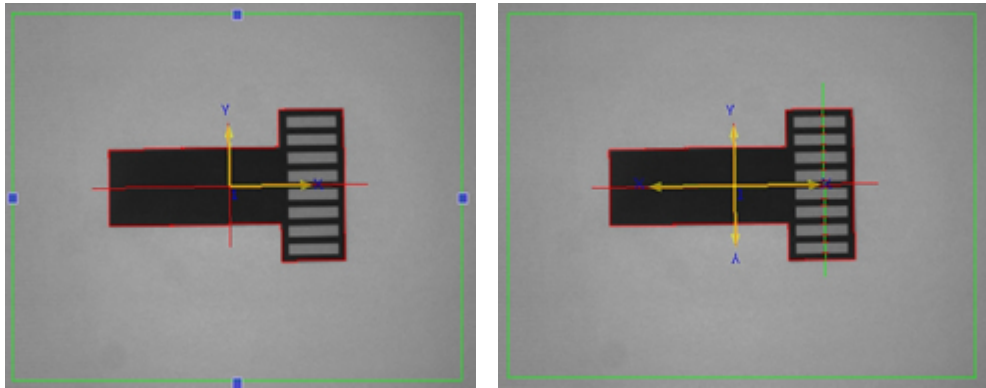
This tool can also be used to perform measurements between the Results of two vision tools. For example, the **InspectType** property can specify that the distance between the XY positions of **InspectTool1** and **InspectTool2** is to be computed and compared to specified min/max values. The outcome of this inspection determines the pass/fail status of this tool. This pass/fail value can trigger the offsetting of the Results or can be used as input to other tools.

For example, when a **Connectivity Tool** is executed, the orientation of its Result is always ambiguous since this algorithm will return the same orientation and position even if an object is rotated by 180 degrees. If the **Connectivity Tool** is specified as the **FrameSource** of an **Inspect Frame Tool**, a measurement of a specific feature of the object can be performed. Based upon the measurement, the frame of reference that is generated by the **Connectivity Tool** can be conditionally rotated to correct its orientation.

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Examples

Below is an example of a **Inspect Frame Tool** that alters the orientation of a **Connectivity Tool** output based on the inspection of an **Edge Locator Tool**. The **Edge Locator Tool** measures the width of the part (along the green line shown below in the picture on the right) by determining the distance between the first and last located edge. Depending upon whether the wide or narrow portion of the part is detected, the **Inspect Frame Tool** conditionally applies an angular offset to rotate the returned frame's orientation angle.



See Also

[Vision Toolkit](#) | [Inspect List](#)

Inspect List Tool

Inspection tool that passes through the XPos, YPos and Angle Results of a referenced tool and tests up to 12 different Results from multiple tools to determine if the object is good or bad. This tool provides a convenient way to perform complex testing of a located object and generating an equivalent location with a single Pass/Fail indicator.

Prerequisites

FrameSource must be defined for this tool to execute.

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
FrameSource	List	n/a	Name of the <i>required</i> tool whose Results XPos, YPos and Angle are passed through as the position and orientation Results of the Inspect List tool.
InspectTool01-12	List	Note: Accessed using "Setup Inspection List" button.	List of vision tools whose Results are tested to determine if the part passes or fails. Many vision tools (i.e. connectivity) have multiple Results. Such tools can be referenced multiple times to test different Results property values.
3A. Advanced Operation			
ShowInspectTools	Boolean	TRUE / FALSE	If True will display the tools defined in the Inspect List during execution, otherwise only the resulting output frame is displayed.
4. Inspection Settings			
InspectPassed	List	Pass / Fail	Standard Inspection Settings properties.
InspectString	String	n/a	Optional label that is displayed in the vision window relative to the position and orientation of this tool. This provides a convenient way to display part ID or other information.
5. Results Settings			

MaxResults	Integer	-1 or 1 to n	Standard Results Settings properties
ResultSelect	Integer	1 - n	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultCount	Integer	0 - n	Standard Results properties . The XPos, YPos and Angle Results are equal to those of the FrameSource .
ResultErrorCode	Integer		
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	As a special case for this tool, <i>GPL:</i> <i>VisResult.Info(0-11)</i> are equal to the Pass(- 1) or Fail(0) results of InspectTool01-12 .
ResultYPos	Single	mm	
			<i>GPL: VisResult.Info(12-23)</i> are equal to the actual values used for the pass/fail tests for InspectTool01-12 .

Remarks

Many vision applications only required one or two tests to determine if a part is acceptable. In these cases, the vision inspection tools can be executed directly in a Vision Process. However, if many tests must be performed, the **Inspect List** provides a very convenient method for executing up to 12 tests on the Results from multiple tools and generating a single Pass/Fail result that indicates if all of the tests are satisfied. This tool can also simplify and improve the efficiency of a GPL program that accesses vision results. If the GPL program only needs to know that all tests passed, the **Inspect List** tool can return a single value instead of requiring the GPL program to read the results from multiple tools.

As a further convenience, the **ResultXPos**, **ResultYPos** and **ResultAngle** of this tool are set equal to the Results of the specified **FrameSource**. So, if **FrameSource** is a tool that locates the position of an object, the output of the **Inspect List** will provide the location of the object together with a single Pass/Fail property that indicates if up to 12 qualifying inspections were successful.

The 12 Results tested by this tool can come from a single vision tool or multiple tools. This permits the Results from multiple measurement or inspection tools to be combined. Alternately, for tools such as Connectivity that return many independent properties (e.g. **ResultBlobArea**, **ResultMajorAxisLength**, **ResultMinorAxisLength**, **ResultMaxRadiusAngle**, etc.), multiple properties from the same tool can be tested to verify that the part is acceptable.

Special Feature Buttons (located above the property editor)

Setup Inspection List

Since this tool has the ability to reference the Results properties from up to 12 other tools and each referenced tool can have properties that are specific to its tool type, a special pop-up dialog is provided to specify the 12 possible tests. The following is an example of this dialog page that is accessed by pressing the "Setup Inspect List" button above the tool's property list.

Inspect List Tool List Setup

Enable and select each vision tool that will be used to determine if the root tool will pass or fail.

Enable	Inspect Tool	Inspect Type	Min	Max	Actual
<input checked="" type="checkbox"/>	el_test_part (Edge Locator)	ResultInspectPassec			Passed
<input checked="" type="checkbox"/>	part (Finder)	ResultScore	0.8	1	0.9558439
<input type="checkbox"/>	NONE	Unknown			
<input type="checkbox"/>	NONE	Unknown			
<input type="checkbox"/>	NONE	Unknown			
<input type="checkbox"/>	NONE	Unknown			
<input type="checkbox"/>	NONE	Unknown			
<input type="checkbox"/>	NONE	Unknown			
<input type="checkbox"/>	NONE	Unknown			
<input type="checkbox"/>	NONE	Unknown			
<input type="checkbox"/>	NONE	Unknown			
<input type="checkbox"/>	NONE	Unknown			

Live Video Acquire Run List Done

Each tool to be accessed can be selected using the pull-down combo box "Inspect Tool". Once a tool is specified, the Results property to be tested can be selected using the "Inspect Type". All tools have the same basic inspection types available: **ResultInspectPassed** / **ResultInspectFailed** / **ResultXPos** / **ResultYPos** / **ResultAngle**. In addition, some tools have special Results that can be tested. Please see the "Info()" array of the selected vision tool for details as to its tool specific Results properties.

Once the Inspect Type is selected, the Min/Max inspection limits can be filled in. The retrieved property values are displayed in the Actual fields and the values are color coded to indicate if they fall within the Min/Max bounds.

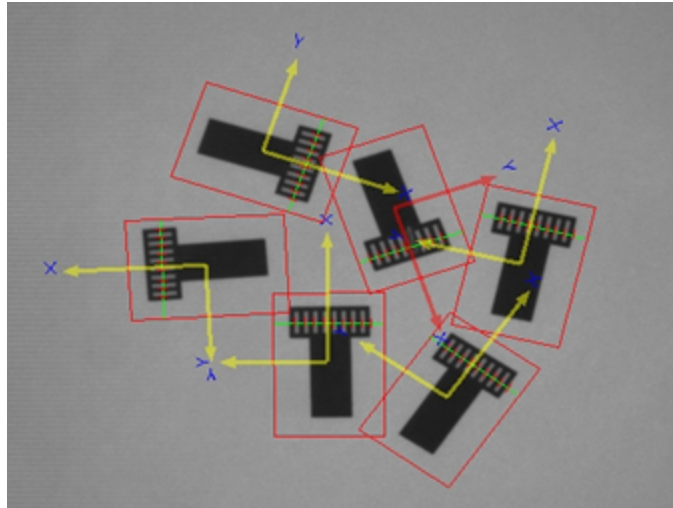
At the bottom of this dialog panel, there are buttons to assist in setting up and testing the tool. When the "Run List" button is pressed, all of the referenced tools are executed and their properties are evaluated.

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Examples

Below is an example of a **Inspect List** tool that is used to locate and qualify multiple parts in the camera's field-of-view. The **FrameSource** is a **Finder** tool. There is a **Edge Fitter** tool that is placed relative to each located object returned by the **Finder**. The **Edge Fitter** counts the transitions on each part. If the count is wrong, the part will fail and will not be picked.

In this example, a part near the center failed since it is missing one of its slots.



Even though multiple tools were utilized to locate and inspect each part, only a single tool result is passed to the connected robot controller for each part. This simplification is especially useful for more complex inspection requirements and when the number of located parts is large.

Vision Results								
Vision tool: inspect_list								
Name	Idx	Vis X	Vis Y	Vis Angle	Rob X	Rob Y	Rob Angle	Passed
inspect_list (Inspect List)	1	112.6181	53.01229	54.98428	0	0	0	Pass
inspect_list (Inspect List)	1	129.839	87.50078	76.54478	0	0	0	Pass
inspect_list (Inspect List)	1	84.72706	62.01287	90.11401	0	0	0	Pass
inspect_list (Inspect List)	1	69.58166	116.6507	-18.40212	0	0	0	Pass
inspect_list (Inspect List)	1	100.3274	101.9932	-71.33251	0	0	0	Fail
inspect_list (Inspect List)	1	56.32088	87.17785	183	0	0	0	Pass

See Also

[Vision Toolkit](#) | [Inspect Frame](#)

Inspect Region Tool

Inspection tool that inspects the perimeter and the interior of an opaque object to determine if there are any flaws in the object's outline or holes in the interior. This tool was designed to inspect wafers, where slight changes in the overall size and shape of the wafer are permitted, but chips in the perimeter or interior holes or cracks are unacceptable.

Prerequisites

FrameSource must be defined for this tool to execute. Multiple source tools must be created that define the perimeter of the object to be inspected.

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
FrameSource	List	n/a	Name of the <i>required</i> tool whose ResultsXPos , YPos and Angle are taken as the nominal Results of this tool.
PerimeterTool01-12	List	n/a	Series of up to 12 vision tools whose results define the outline of the region to be inspected. These tools are normally Line Fitters , Arc Fitters or computed line tools. <u>These tools must be listed in sequence as the perimeter is traversed in a counter-clockwise direction.</u> The located lines and arcs plus the points of intersection that are automatically computed between adjacent tools define a mask that is applied to the

			image to detect flaws. The resulting mask must be a closed convex shape.
SetMinBlobArea	Integer	0 - n	Specifies the minimum number of connected binary or edge pixels that a flaw must contain in order for it to be considered a defect. This test is applied both to perimeter and interior flaws. Any flaw that consists of a smaller number of pixels will be ignored.
SetNumOfErosions	Integer	0 - n	After the mask is dynamically generated from the results of the PerimeterTools , the size of the mask can be reduced by a few pixels via an iterative erosion operation. If the outline of the region to be tested in the image is somewhat rough, this permits small errors in the outline to be ignored.
SetThreshold	String		Threshold that is used when the ImageMode is Binary to convert gray scale values into black and white pixels. For EdgeLevel mode, this 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 Locator for more information on edge gradients. The default value is 30.
3A. Advanced Operation			
ImageMode	List	EdgeLevel / Binary	Specifies if the region of interest is to be analyzed as a binary or an edge image.

ProcessMode	Boolean	NORMAL / LINE_ARC_BOUNDARY / FLOODED_REGION / ERODED_IMAGE / EDGE_IMAGE / THRESHOLDED_IMAGE / ANDED_IMAGE / ANDED_IMAGE_WITH_BLOB	This is a setup / debugging aid. It permits the tool to be stopped at the completion of the specified processing step so that the results of the step can be viewed in the Camera Window. If this property is not set to Normal, the results of this tool will not be valid since the tool will not complete its full analysis.
ShowPerimeterTool	Boolean	TRUE / FALSE	If TRUE, the Results of each of the PerimeterTools will be displayed. These results can sometimes be useful to see, but at other times, can clutter the Camera Window.

4. Inspection Settings

InspectActual	Single		Standard Inspection Settings properties. The InspectActual returns the number of defects that are detected. If no defects are found, the InspectPassed is set to Pass.
InspectPassed	List	Pass / Fail	
InspectString	String	n/a	Optional label that is displayed in the Camera Window. This provides a convenient way to display part ID or other information.

5. Results Settings

MaxResults	Integer	-1 or 1 to n	Standard Results Settings properties.
OffsetAngle	Single	degrees	
OffsetX	Single	mm	
OffsetY	Single	mm	
ResultSelect	Integer	1 - n	
ShowResults	List	NONE / FRAME / LINE / POINT	

6. Results

ResultCount	Integer	0 - n	Standard Results properties.
ResultErrorCode	Integer		
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	

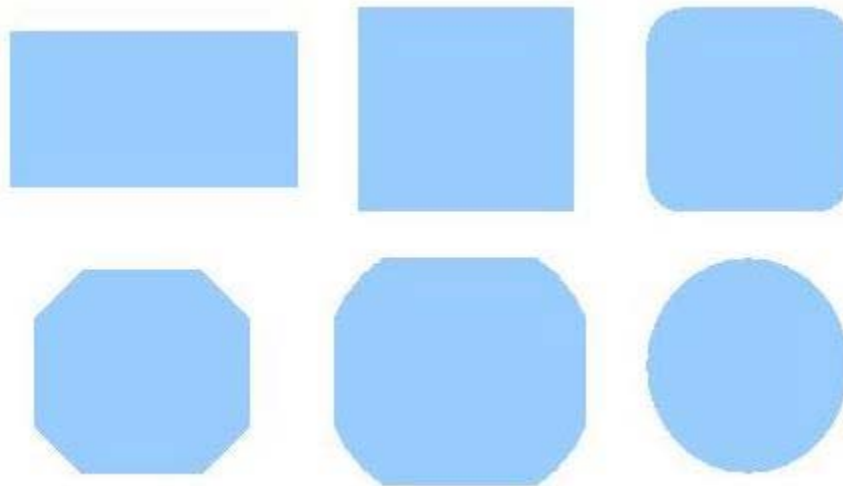
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ResultYPos	Single	mm	
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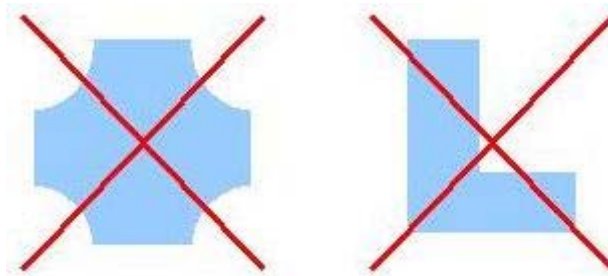
Remarks

This is a specialized inspection tool that is designed to locate chips in the perimeter of a smooth convex outline and interior holes and cracks. This was developed to inspect for defects in wafers, whose size and outline might vary slightly from one wafer to the next. Since acceptable wafers can vary in their exact size and shape, a fixed mask cannot be applied to inspect the perimeter. Instead, a mask is dynamically generated for each image using the results of **Line Fitter**, **Arc Fitter** and computed line tools. These tools can locate the actual perimeter to be inspected and can take into account expected variations in the outline of the wafer to be inspected.

This tool can operate on any convex shape whose outline can be defined by 12 lines and arc. An example of acceptable shapes are as follows:



While this tool could be extended to handle outlines with concave features, the following shapes are currently not supported.



This tool dynamically generates a mask to compare against the image using the results of up to 12 lines and arcs. The intersection of the lines and arc are automatically computed to bound the mask. Therefore, the lines and arc must be specified in the **PerimeterTools** list in the order in which they appear as you trace around the perimeter in a counter-clockwise direction. After the mask has been created, it can be shrunk if desired by a series of erosion operations. If the object to be tested has slightly rough edges, this will eliminate a few pixels along the perimeter from consideration.

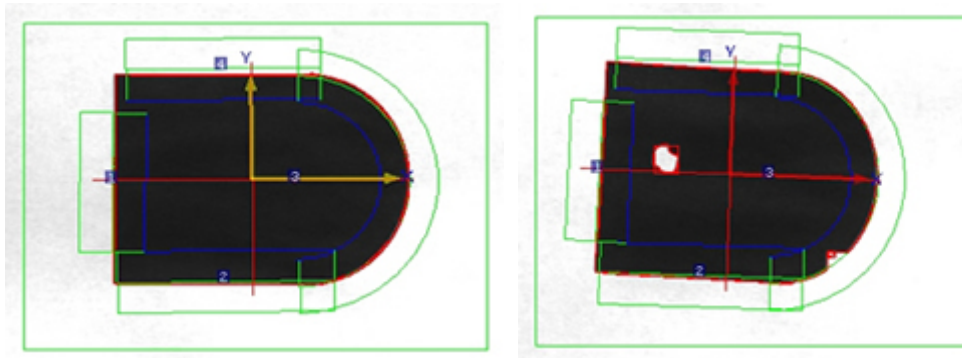
The region to be tested is then converted to either a binary or an edge image and the mask is AND'ed with the converted region. Any flaws along the perimeter or in the interior of the region will be left as non-zero pixels. A connectivity algorithm is next applied to identify any collection of non-zero pixels that are large enough to constitute an important defect.

The number of detected defects are counted and if any defects exist, this tool returns with a failure indication.

The sensitivity of the tool can be adjusted using the **SetMinBlobArea** and **SetNumOfErosions** properties. These parameters control the minimize size of flaws that are considered defects and how much the mask is shrunk before it is applied.

Examples

Below is an example of a **Region Inspect** tool that detects missing regions along the perimeter of a part. On the left is a good part that passes. On the right is a part that fails due to a missing region along an "arc" and an interior defect. Any detected defects are automatically highlighted by a bounding red rectangle.

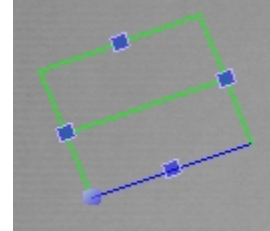


See Also

[Vision Toolkit](#) | [Line Fitter](#) | [Arc Fitter](#)

Line Fitter Tool

Vision tool that searches a specified region for edge points and returns the line that best fits the edges.



Prerequisites

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	-360 to 360	Standard Placement / Size properties. The X and Y values define the center of the tool and the center of the search region. The Height and Width specify the size of the search region.
Height	Single	0 - AOI (mm)	
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	-360 to 360	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
EdgeMode	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

			<p>line with the highest contrast.</p> <p>The concentration mode is particularly useful if there are two or more distinct non-collinear 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.</p>
EdgeThreshold	Integer	0 - 254	<p>Specifies the threshold below which weak (low contrast) gradients edges are ignored. The smaller the number, the more sensitive the system is in locating edges. Please see the description of the Edge Locator for more information on edge gradients. The default value is 30.</p>
3A. Advanced Operation			
BiasFilter	List	..._BIAS_NONE / ..._BIAS_TO_LIGHT / ..._BIAS_TO_DARK	<p>For 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 the line to the tips of the high or low points rather than along the center line.</p>
DrawEdgePoints	List	..._NO_EDGE_POINTS / ..._ALL_EDGE_POINTS / ..._USED_EDGE_POINTS	<p>If set, draws yellow dots to indicate ALL edge points that are selected after the EdgeMode is applied or only those edges that are USED to fit lines after the EdgeMode is applied and all outliers are eliminated. This is very helpful for understanding the effect of changing various property settings. This value is NO_EDGE_POINTS by default.</p>
MaxEdgePoints	Integer	2 - n	<p>Maximum number of edge point searches to perform. Higher numbers produce greater accuracy at the expense of execution speed. The minimum value of this</p>

			parameter is 2. This value is automatically limited to the number of pixels across the width of the tool. The default value is 30.
MaxIterations	Integer	0 - n	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.
MinFilterDistance	Single	0 - n.nn	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.
SigmaFilter	Single	0 - n.nn	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.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	
InspectType	List	NONE / ..._RMS / ..._ANGLE / ..._NUM_EDGES_FOUND / ..._NUM_EDGES_USED	
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
OffsetAngle	Single	degrees	Standard Results Settings

OffsetX	Single	mm	properties
OffsetY	Single	mm	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultErrorCode	Integer		Standard Results properties
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	
ResultNum-EdgesFound	Integer		Number of edge points found. [GPL: VisResult.Info(1)]
ResultNum-EdgesUsed	Integer		Number of edge points remaining after the filtering process. [GPL: VisResult.Info(2)]
ResultRMS	Single		Root mean square of the line fit. [GPL: VisResult.Info(0)]

Remarks

The Line Fitter searches the region defined by its green and blue outlined 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 dark (blue) and light (green) sides of 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 blue 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 **MaxEdgePoints** number of linear edge searches using the **Edge Threshold**.
2. For each edge search, the single edge point that best fits the **EdgeMode** 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. **MaxIterations** specifies the maximum number of fits to perform. After each line fit, edges that are beyond **SigmaFilter** standard deviations are rejected, unless the edge is within

MinFilterDistance pixels of the fit line. The iterative process stops if (i) **MaxIterations** 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 **MaxEdgePoints**. 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 **MaxEdgePoints**. On the other hand, the accuracy of the tools increases approximately as the square root of **MaxEdgePoints**. That is, if you increase **MaxEdgePoints** by a factor of 4, the tool execution time will quadruple but the accuracy will only double.

In order to address some unusual cases, the Line Fitter provides special modes of operation. For lines with an irregular or jagged edge, the **BiasFilter** 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 **EdgeMode** 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.

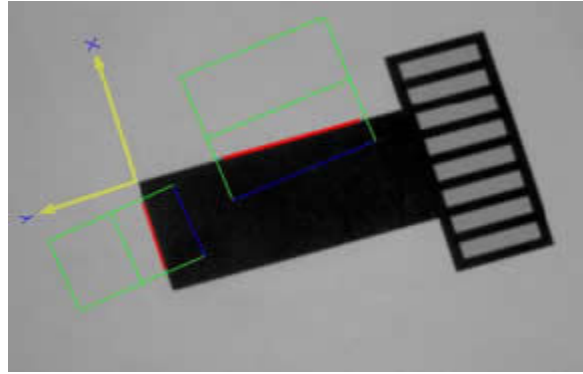
Special Feature Buttons (located above the property editor)

Adjust Threshold

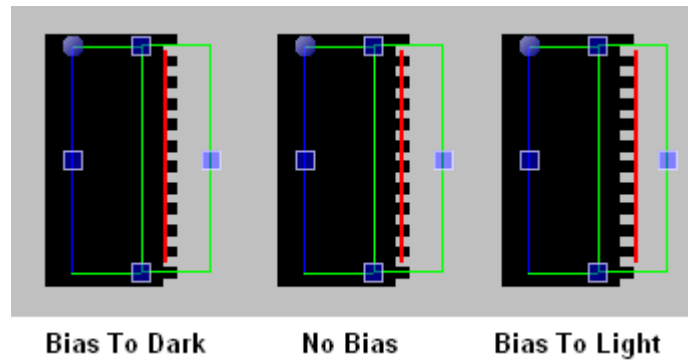
Pressing this button displays a pop-up window that permits the value of the **Edge Threshold** property to be manually adjusted while dynamically viewing the effect of the new setting in the Camera Display. The edges that satisfy the threshold criterion are displayed in white.

Examples

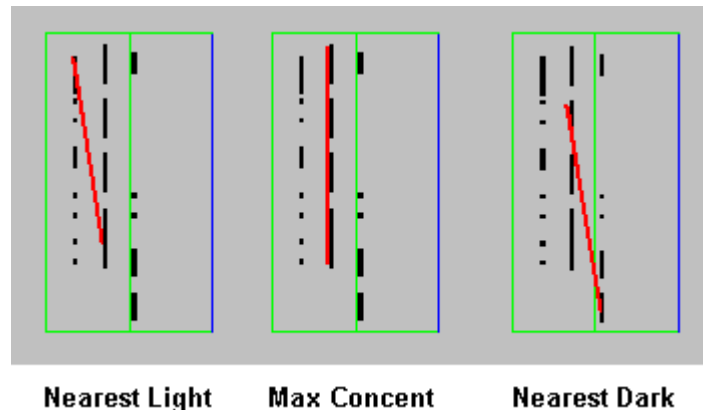
In the following example, two Line Fitters are utilized to accurately determine the positions and orientations of the straight sides of an object. A Computed Line-Line Intersection tool then takes the output of the two Fitters and generates a reference frame whose origin is at the intersection of the two fit lines. Since the two Line Fitters compute their results based upon multiple pixel values, their output values are very accurate.



The following example demonstrates the special case where the outer or inner edge of a series of fingers is to be located. If the standard Line Fitter is applied with FITLINE_BIAS_NONE, the fit line is located somewhere along the center of the fingers. To properly locate the inner or outer edge of the fingers, the **BiasFilter** should be set to FITLINE_BIAS_TO_DARK or FITLINE_BIAS_TO_LIGHT.



The following example demonstrates the special case where there are a series of closely spaced discontinuous parallel edges and you wish to locate the strongest edge. If you are not able to accurately position the finder and use **EdgeMode** to distinguish the desired line by specifying the nearest light, dark or nominal, FITLINE_MAX_CONCENTRATION may be of use. This method locates the line with the greatest concentration of strong edges and uses this to select the edge points that are considered during the iterative line fitting.



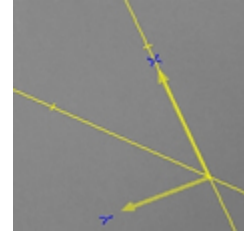
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See Also

[Vision Toolkit](#) | [Arc Fitter](#) | [Edge Locator](#) | [Find Centerline Tool](#) | [Point-Point Line Tool](#)

Line-Line Frame Tool

Computational tool that determines the intersection of two lines defined by vision objects and returns a reference frame.



Prerequisites

Requires two vision objects that each supply either a line or a frame.

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
SourceLine1Name	List	n/a	Name of the vision object that defines the line that determines the X-axis of the computed reference frame.
SourceLine2Name	List	n/a	Name of the vision object that defines the second line that is intersected with the first line.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties. Can be used to validate the ResultAngle .
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	
InspectType	List	NONE / RESULT_ANGLE	
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			

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OffsetAngle	Single	degrees	Standard Results Settings properties
OffsetX	Single	mm	
OffsetY	Single	mm	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultAngle	Single	-360 to 360	Standard Results properties
ResultXPos	Single	mm	
ResultYPos	Single	mm	

Remarks

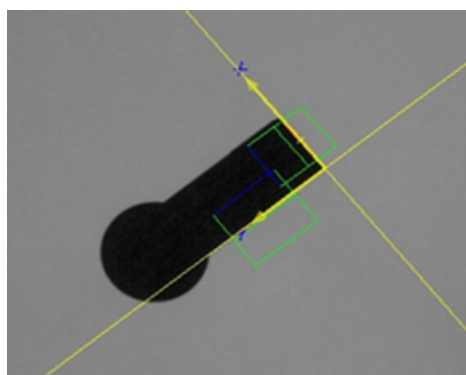
This computational tool combines the results of two vision tools to compute a new reference frame. The inputs to this method from the vision objects are two non-parallel lines. The X-axis of the new reference frame will be collinear with the first input line. The origin of the new frame will be at the 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.

Alternately, this method can be utilized to compute the position of a corner of an object as determined by its two adjacent straight sides.

Examples

The following example illustrates how two Line Fitters can be applied to accurately identify the position and orientation of two adjacent sides of an object. The results of the two Fitters are then fed into a Line-Line Frame Tool to yield a reference frame that accurately represents the position and orientation of the enclosed corner.

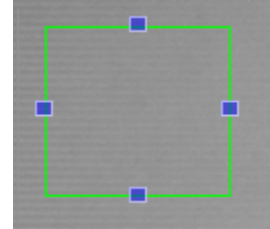


See Also

[Vision Toolkit](#) | [Fixed Frame Tool](#) | [Point-Line Frame Tool](#) | [Point-Point Line Tool](#)

Pixel Window Tool

Vision tool that counts pixels of a specific type or computes pixel statistics within a rotated rectangular or circular region. This tool is typically used to quickly determine if a feature is present or to verify that the average gray-level reading of a region is correct.



Prerequisites

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	-360 to 360	Standard Placement / Size properties. The X and Y values define the center of the region to be processed. The Height and Width define the dimensions of the region.
Height	Single	0 - AOI (mm)	
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	-360 to 360	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
PixelMode	List	BINARY_STATS / GRAY_STATS / EDGE_LEVEL	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.
CountWhitePixels	Boolean	TRUE / FALSE	(BINARY) If TRUE indicates that the white pixels are to be counted. Otherwise, black pixels are counted.
Threshold	Integer	0 - 254	(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. Please see the description of the Edge Locator for more information on edge gradients. The default value is 30.
ToolShapeType	List	RECTANGULAR / ROUND / SQUARE	Shape of the window in which the pixels are analyzed. A square window has its aspect ratio forced to 1:1.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	
InspectType	List	NONE / MEAN / NUM_PIXELS / STANDARD_DEV / MINPIXELVAL / MAXPIXELVAL / PIXELSUM / PIXELSUMSQUARE	
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
OffsetAngle	Single	degrees	Standard Results Settings

OffsetX	Single	mm	properties
OffsetY	Single	mm	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultErrorCode	Integer		Standard Results properties
ResultAngle	Single	0 (non-rotating)	(BINARY,EDGE) X and Y position represent the centroid of the counted binary or edge pixels.
ResultXPos	Single	mm	
ResultYPos	Single	mm	
ResultPixelCount	Integer		(BINARY,EDGE) Total number of counted binary or edge pixels in the rectangular region. <i>[GPL: VisResult.Info(0)]</i>
ResultMean	Single		(GRAY) Mean gray-scale value of all pixels in the region. <i>[GPL: VisResult.Info(1)]</i>
ResultMaxPixelValue	Integer		(GRAY) Maximum gray-scale value of all pixels in the region. <i>[GPL: VisResult.Info(4)]</i>
ResultMinPixelValue	Integer		(GRAY) Minimum gray-scale value of all pixels in the region. <i>[GPL: VisResult.Info(3)]</i>
ResultPixelSum	Integer		(GRAY) Sum of gray-scale values of all pixels in the region. <i>[GPL: VisResult.Info(5)]</i>
ResultPixelSumSqr	Integer		(GRAY) Sum of the squares of the gray-scale values for all pixels in the region. <i>[GPL: VisResult.Info(6)]</i>
ResultStandardDev	Single		(GRAY) Standard Deviation of the gray-scale values for all pixels in the region. <i>[GPL: VisResult.Info(2)]</i>

Remarks

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 mode can be applied to detecting defects in a uniform area such as inspecting for scratches or pits in a lens. The GRAY 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.

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When this tool is operated in the BINARY 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 **CountWhitePixels** 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 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 GRAY 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.

Special Feature Buttons (located above the property editor)

Adjust Threshold

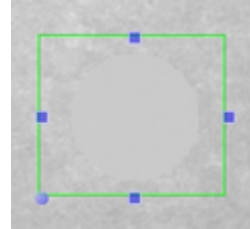
Pressing this button displays a pop-up window that permits the value of the **Threshold** property to be easily adjusted while dynamically viewing the effect of the new setting in the Camera Display. In BINARY mode, the displayed image shows all pixels converted to black or white, where the white pixels are the ones that are counted. In EDGE mode, the edge pixels that are extracted and will be counted are displayed in white.

See Also

[Vision Toolkit](#) | [Pixel Color Window](#)

Pixel Color Window Tool

Vision tool that tests if the color of a region matches a trained color. Within each of the RGB layers of a color image, this tool computes the mean intensity value for a specified region and determines if each mean is within an acceptable tolerance of the trained value for the color layer.



Prerequisites

Requires a color camera.

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	0 (<i>non rotating</i>)	Standard Placement / Size properties. The X and Y values define the center of the region to be processed. The Height and Width define the dimensions of the region.
Height	Single	0 - AOI (mm)	
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	0	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation properties
Relative-ToolName	List	n/a	
ToleranceBlue	Integer	0-100%	Define the tolerances that must be satisfied between
ToleranceGreen	Integer	0-100%	

ToleranceRed	Integer	0-100%	the computed mean intensity values of the specified region in each color layer and the corresponding trained mean values. For example, if the ToleranceBlue is set to 5%, the computed mean of the pixel values in the specified region of the blue color layer must be within +/-5% of the InspectNominalBlue value for the inspection to return "Pass"..
ToolShapeType	List	RECTANGULAR / ROUND / SQUARE	Shape of the window in which the pixels are analyzed. A square window has its aspect ratio forced to 1:1.
4. Inspection Settings			
InspectActualBlue	Integer	0-255	Standard Inspection Settings properties . In the RESULT_FIXED mode, the tolerance comparison is performed with the raw nominal and actual mean intensity values. This can be used when the lighting is very controlled and the product color does not vary. In the RESULT_NORMALIZED mode, the nominal and actual mean values are adjusted each time the tool is executed to compensate for uniform variations in the color intensity values. This enables the color matching to be robust even when there is some variation in the lighting.
InspectActualGreen	Integer		
InspectActualRed	Integer		
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	
InspectType	List	NONE / RESULT_NORMALIZED / RESULT_FIXED	
InspectPassed	List	Pass / Fail	
InspectNominalBlue	Integer	0-255	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. These values are typically taught by pressing the Train Color button (see below).
InspectNominalGreen	Integer		
InspectNominalRed	Integer		
5. Results Settings			

OffsetAngle	Single	degrees	Standard Results Settings properties
OffsetX	Single	mm	
OffsetY	Single	mm	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultErrorCode	Integer		Standard Results properties
ResultAngle	Single	0	
ResultXPos	Single	mm	
ResultYPos	Single	mm	
ResultMeanBlue	Single	0-255	Mean color value of pixels in specified region. [GPL: VisResult.Info(2)]
ResultMeanGreen	Single	0-255	Mean color value of pixels in specified region. [GPL: VisResult.Info(1)]
ResultMeanRed	Single	0-255	Mean color value of pixels in specified region. [GPL: VisResult.Info(0)]
ResultPercentBlueMatch	Integer	0-100	Match percentage for a color layer [GPL: VisResult.Info(5)]
ResultPrecentGreenMatch	Integer	0-100	Match percentage for a color layer [GPL: VisResult.Info(4)]
ResultPrecentRedMatch	Integer	0-100	Match percentage for a color layer [GPL: VisResult.Info(3)]

Remarks

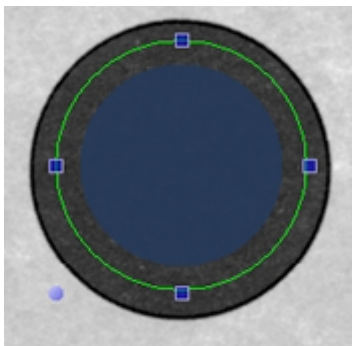
This tool compares the general color of a region of interest with a taught color and returns a Pass/Fail indication of whether the colors matched within a specified tolerance. The region can be defined as a rectangular, square or circular shape. The color of the region is determined by computing the mean intensity value for each of the three color layers (RGB). These actual mean values are compared against three taught mean values. If all three pairs of number are within specified % tolerances, the colors are considered to be a match and this tool returns a pass indication.

To improve the robustness of this tool when the lighting conditions may vary, the **InspectionType** can be set to RESULT_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 color layers of the captured color image independent of which layer the picture **Acquisition Tool** loaded into the current frame buffer.

To assist in teaching this tool, the center of the tool is always displayed with a semi-transparent circular area that is tinted with the mean color for the region of interest. This is illustrated in the following picture where the center is tinted in blue.

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In addition, the camera display window can always be switched into color display mode by pressing on the "Toggle Color Display Mode" button in the main Toolbar.

Special Feature Buttons (located above the property editor)

Train Color

Pressing this button assists in teaching the color for the region of interest. After confirmation, the values for the **InspectNominalRed**, **InspectNominalGreen**, **InspectNominalBlue** properties are set to the current mean values of the selected region of the currently displayed image.

Examples

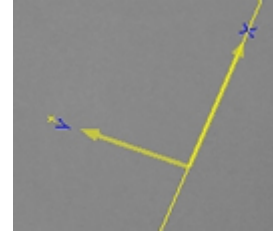
none

See Also

[Vision Toolkit](#) | [Pixel Window](#)

Point-Line Frame Tool

Computational tool that takes a point and a line from two vision objects and returns a reference frame.



Prerequisites

Requires two vision objects, one of which supplies a line or a frame and the other of which supplies a point.

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
SourceLineName	List	n/a	Name of the vision object that defines the line.
SourcePointName	List	n/a	Name of the vision object that defines the point.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties. Can be used to validate the ResultAngle .
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	
InspectType	List	NONE / RESULT_ANGLE	
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
OffsetAngle	Single	degrees	Standard Results Settings properties

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OffsetX	Single	mm	
OffsetY	Single	mm	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultAngle	Single	-360 to 360	Standard Results properties
ResultXPos	Single	mm	
ResultYPos	Single	mm	

Remarks

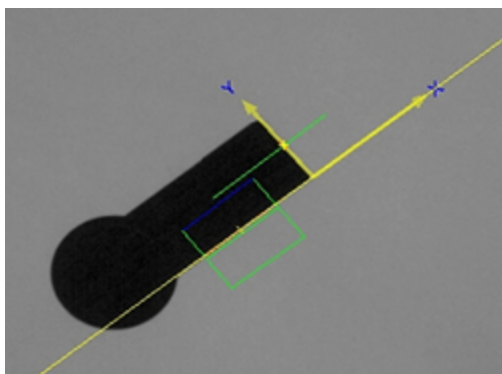
This computational tool combines the results of two vision tools to compute a new reference frame. The inputs to this method from the vision objects are a line and a point that is not on the line. The X-axis of the new reference frame will be collinear with the input line. The Y-axis of the new frame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

Examples

The following example illustrates how a Line Fitter and an Edge Locator can be applied to accurately identify the position and orientation of one side of an object and a point on a perpendicular side. The results of the Fitter and Locator are then fed into a Point-Line Frame Tool to yield a reference frame that accurately represents the position and orientation of this section of the object. The origin of this reference frame also specifies the point on the line that is closest to the point determined by the Edge Locator.

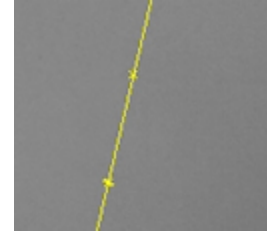


See Also

[Vision Toolkit](#) | [Fixed Frame Tool](#) | [Line-Line Frame Tool](#) | [Point-Point Line Tool](#)

Point-Point Line Tool

Computational tool that computes a line given two points from vision objects.



Prerequisites

Requires two vision objects that each supply either a point, a line or a frame.

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
SourcePoint1Name	List	n/a	Name of the vision object that defines one of the two points on the line.
SourcePoint2Name	List	n/a	Name of the vision object that defines one of the two points on the line.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties. Can be used to validate the ResultAngle .
InspectLabel	List	NONE / PASS_AND_FAIL / PASS / FAIL / VALUE_REAL / VALUE_INTEGER	
InspectType	List	NONE / RESULT_ANGLE	
InspectMax	Single		
InspectMin	Single		
InspectPassed	List	Pass / Fail	
5. Results Settings			
OffsetAngle	Single	degrees	Standard Results Settings properties
OffsetX	Single	mm	

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OffsetY	Single	mm	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultAngle	Single	-360 to 360	Standard Results properties
ResultXPos	Single	mm	
ResultYPos	Single	mm	

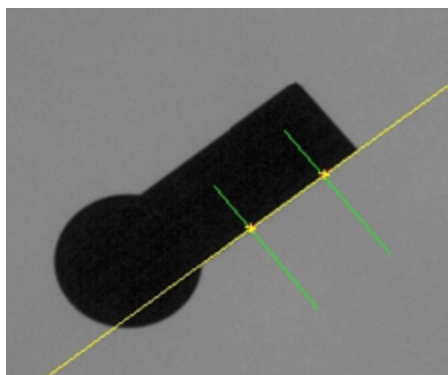
Remarks

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.

Examples

The following example illustrates how two Edge Locators can be applied to find two reference points on the edge of an object to sub-pixel accuracy. The results of the two Locators can then be fed into the Point-Point Line Tool to compute a line that represents the location of one side of the object. This line can then be combined with other tools to measure the dimensions of the object or to establish reference frames. Note that, in general, a more accurate line fit can often be obtained using the Line Fitter Tool. However, there are incidences where an edge is non-uniform and selecting two good points to construct a line is advantageous.

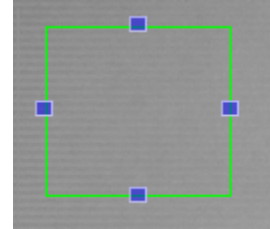


See Also

[Vision Toolkit](#) | [Fixed Frame Tool](#) | [Line-Line Frame Tool](#) | [Point-Line Frame Tool](#) | [Line Fitter Tool](#)

Sensor Window Tool

Vision tool that detects part movement or no movement within a specified region of the image. This tool takes multiple camera images in succession using a single camera and determines if there are any significant changes.



Prerequisites

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	an/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Height	Single	0 - AOI (mm)	Standard Placement / Size properties. The X and Y values define the center of the tool. The Height and Width specify the size of the image region being tested.
Width	Single	0 - AOI (mm)	
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
DelayAfterComplete	Single	0-n	Specifies an amount of time to wait after the operation is completed (post-processing dwell time).
EdgeThreshold	Integer	0 - 254	Specifies the threshold below which weak (low contrast) gradients edges are ignored. The lower this property is set, the more sensitive the system is in locating edges. Please see the description in the Edge Locator Tool for more information on edge gradients. The default value is 30.
MaximumTimeout	Single	0-n (seconds)	Specifies a maximum time (in

			seconds) that the tool will execute. If this time is exceeded, the tool stops processing and returns an error.
PixelChangeAmount	Integer	0-n	If more than this specified number of edge pixels change between successive images, this tool declares that motion has been detected.
SenseMode	List	WAIT_MOTION_STOP / WAIT_MOTION_START	Specifies the operating mode of this tool. The default is to "wait for no motion".
3A. Advanced Operation			
ExposureTime	Integer		Same properties as in the Acquisition Tool . See that tool for details.
VideoGain	Integer		
VideoOffset	Integer		
5. Results Settings			
ShowResults	List	NONE / FRAME / LINE / POINT	Standard Results Settings property
6. Results			
ResultErrorCode	Integer		Standard Results properties
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	
ResultActualTime	Single	sec	Actual time in seconds for operation to complete. <i>[GPL: VisResult.Info(1)]</i>
ResultPixelCount	Integer		Actual number of pixels detected during the operation. <i>[GPL: VisResult.Info(0)]</i>

Remarks

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 **PixelChangeAmount** to determine if sufficient pixels have changed to declare that movement has been detected. Based upon the setting of the **SenseMode** 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 are always taken. During this operation, no graphics are displayed on the screen. A dialog is placed above

the vision window to indicate that the operation is in progress and permits the operator to abort the tool.

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.

Special Feature Buttons (located above the property list):

Show Motion Image

Displays the output of comparing a single pair of images. Any pixels that are detected as changed (moving) are drawn in white. If zero motion is taking place, the entire image will be black.

Test Motion (Continuous)

Places tool in a continuous execution mode that allows the user to see the results of the motion dynamically. A small dialog box will appear in the center of the vision window that displays the number of pixel counts sensed as being in motion. Click the 'abort' button on the dialog to stop the test operation.

See Also

[Vision Toolkit](#) | [Acquisition Tool](#) | [Edge Locator Tool](#)

Text Label Tool

Text labeling tool that displays string constants plus inspection and results data from a referenced tool. Text is shown in the Camera Display Window relative to the position of the referenced tool.

Prerequisites

None

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
2. Placement/Size			
Angle	Single	-360 to 360	Standard Placement / Size properties. The X and Y values define the starting point for the text output and the Angle defines the orientation of the text string.
XPos	Single	0 - AOI (mm)	
YPos	Single	0 - AOI (mm)	
RelAngle	Single	-360 to 360	
RelXPos	Single	0 - AOI (mm)	
RelYPos	Single	0 - AOI (mm)	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
SourceToolName	List	n/a	Name of the vision object whose results are displayed by this tool.
EnableResultName	Boolean	True / False	If True, the name of the results data specified by ResultToolInfo will automatically be included in the output text string.
ResultToolInfo	List	NONE / InspectPassed / InspectFailed / ResultXPos / ResultYPos / ResultAngle / ...	This is a list of Inspection and Results properties that can be displayed. The items in the list are a function of the type of the tool selected by SourceToolName . For most tools, at least the properties listed in the Range field are available.
TextColor	Window Color	n/a	Permits the font color to be selected from the system color

	Selector		palette.
TextForceZeroAngle	Boolean	True / False	If True, will force the output text string to have a zero Angle even if the text is relative to a source tool whose result is rotated.
TextOutputType	List	FORMAT_INTEGER / FORMAT_REAL	Defines if numerical values should be output as integer or real numbers.
TextSize	Integer	1 - 50	Specifies the font size of the output string as a Windows Font Size (not in pixels).
TextTitle	String	n/a	Optional string that is placed at the start of the output text. This provides a way to customize the label for the results data. For multiple lines use the delimiter pipe character ' '. When this character is encountered, subsequent items will automatically be placed on the next line, including the results.
5. Results Settings			
ShowResults	List	NONE / FRAME / LINE / POINT	Standard Results Settings properties
6. Results			
ResultAngle	Single	-360 to 360	Standard Results properties
ResultXPos	Single	mm	
ResultYPos	Single	mm	

Remarks

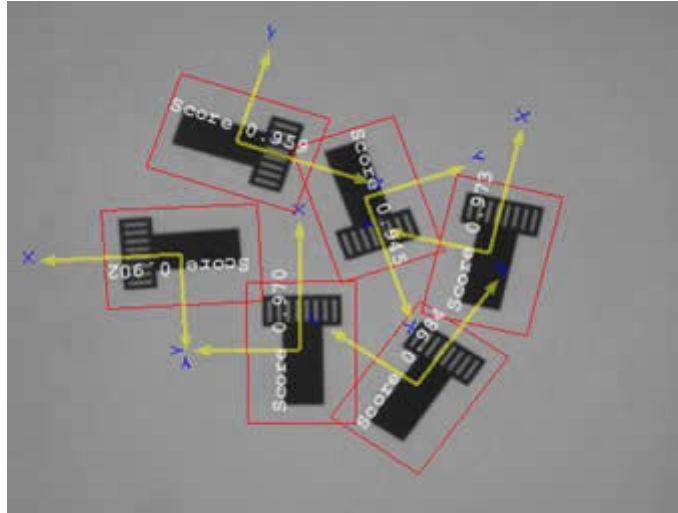
This tool displays text labels either in fixed positions in the Camera Display Window or relative to the results of other tools. If the text tool is relative to a source tool, the text can automatically include the values of selected Inspection and Results properties of the source tool.

NOTE: This tool cannot be specified as one of the source tools in an **Inspect List Tool**.

Examples

Below is an example of the **Text Label Tool**. In this example, each of the objects that has been located by a **Finder Tool** is labeled with the Finder's recognition score.

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See Also

[Vision Toolkit](#)

Tool Filter Tool

Filter tool that takes the output from another vision object that generates multiple sets of results, and returns a subset of the results based upon specified criteria.

Prerequisites

Requires another vision object that generates multiple sets of results.

Properties

Property Name	Data Type	Range	Description
1. Identity			
Name	String	n/a	Standard Identity properties
Type	String	n/a	
3. Operation			
Camera	Integer	1 - 6	Standard Operation property
SourceToolName	List	n/a	Name of the vision object that outputs multiple sets of results. These sets of results serve as the input to this tool.
3A. Advanced Operation			
SortResults	List	NONE / SORTFROMLEFT / SORTFROMRIGHT / SORTFROMTOP / SORTFROMBOTTOM	Automatically sorts the results based on the selection. This is useful for items on a conveyor belt that may need to be picked in order from the front to back of the conveyor.
ZeroAngle	Boolean	True / False	If True, will force the ResultAngle to ZERO. This is useful for randomly oriented parts that require the angle to be removed for picking. This operation does NOT change the sorting operation.
4. Inspection Settings			
InspectActual	Single		Standard Inspection Settings properties . All of the sets of results generated by the SourceToolName object are tested against this inspection criteria and those that pass become the output of the Tool Filter.
InspectType	List	NONE / RESULT_ID / RESULT_X_POS / RESULT_Y_POS / RESULT_ANGLE / RESULT_INSPECT_- STATUS	
InspectMax	Single		
InspectMin	Single		

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InspectPassed	List	Pass / Fail	
InspectString	String	n/a	Optional label that is displayed in the vision window on all input results that satisfy the inspection criteria. This provides a convenient way to display part ID or other information.
5. Results Settings			
MaxResults	Integer	-1 or 1 to n	Standard Results Settings properties
OffsetAngle	Single	degrees	
OffsetX	Single	mm	
OffsetY	Single	mm	
ResultSelect	Integer	1 - n	
ShowResults	List	NONE / FRAME / LINE / POINT	
6. Results			
ResultCount	Integer	0 - n	Standard Results properties
ResultAngle	Single	-360 to 360	
ResultXPos	Single	mm	
ResultYPos	Single	mm	

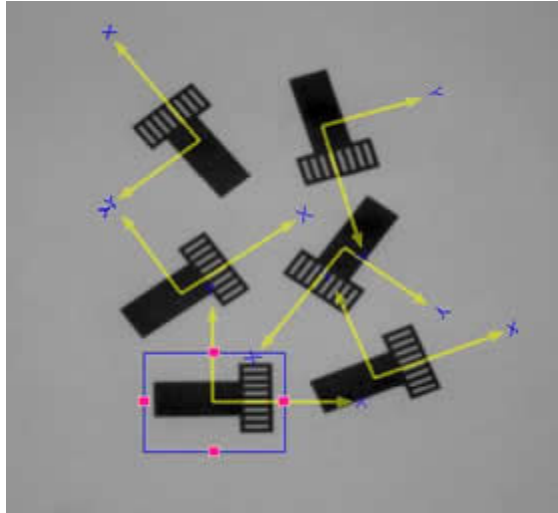
Remarks

This tool inputs the results from another vision object that generated multiple sets of results, and applies criteria specified by the "Inspection Settings" to filter the results. This allows a process to isolate results that require further special processing or to create queues of results based upon specified criteria. Multiple **Tool Filters** can be applied to the same vision object to allow all of the results of the input tool to be segmented and processed.

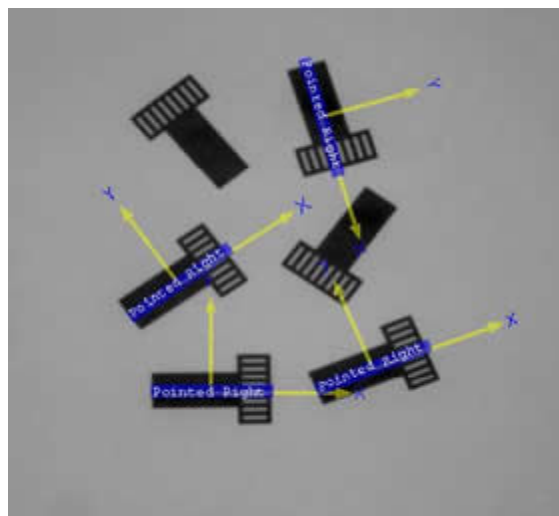
For example, if the input tool is a **Finder**, special processing can be applied to all objects located by the **Finder** that are in a specific region of the screen by defining a **Tool Filter** with the **InspectType** set to "RESULT_X_POS" or "RESULT_Y_POS".

Examples

Below is an example of a single **Finder** that has located 6 identical parts. You will note that the bottom left part was used as the tool template, so that all future part orientations will be with respect to this horizontal position with the top of the "T" pointed to the right.



If we now wish to segment these 6 parts by their orientation, we can apply a **Tool Filter** that references the output of the **Finder** by specifying the **Finder's SourceToolName**. By setting the **Tool Filter's InspectType** to "RESULT_ANGLE", we can select only those parts with a specific orientation. If we set the **InspectMin** and **InspectMax** to -90 degrees and 90 degrees respectively, only those objects that are approximately pointed to the right will be selected as the output of the Filter. We can also add a label to these parts by filling in the **InspectString**. The picture below shows the results of this filter where **InspectString** has been set to "Pointed Right". You will note that only four of the six parts located by the Finder will be output by the Tool Filter. If we wanted to further process these four parts, the Tool Filter output could be utilized as the input to yet another tool.



See Also

[Vision Toolkit](#) | [Finder Tool](#)

Camera Calibration

Camera Calibration Introduction

The PreciseVision camera calibration procedures generate the data necessary to convert camera pixel positions into real world units of measure, typically millimeters. For robot guidance, this calibration also translates camera positions into the robot's world coordinate system. This permits a robot to grasp a part that has been located by the vision system. Consequently, a camera must be calibrated with respect to a robot before a vision-guided application can be executed. Even for simple vision testing where PreciseVision is not communicating with a robot, calibration is still highly desirable (but not required), since the calibration process corrects for non-square pixels and cameras that are not perfectly perpendicular to the imaged plane, which causes perspective distortion. This correction is important as parts rotate to ensure that dimensions are always computed the same independent of the part's orientation.

So, when a camera is first put into use, it should be calibrated. In addition, calibration data should be updated if a camera with different optical characteristics is utilized, a camera is moved, a different camera lens is used or the length to the focal plane is altered. In general, it is always best to calibrate each camera that is placed into service and whenever any of the optical characteristics of a camera are modified.

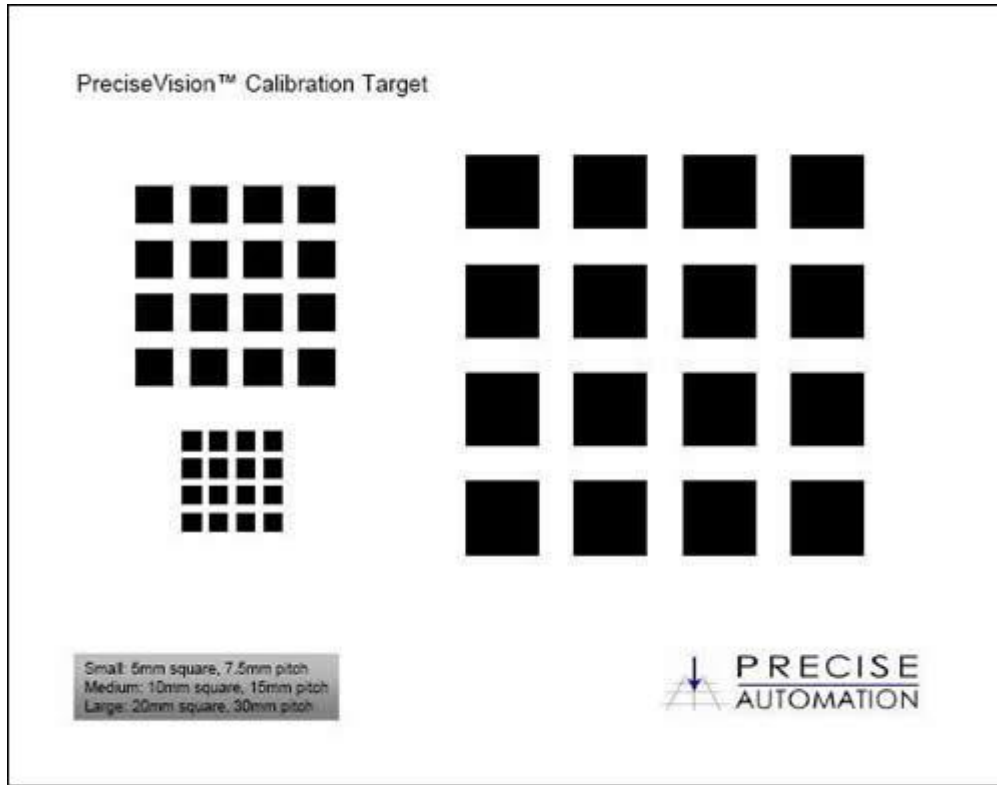
In the next section, general instructions and information that apply to all calibration methods are presented. This is followed by information concerning the various calibration methods.

General Calibration Instructions

This section includes descriptions of general procedures that apply to all calibration methods. This section should be read prior to executing any of the calibration methods.

Standard Calibration Target Sheet

All calibration methods are required to establish the conversion between camera pixel positions and millimeters. In most cases, PreciseVision determines this relationship based on viewing a Standard Calibration Target Sheet that contains patterns of squares that have a known size and pitch. Three different pattern sizes are provided to accommodate different camera fields of view. The target sheet can be used without a robot or any automatic motion. This sheet looks like the following:



This target sheet is provided as a .pdf file and can be found via the Windows Start menu:

Start > Programs > Precise Automation > PV xxx > Documentation > PreciseVisionCalibrationTarget.pdf

or by browsing to the "\resource\" folder created upon installation of PreciseVision.

**\Program Files\Precise Automation\PreciseVision
#.resource\PreciseVisionCalibrationTarget.pdf**

The calibration target sheet should be printed out at the highest possible resolution and quality. When you are instructed to do so, this sheet should be placed in the focal plane of the camera. The focal plane of the camera should be as close as possible to the actual Z height of the primary part features to be located or inspected.

Camera Setup

Prior to executing a calibration process, the camera must be rigidly mounted, selected in software and carefully setup. The camera can be selected from the **View > Select Camera** top-level menu. The aperture and focus can then be manually set by viewing the camera image in "live video" mode. If the camera is not in this mode, it can be initiated by pressing an icon in the main toolbar. Finally, the camera gain and offset that control the brightness and brightness range should be set by selecting **Tool > Camera Video Properties**.

Camera Calibration Wizard








PreciseVision

When you select **Tool > Calibrate Vision > Camera Calibration Wizard**, a wizard is initiated and the following pop-up is displayed.



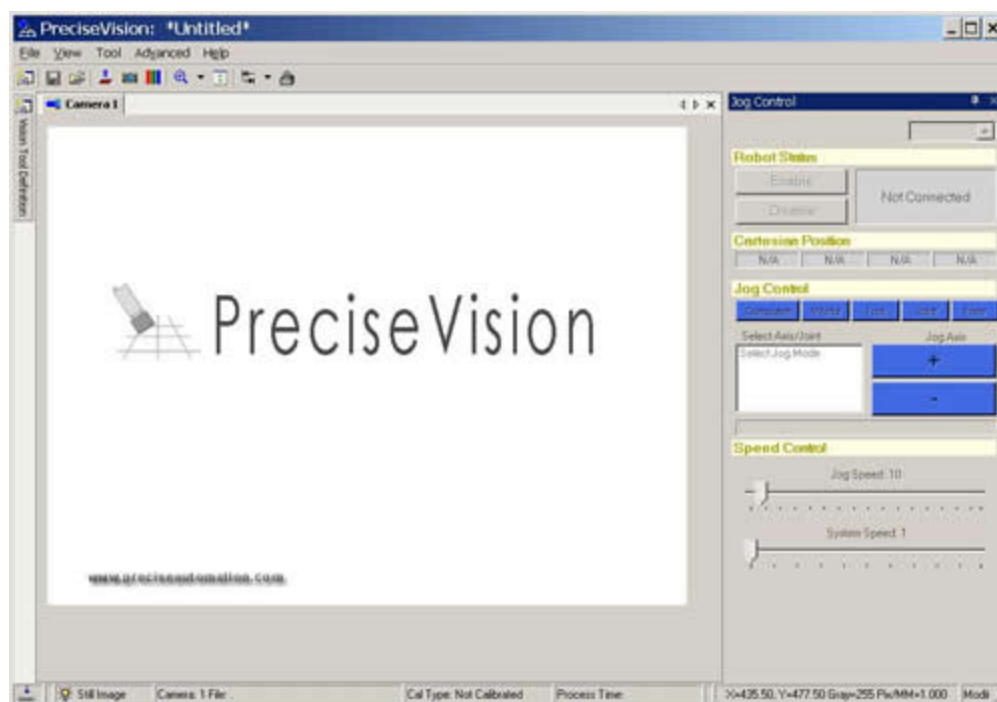
This wizard takes you step-by-step through the process of calibrating a camera either for standalone vision or for a vision-guided robotic application with the camera mounted in a variety of configurations. The instructions are fairly self-explanatory.

While each page of the wizard is different, the following toolbar buttons are available on every page to assist you with the calibration process.

CalibrationWizard Toolbar		
Icon	Tool Tip Title	Description
	Live Video	Continuously updates the displayed camera image to show a "live" image.
	Single Picture	Captures a single picture (snap shot) from the selected camera.
	Load Robot Calibration	Displays a pop-up file folder window that permits an existing vision calibration file to be selected and loaded. This allows an old calibration file to be loaded and tested.
	Save Robot Calibration	Displays a pop-up file folder window that permits the current calibration data to be saved to a disk file.
	Continuous Threshold	Updates the displayed camera image as a thresholded binary image instead of the standard gray scale.
	Open Threshold Tool	Displays the pop-up that permits changing the threshold for the binary image.
	Reset Calibration	Provides a way to reset the camera calibration to its default (unity scaling).

Calibration Layout

When the Camera Calibration Wizard is selected, the layout of the main PreciseVision window automatically changes to the following "Calibration Layout".



This arrangement has a large Camera Display Window on the left and a panel on the right that is provided as a convenience for moving a robot in manual control. The robot panel is utilized if a camera-to-robot calibration is performed. The Calibration Wizard includes a panel for connecting to a robot controller. When this connection is established, the manual control panel becomes active.

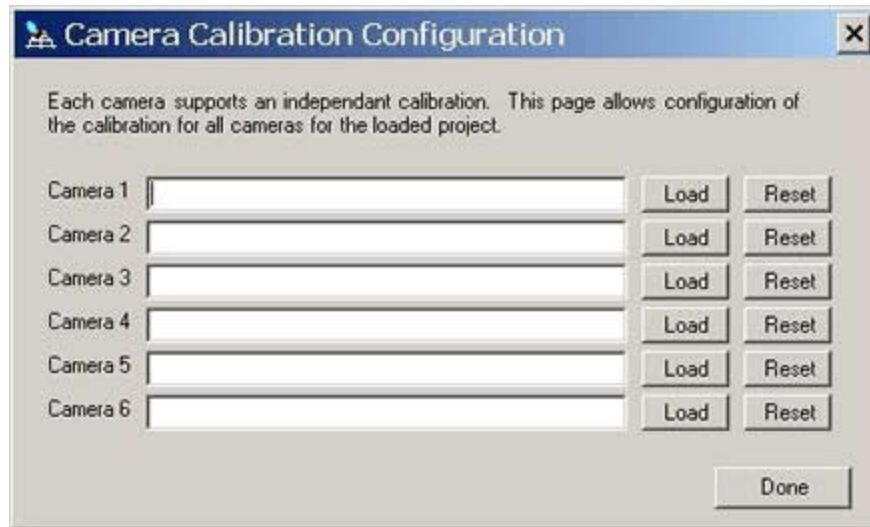
To switch back to the default arrangement for the main PreciseVision window, select **View > Layouts > Load Default** or **View > Layouts > Load Edit Layout**.

Calibration Data Files

Calibration information is stored in disk files with a ".dat" extension. By default, these files are stored in the "ExampleProjects" folder in the PreciseVision directory. For example, for the default installation directory for PreciseVision version 1.2, the calibration files will be stored in the following directory:

C:\Program Files\Precise Automation\PreciseVision 3.0\ExampleProjects

After a calibration data disk file has been created, it has to be specified in each Vision Project in which it is to be used. When a Vision Project is opened, to associate a calibration file with a camera, open the Camera Calibration Configuration pop-up by selecting **Tool > Camera Calibration Configuration**. The pop-up panel should appear as follows:



Click the Load button to select a calibration file to be associated with a camera. A dialog window will be displayed that will allow you to browse to the directory location that contains the calibration (.dat) file. If you wish to delete an association between a camera and a calibration file, click on the Reset button.

Once a camera calibration file is specified in the Camera Calibration Configuration menu, the calibration will automatically be applied whenever a picture is acquired from the referenced camera within the Vision Project. Also, whenever the Vision Project is opened, the specified calibration files will be automatically opened and reloaded.

Basic Camera Calibration

All of the calibration methods including standalone vision (Camera Only) and robot guidance begin by calibrating the camera's pixel coordinate system into real world units of measure, typically millimeters. In addition, this procedure adjusts for perspective distortion, which occurs when the camera is not perfectly perpendicular to the plane of the objects to be located. The origin of the camera's coordinate system is set to the bottom left-hand corner of the camera image.

After this basic calibration is completed, the vision system can be used for metrology operations or for other applications not needing a robot. However, since this step does not include a transformation between the camera frame of reference and the world coordinate system of a robot, this step is not sufficient for vision-guided robot applications.

This procedure relies upon the Standard Calibration Target Sheet and does not require a robot or any automated motion.

Prior to executing the Calibration Wizard, the following steps must first be performed:

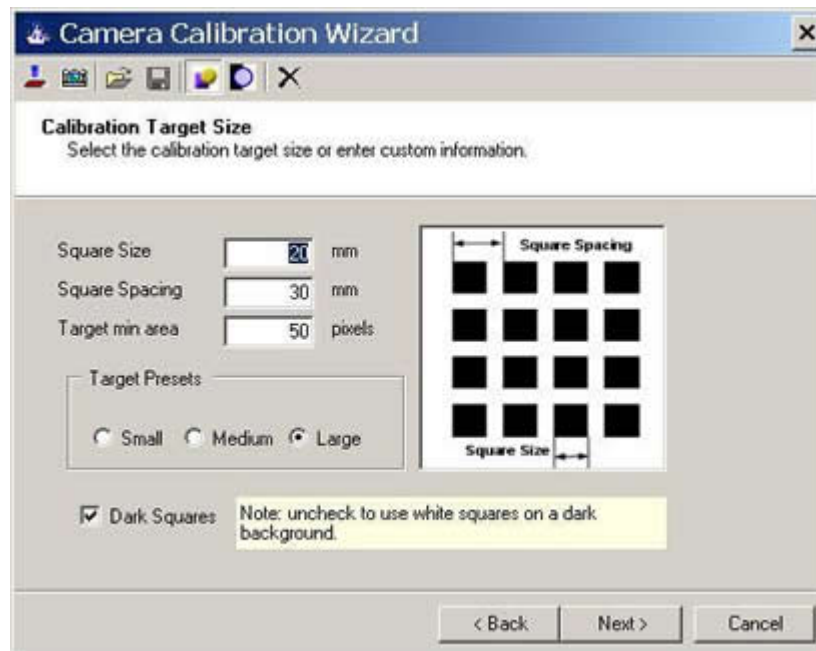
- The "[General Calibration Instructions](#)" section of this manual should be read.
- The Standard Calibration Target Sheet must be printed and available.
- The camera must be rigidly mounted, selected, and accurately setup in terms of its focus, aperture setting, and gain and offset.

The Calibration Wizard is fairly self-explanatory. The following provides some additional information for first time users.

- » To start this calibration method, select **Tool > Calibrate Vision > Camera Calibration Wizard**.
- » Advance past the title page by pressing the **Next** key. You can stop the calibration process at anytime by pressing the **Cancel** key.
- » Select the type of camera calibration you wish to perform. **Camera Only** will not perform the camera to robot calibration and is only appropriate for testing and standalone vision.



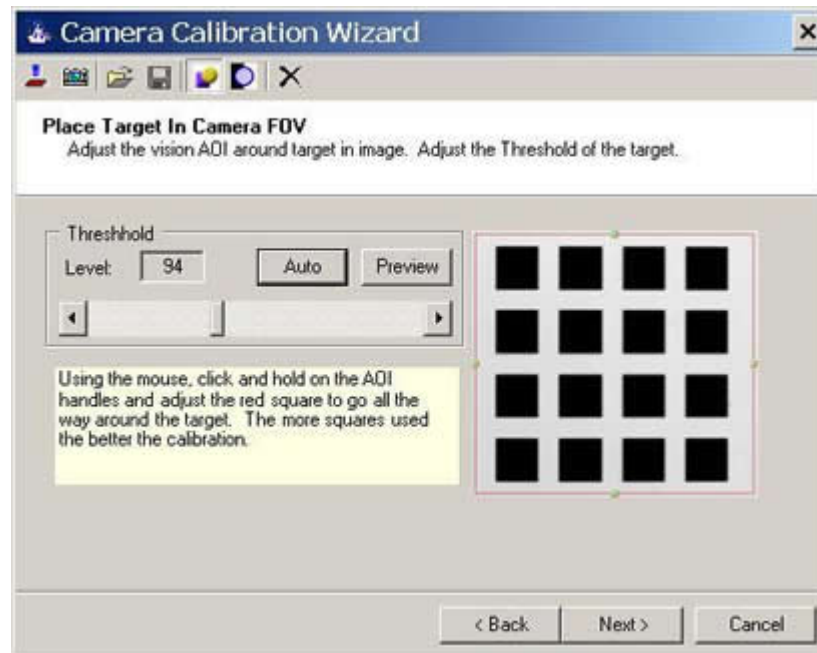
- » Advance to the next page of the wizard and specify the size of the calibration target you will be using.



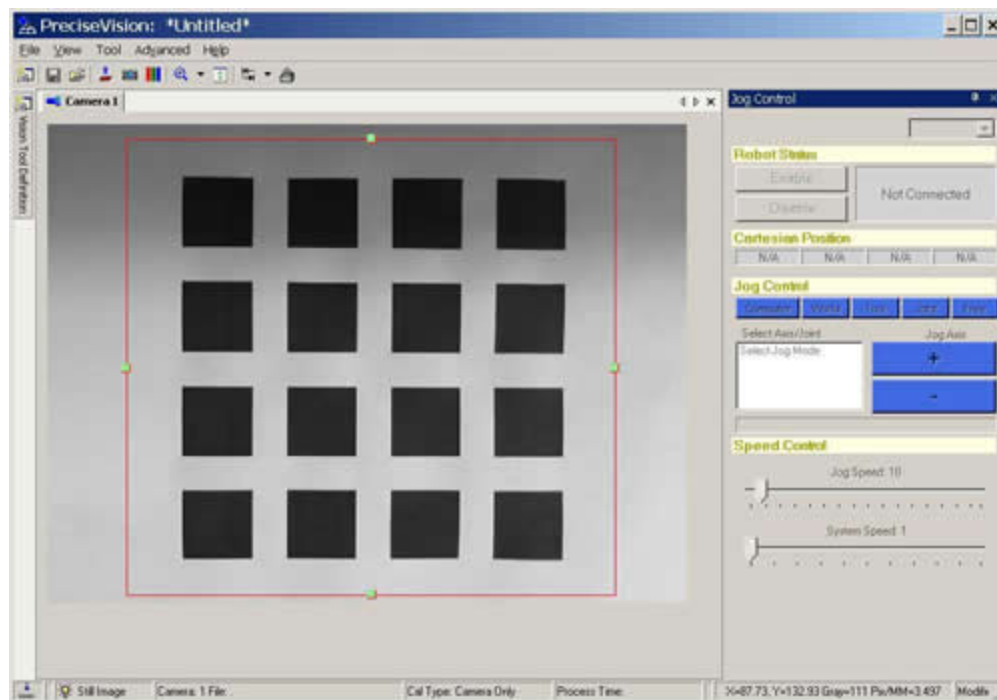
This page permits you to select from one of the standard sizes that are provided on the PreciseVision Calibration Target sheet or to manually enter the target dimension parameters if you have generated a custom sized target that is more appropriate for your application. You should select the largest pattern that is fully visible within the camera's field-of-view.

The standard target has black squares printed on a white background, so the **Dark Squares** should normally always be checked.

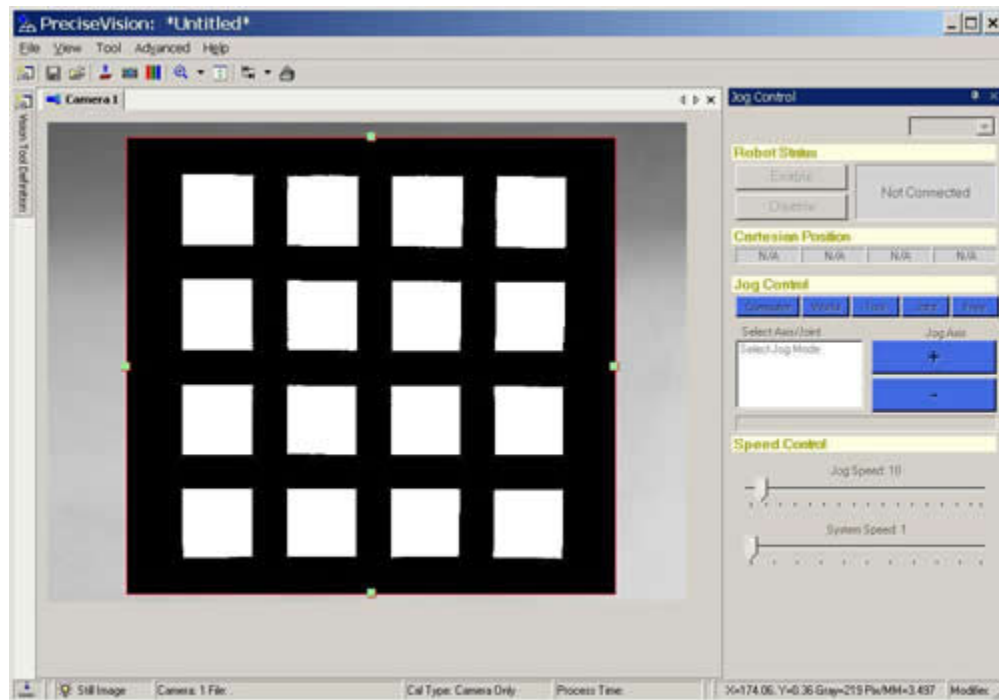
- » Place the Calibration Target Sheet in the same focal plane that you expect the primary part features to be located. Position the sheet such that the pattern you have selected is fully visible in the field-of-view.
- » Advance to the next page of the Wizard to adjust the binary threshold of the image and to set the size and position of the AOI that contains the target.



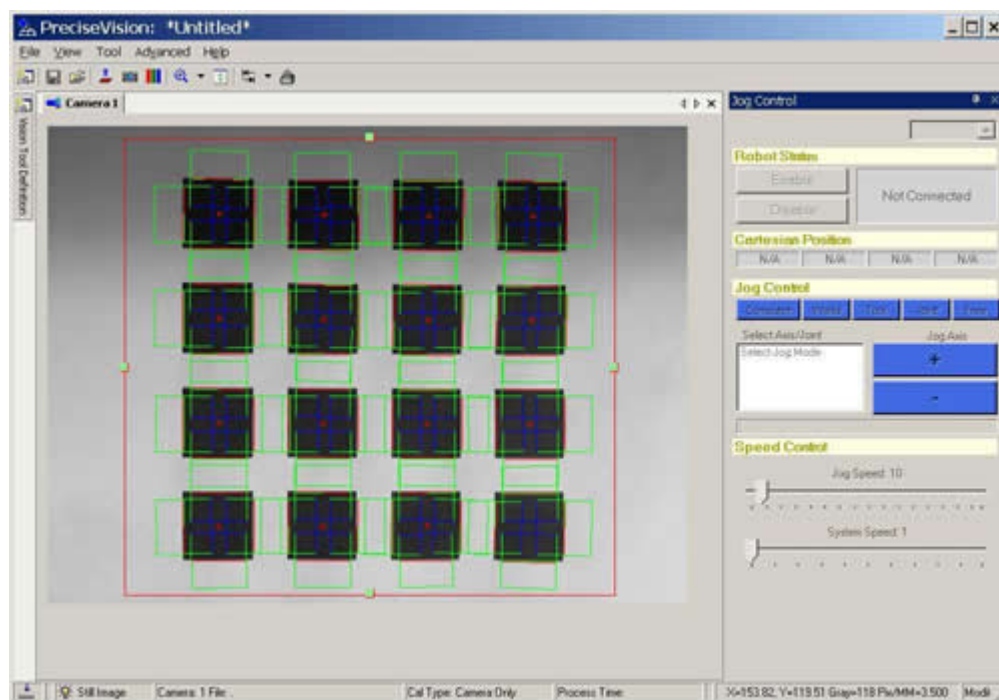
As instructed in the Wizard, you should view the Camera Window and adjust the size and position of the red square outline using the green handles so that the red outline completely surrounds the calibration squares.



When the image is thresholded, it will appear as follows:



» Follow the Wizard's instructions to compute the camera calibration using the target image.



At the completion of the process, the Camera Window will appear as shown above, which indicates how vision tools were used to locate the calibration squares. Each of the four sides of each square should have been automatically and accurately located with a Line Fitter tool. If a message indicates that an error has occurred, most likely, the **Threshold** value or the **Dark Target** check box were not set correctly.

This completes the Basic Camera Calibration procedure.

Robot Vision Camera Calibration

After the Basic Camera Calibration is completed, if vision is being used with a robot, the transformation from the camera's frame of reference to the robot's world coordinate system must be computed. This information permits PreciseVision to send object X/Y/Z/Theta values to a motion controller in a form that can easily be used to define a pick-up location. PreciseVision includes several different methods for performing this calibration because cameras can be mounted in a number of different positions (e.g. fixed in a stationary position, mounted on a link of the robot, etc.).

Since the instructions for executing the Calibration Wizard are fairly self-explanatory, this section includes just an overview of the methods that are common to all of the procedures.

In general, these methods compute the calibration data by having the operator move a customer supplied calibration disk to several positions in the camera's field of view. At each position, a gripper or pointer attached to the robot must be moved to the same position to establish a correspondence between vision positions and robot positions. In order to execute this procedure, the robot's controller must be powered up and properly setup so that it can be safely operated.

Prior to executing this calibration method, the following steps must first be performed:

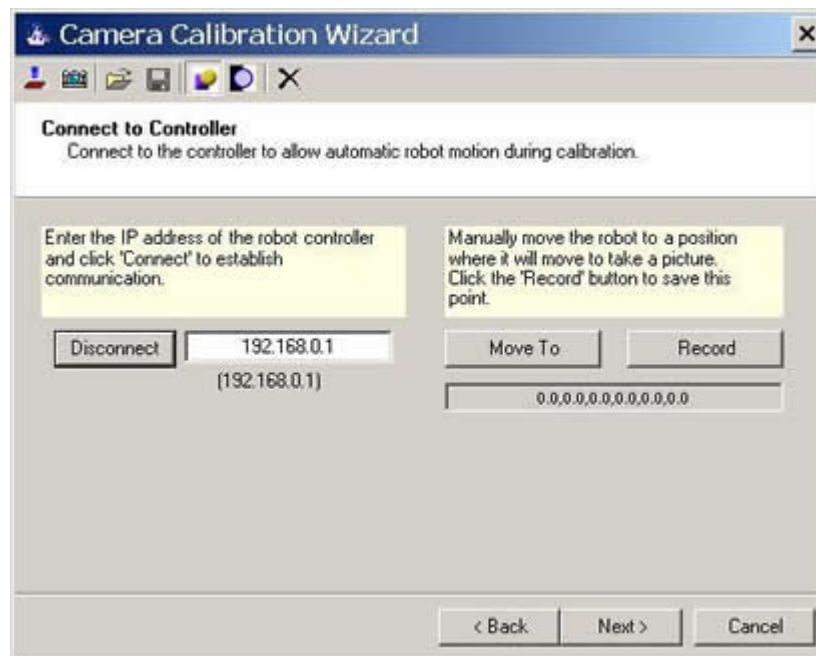
- The "[General Calibration Instructions](#)" section of this manual should be read.
- The Standard Calibration Target Sheet must be printed and available.
- The camera must be rigidly mounted, selected, and accurately setup in terms of its focus, aperture setting, and gain and offset.
- A circular, relatively flat calibration disk and a pointer or gripper mounted to the tool flange of the robot must be obtained. The calibration disk's diameter is recommended to be roughly 10-15% of the width of the camera's field of view. The calibration methods typically rely upon locating the center of the disk at several different positions. Consequently, if the disk is too large, its size would limit the maximum distance between center points. The color of this disk should be selected to maximize its contrast with the background. The disk should also have a feature that aids the user in aligning the center of the pointer with the center of the disk.
- The Guidance Controller for the robot must be powered on and interfaced via Ethernet to the PC that is executing PreciseVision.
- The robot must be homed and capable of being moved. Some procedures do not require the robot to be moved automatically or under power, while other do.



DANGER: Before proceeding with this procedure, please ensure that the robot has been properly mounted, all required safety interlocks have been installed and tested, and power has been connected. All safe guards required to permit the robot to be manually or automatically repositioned must be in place. For the Precise robots, this information is provided in the robot's *Hardware Introduction and Reference Manual*.

The following general instructions and pictures illustrate the concepts that are common to all of the robot vision calibration procedures.

» When prompted by the Calibration Wizard, specify the IP address of the robot controller and press the **Connect** button to establish an Ethernet connection between the PC and the controller.

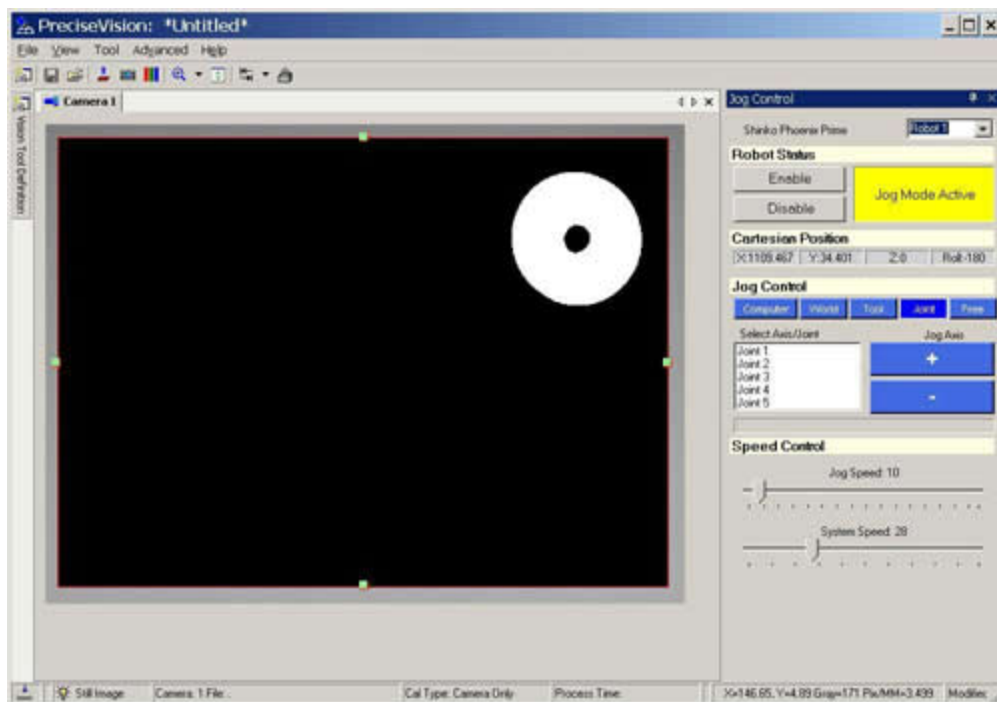
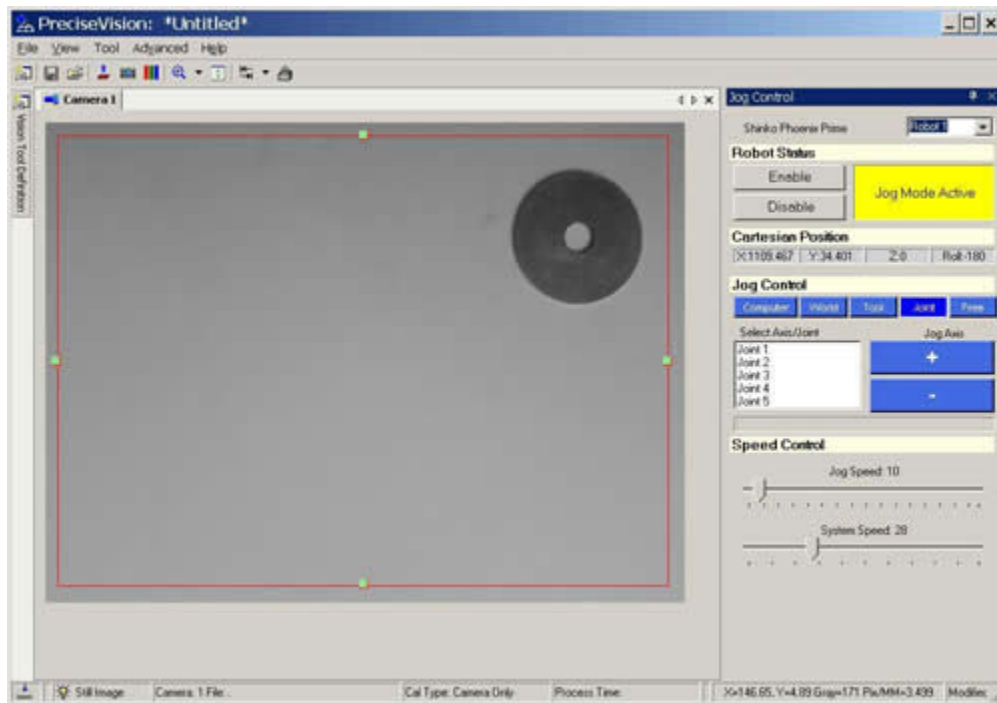


This connection is required in order for PreciseVision to automatically read the position of the robot and to permit manual and automatic control of the robot. After this connection is made, the manual control panel in the main PreciseVision window will become active, although a hardware MCP or the standard web based Virtual MCP can be used as well.

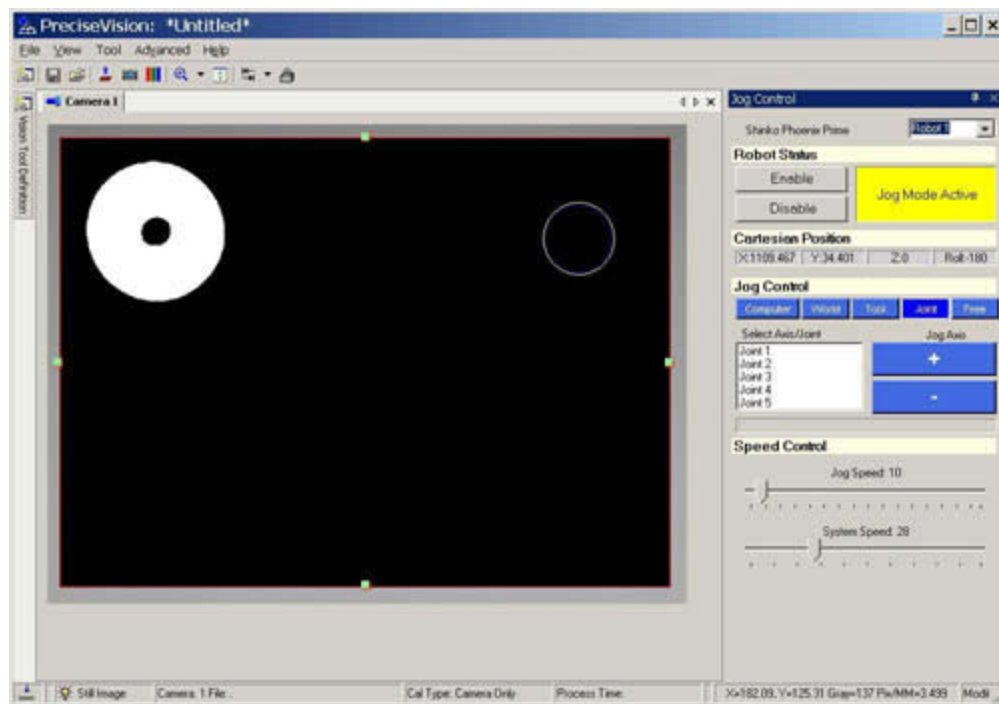
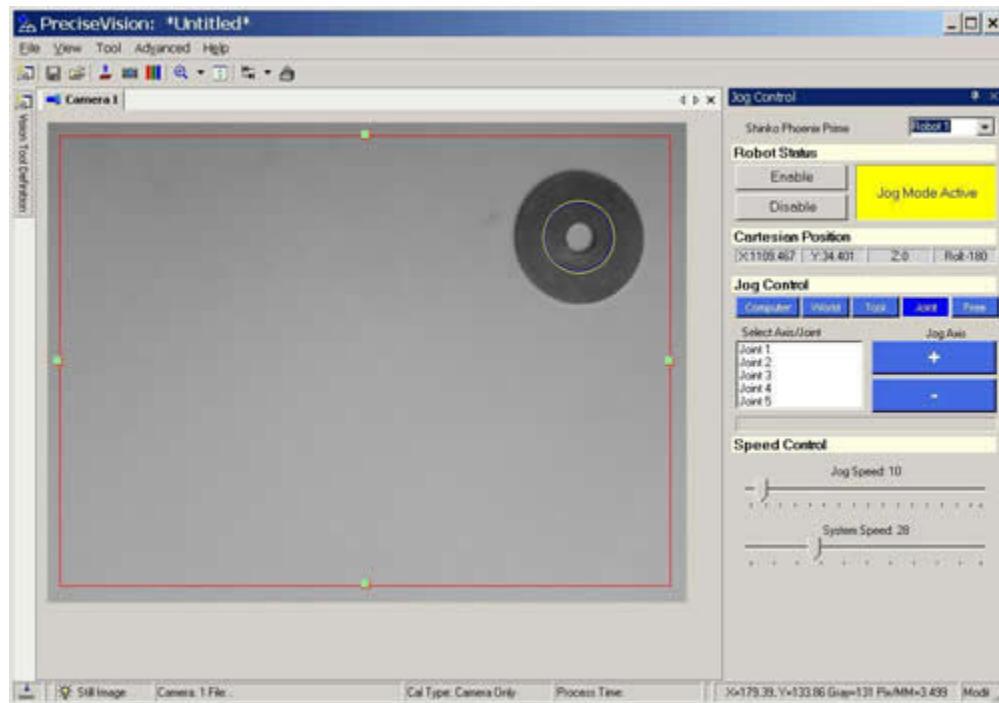
As you execute the Wizard, you will be presented with various options for teaching locations, selecting the teaching method, and moving the robot automatically to return to picture locations or to clear the picture area. These options are dependent upon the specific camera calibration method being performed.

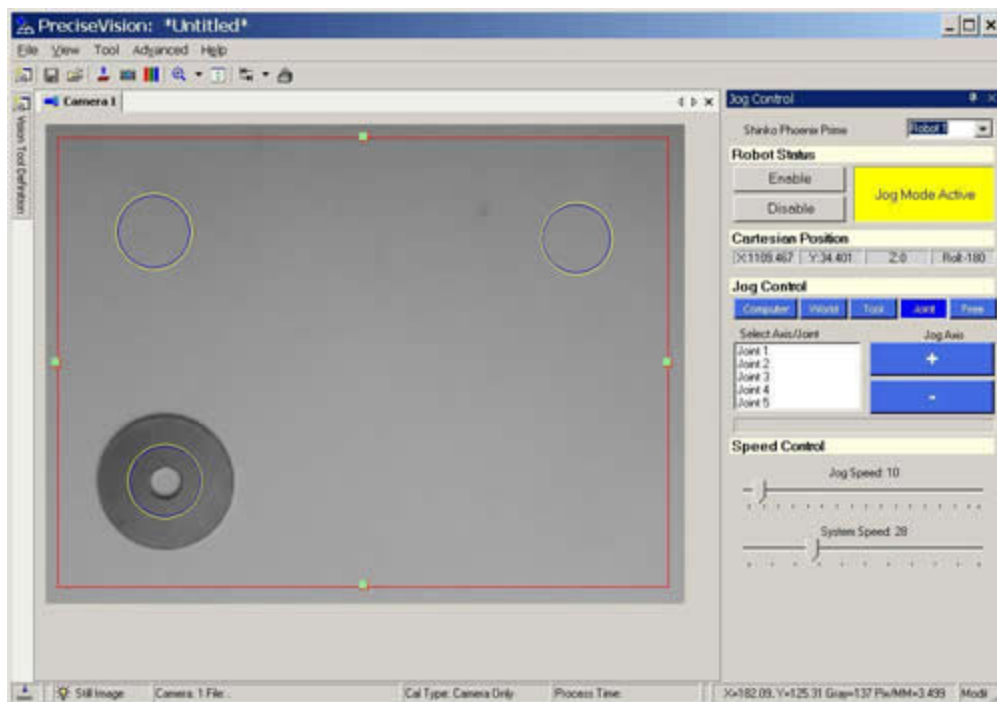
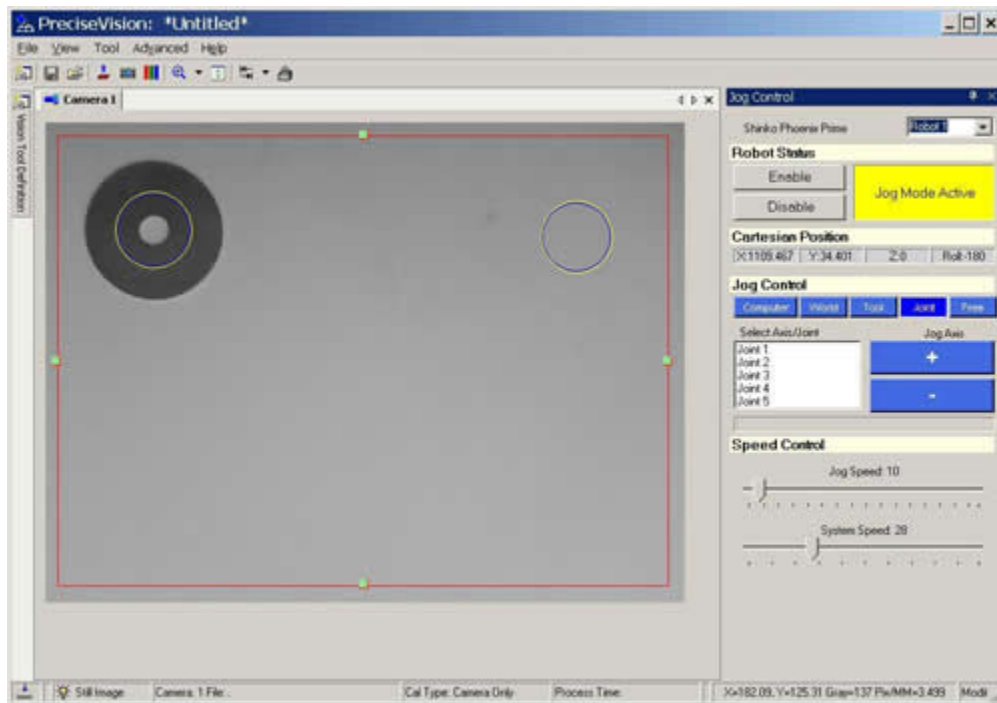
Independent of the specifics of the calibration procedure, fundamentally, all of these methods provides a means for taking multiple pictures, visually locating a calibration disk in different positions within the camera's field of view, and recording the robot's corresponding positions.

The following series of pictures illustrates how a disk is moved to various quadrants of the camera's field of view and PreciseVision locates disk and marks the spot with a circular indicator. At each position, the robot's location also needs to be recorded.

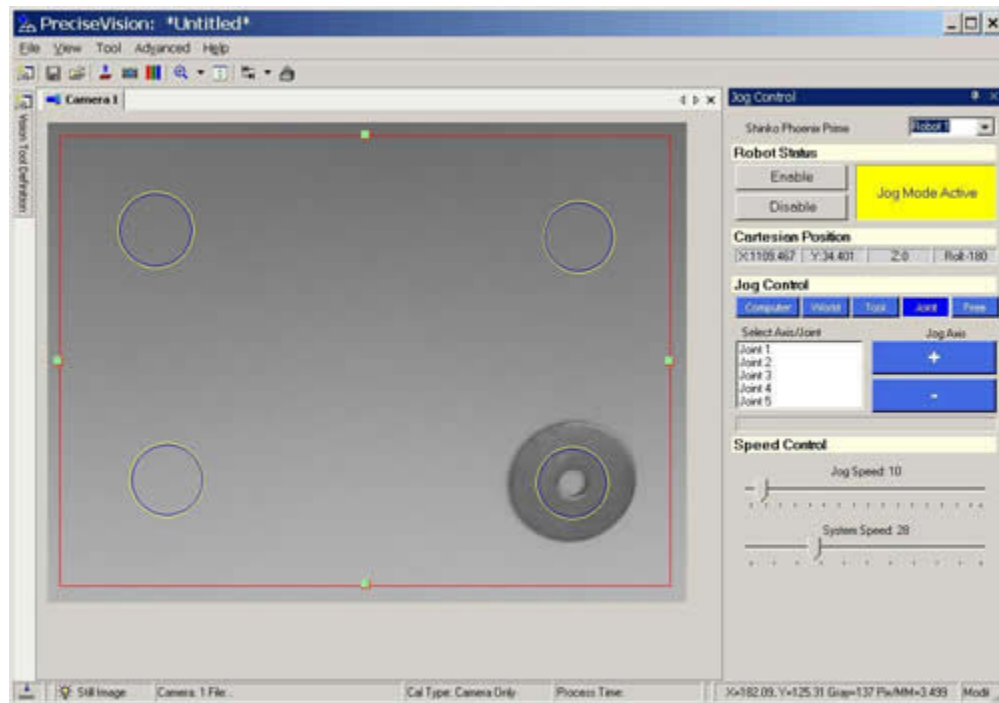


PreciseVision





PreciseVision



After this or similar data is collected, PreciseVision will automatically compute the required transformation between the camera and the robot. This information is then stored in a camera calibration file along with the camera calibration data for subsequent use.

This completes the overview of the Robot Vision Area Camera Calibration procedures.

Appendix A: FAQ

Frequently Asked Questions

This section contains a compilation of frequently asked questions related to PreciseVision.

A. General Questions

1. [What do you do if PV was working but will no longer properly start up?](#)
2. [How do I transfer my PV license to another host computer?](#)

B. DALSA Cameras

1. [What does the DALSA camera LED indicate?](#)
2. [What do you do if you are not able to get an image with a DALSA camera?](#)
3. [What do you do if other NIC's stop operating after DALSA drivers are installed?](#)
4. [How do you eliminate diagonal stripes in the DALSA camera image?](#)

General Questions

What do you do if PV was working but will no longer properly start up?

Sometimes the preferences information for PreciseVision can become corrupted or can reference a PV project that is corrupted. When this occurs, PV will fail to launch. To work around this problem, do the following.

1. Locate the folder where PreciseVision is installed. Typically, this will be "C:\Program Files\Precise Automation\PreciseVision V__\".
2. Rename your preferences file "Preferences.vpr" to "Preferences.bad".
3. Restart PreciseVision.

If PreciseVision starts properly, please email your bad Preferences file and your PreciseVision projects to support@preciseautomation.com with a short explanation so we can diagnosis the problem.

How do I transfer my PV license to another host computer?

The PreciseVision software is only licensed to execute on a single PC. In general, if you need to execute PV on additional PC's, additional licenses must be purchased.

However, if the PC on which PV is licensed to execute is being obsoleted, you can transfer a purchased PV license to a new PC.

Note, as soon as you execute the following procedure, PV will no longer be permitted to execute on your old PC.

To transfer a purchased PV license to another PC, perform the following procedure.

1. Follow the standard procedure for installing PV on the **new** PC.
2. On the **new** PC, execute the procedure for licensing PV to obtain the PC's ID information. This is needed to issue you a new license for this PC.
3. Execute PV 2.0 or later on the **old** PC. If you are executing an older version of PV, obtain a new version from the Precise Support website and install it on the **old** PC.
4. Select "*Help > Product Activation*".
5. Click the "*Uninstall*" button.
6. Follow the instruction to execute the uninstall procedure. *After you execute this procedure, you will no longer be able to execute PV on the **old** PC.*
7. Email the following information to sales@preciseautomation.com and request that the license be transferred.
 - o Your company name
 - o The name of the individual that the license was issued to, if you know
 - o The original license code displayed by the uninstall procedure
 - o The uninstall code displayed by the uninstall procedure
 - o The new PC's ID displayed by the licensing procedure
8. Once you obtain your new license key, execute the standard activation process on the **new** PC.

This completes the license transfer process.

DALSA Cameras

What does the DALSA camera LED indicate?

The back surface of the DALSA camera that contains the Ethernet and DC power plugs includes an LED that indicates the current status of the camera. The interpretation of the LED's color and blinking state is described in the following table.

LED State	Camera Status
Off	Camera is not receiving power
Steady Red	Camera is not initialized
Slow Flashing Red	Camera initialization problem. Most likely indicates a camera hardware failure.
Fast Flashing Red	Camera is too hot
Slow Flashing Blue	Waiting for an IP address
Fast Flashing Blue	Ethernet cable disconnected (no link)
Steady Blue	IP address assigned, PreciseVision not connected to camera
Steady Green	PreciseVision connected to camera, standard

	operational state
Slow Flashing Green	Camera waiting for hardware trigger to take picture
Fast Flashing Green	Continuous acquisitions in progress, standard live video state

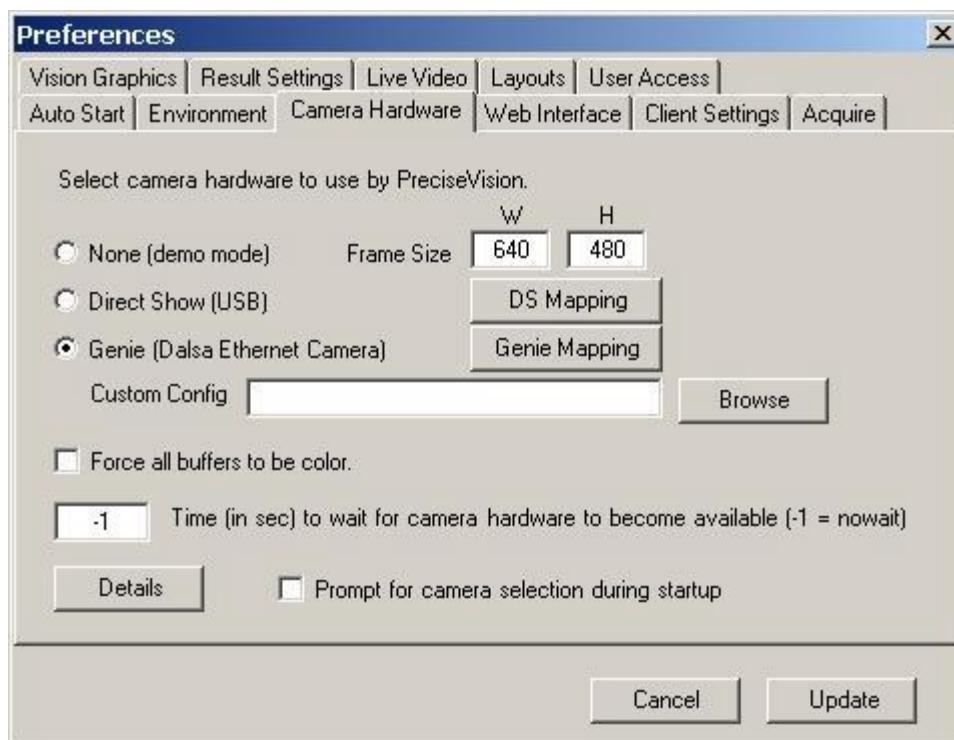
What do you do if you are not able to get an image with a DALSA camera?

If you are not able to get a image from a DALSA camera from within PreciseVision, there are several possible sources for this problem. Most of the problems and remedies described below apply to systems that are being executed for the first time, but some are appropriate for systems that have already operated.

A. The DALSA camera may not be configured as the hardware to use within PreciseVision.


PreciseVision can operate with a variety of Ethernet camera devices and can even operate in a demonstration mode without a camera. However, at any given time, only one camera type is permitted. The following procedure verifies that PreciseVision is configured to capture images from DALSA cameras.

1. Launch PreciseVision, typically by selecting *Start > Programs > Precise Automation > PV_ > PreciseVision*.
2. Open the Preferences pop-up by selecting the following within PV: *File > Preferences*.
3. Select the "Camera Hardware" tab in the Preferences pop-up window.
4. Ensure that the "Genie" option is selected. You can also click on "Genie Mapping" to specify the logical camera number associated with each physical camera.




B. The required software drivers may not be installed. The use of the DALSA cameras with PV requires the installation of three separate software packages on a Windows PC system.

1. To verify that all three software packages have been installed, bring up the Windows Control Panel typically by selecting *Start > Settings > Control Panel*.
2. Select *"Add or Remove Programs"*.
3. Verify that the following packages are installed: (i) DALSA Coreco Sopera LT, (ii) DALSA Genie Framework, (iii) DALSA Sopera Network Imaging Package, and (iv) PreciseVision.
4. If any of these packages are missing, refer to the PV installation instructions for installing the missing application packages.

C. No cameras found by the PC. Typically after the software is installed and the PC is rebooted, any DALSA cameras will immediately be located by the PC and be accessible. However, if you click on the small camera icon that is displayed in the Window's start bar  and see the "No Device Found" message in the Device's pop-up, it means that the PC could not locate a camera on its local Ethernet Network.

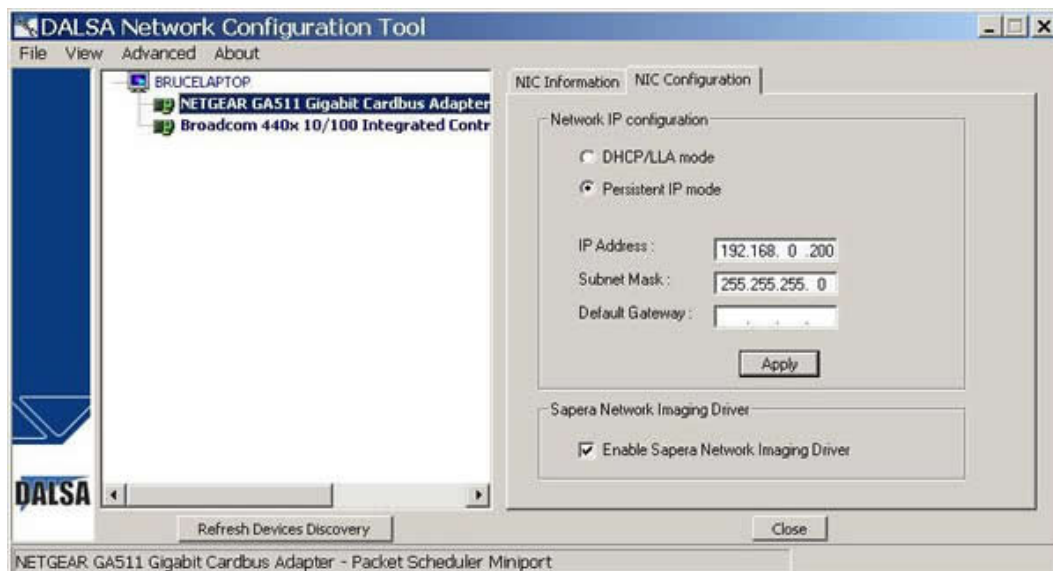


1. Verify that the camera is receiving power and is properly connected to the network. The LED on the camera should have initially been red and then changed to a blue color. If the LED is not lit or is red, either the camera is not receiving power or is defective or is not connected to the network.
2. If the camera LED is blue, the PC's firewall or virus protection is probably blocking the camera connection. Disable your PC's firewall and turn off any virus protection. If the camera becomes visible by the PC, go to the DALSA website (www.imaging.com) for information on how you still might be able to enable your virus protection or firewall.

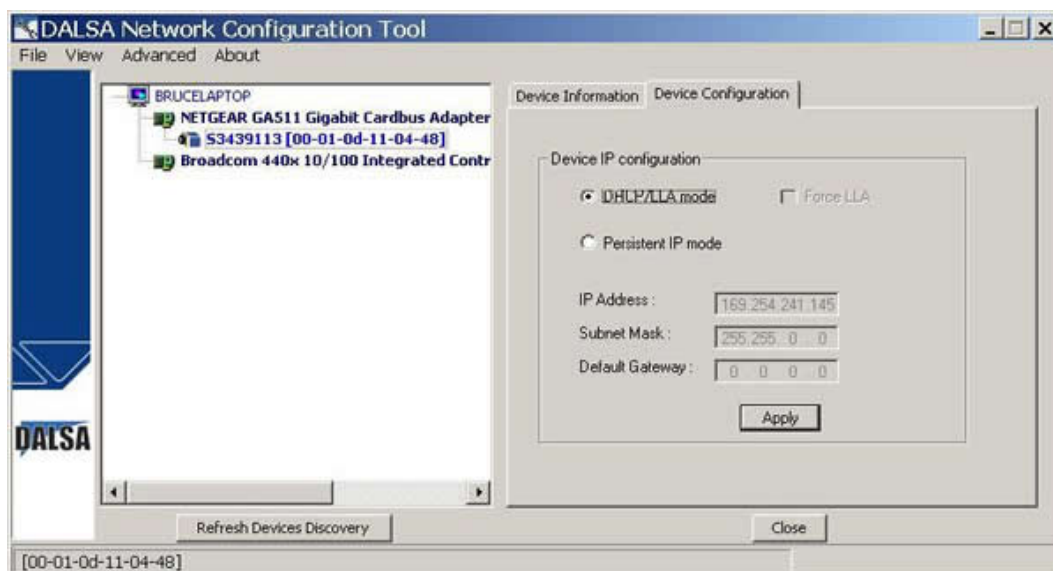
D. The camera may not have an IP address compatible with your PC. Normally, the camera will automatically obtain an IP address from a DHCP server within your network. However, a DHCP server may not be available or the camera may have been set to a fixed (Persistent) IP address that is not consistent with your network. If you click on the small camera icon that is displayed in the Window's start bar  and see "IP Error" in the Status area of the Device's pop-up, it indicates that the IP address of the camera is not set compatibly with your Ethernet network.



1. Execute the "DALSA Network Configuration Tool". Typically this is launched by selecting *Start > Programs > DALSA > Sopera Network Imaging Package > DALSA Network Configuration Tool*.



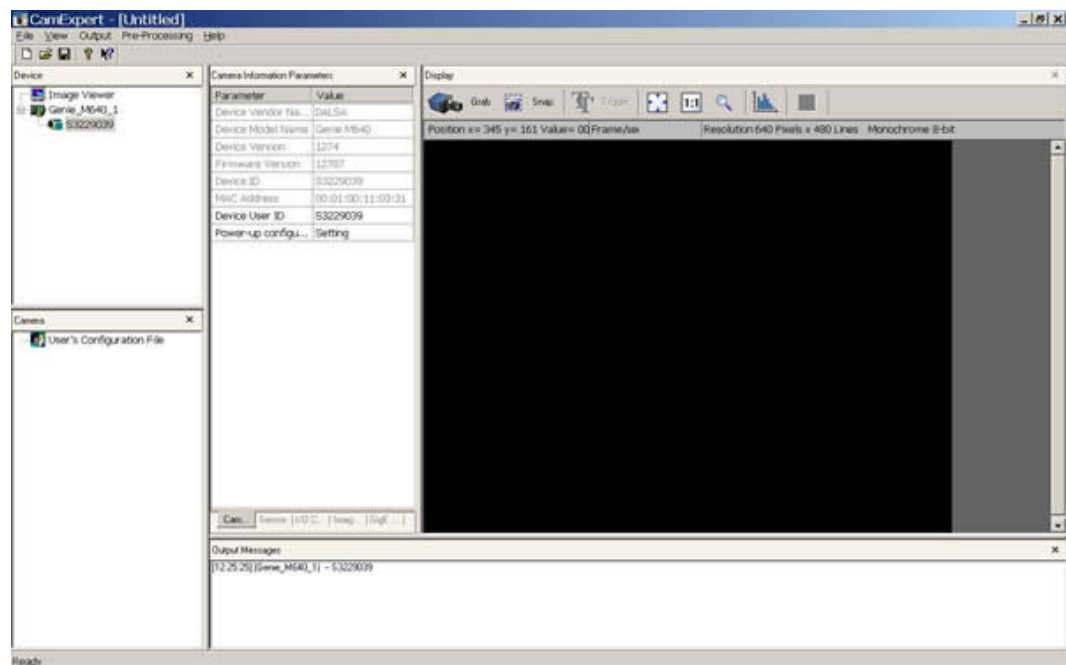
2. Click on the Ethernet network interface card (NIC) that is connected to the camera.
3. Select the "NIC Configuration" tab on the right. This tab will permit you to change the IP address of your PC. Change the IP address and subnet mask to be compatible with the address of the camera as displayed in the Devices window shown above. For example, in the previous picture, the camera IP address was 169.254.241.145. IP addresses whose first number are between 128-191 fall into Class B and require a subnet mask of 255.255.0.0. Set a compatible IP address and subnet mask and click "Apply".
4. After you have selected a compatible address, the camera information should be displayed in the left hand window below the NIC. If you click on the camera information, its IP information will be displayed on the "Device Configuration" tab as shown below.



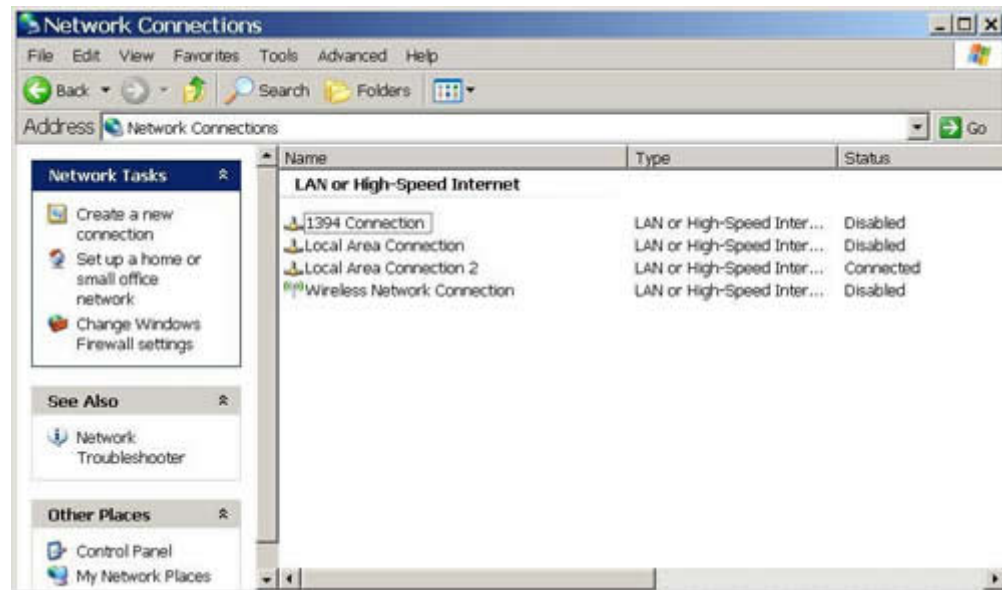
5. Enter the desired IP address and subnet mask for the camera and press "Apply".
6. Repeat steps 2 and 3 to reset your PC to the previous IP information.
7. Close the Devices window and double click on the camera icon in the start bar to redisplay this window. The status should no longer indicate an IP Error.

E. The camera Ethernet drivers may be incorrectly configured. If the camera and its Windows drivers are compatible and properly configured, the CamExpert Windows applications should always be able to display a live camera image.

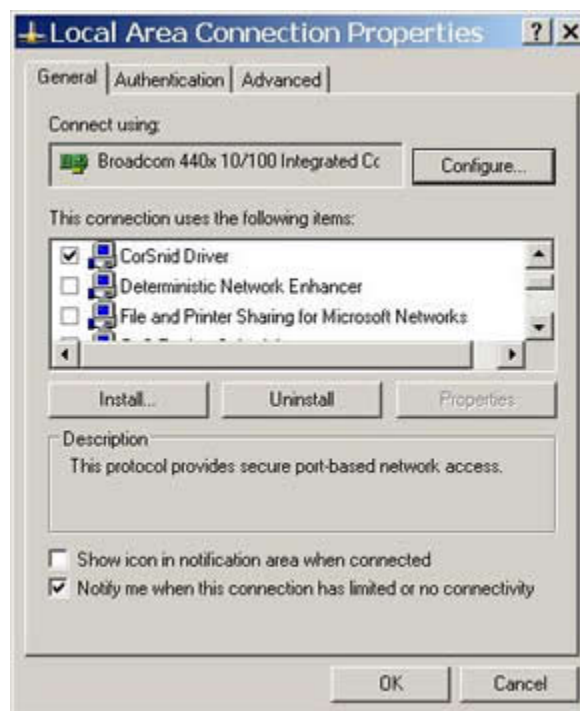
1. To test the camera and its Windows driver, launch the DALSA CamExpert, typically by selecting *Start > Programs > DALSA > Sapera LT > CamExpert*. You should see the following application window.



2. Click on the camera listed in the top-left hand window and click the "Grab" button above the camera display window.
3. If the camera and its Windows drivers are operating properly, you should see live camera video in the camera window and the "Frame/sec" above the video should be displaying the frame capture rate. If this is all correct, close the CamExpert and restart PreciseVision (**NOTE: The CamExpert and PV can not be executed simultaneously**). PreciseVision should now be able to capture images.
4. If the live video output of the camera was not displayed, try disabling unnecessary NIC's (especially wireless NIC's) by opening *My Network Places > View Network Connections*. Right click on unnecessary NIC's and select "Disable".



5. If this did not resolve the problem, try disabling all unnecessary software options associated with the NIC connected to the camera. To do this open *My Network Places* > *View Network Connections*.
6. Double click the NIC attached to the camera to display the "Local Area Connection" window.
7. Click on the "Properties" button.
8. In the Properties window, uncheck all software services except for "CorSnid Driver" and "Internet Protocol (TCP/IP)", and press "Ok".



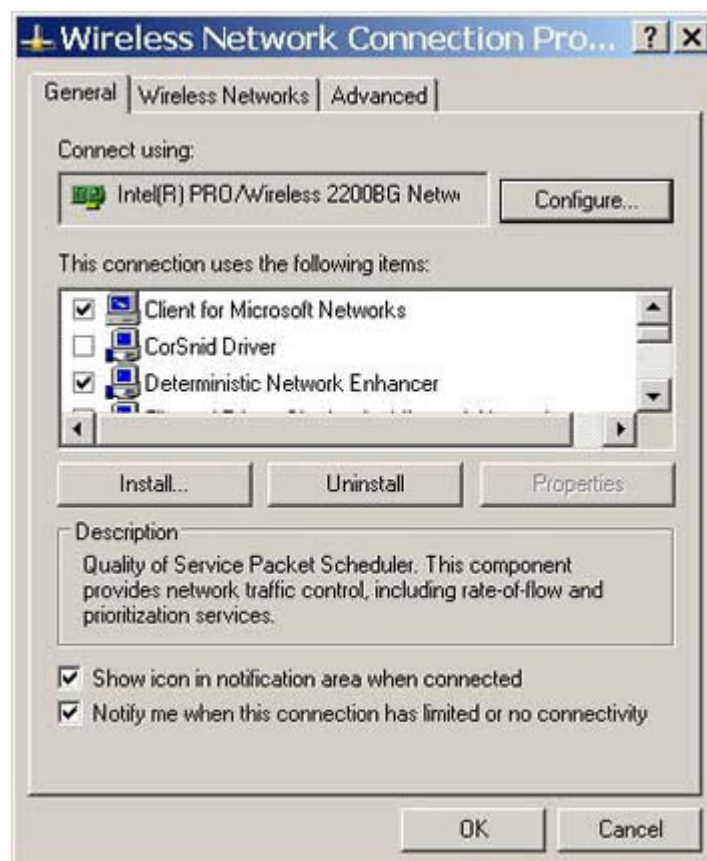
9. If this does not resolve the problem, there may be a fundamental incompatibility between your NIC and the DALSA camera. Please contact Precise Automation for further assistance.

What do you do if other NIC's stop operating after DALSA drivers are installed?

When you install the DALSA camera drivers, they automatically add camera specific software that is executed as part of the driver for every Ethernet card (NIC) in your PC. For certain NIC's, this additional software can cause the Ethernet interface to malfunction even if you do not connect to a camera using this device. This seems to often be the case with wireless Ethernet interfaces in particular.

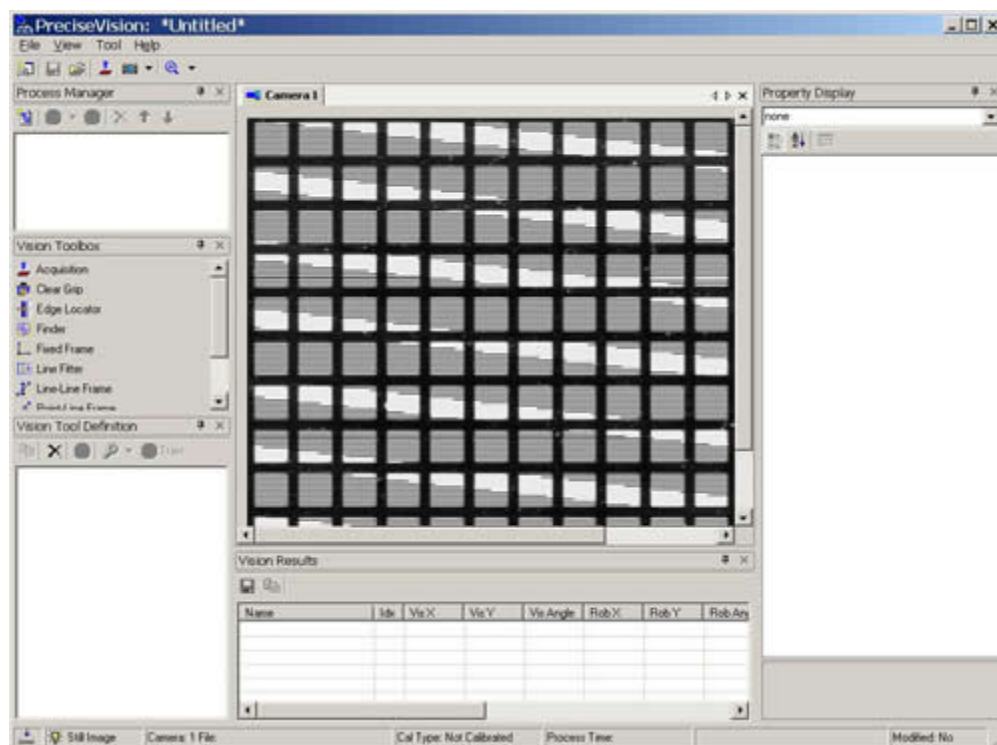
To disable the DALSA specific software for a NIC, do the following:

1. Access the software options for the NIC by opening *My Network Places > View Network Connections*.
2. Double click the NIC that is causing the problem to display the "Local Area Connection" window.
3. Click on the "Properties" button.
4. In the Properties window, uncheck the software labeled "CorSnid Driver" and press "Ok".



How do you eliminate diagonal stripes in the DALSA camera image?

You may sometimes see a blinking pattern of diagonal stripes in the live video image generated by a DALSA camera. For example, in the image below, the true image should be a grid of horizontal and vertical lines. Interspersed in the grid is a pattern of diagonal lines that is not in the real image.



This pattern of lines is due to a problem with the DALSA communications buffer size. To correct this error, do the following:.

1. Exit from PreciseVision.
2. Start the DALSA CamExpert application. Normally, this can be launched from the Start bar by selecting: *Start > Programs > DALSA > Sopera LT > CamExpert*.
3. Press the "Grab" button to verify that the problem can still be seen.
4. Press the "Grab" button again to stop the live image capture mode.
5. In the "Camera Information Parameters" table, select the "GigE Vision" tab.
6. Change the "Network Configuration Mode" from "Automatic" to "Manual".
7. Decrease the size of the "Packet Size (in Bytes)". This value might be set to 1984. Set it to 1500 instead.
8. Press the "Grab" button to verify that the problem has been corrected.
9. Exit the CamExpert application, saving your changes and restart PreciseVision.

Appendix B: Remote PC Control

PreciseVision Remote PC Control

Even though PreciseVision executes as a standalone application within a PC environment, its user interface can be integrated with the user interface of another PC application. PreciseVision provides the ability for any PC application to send commands to PreciseVision using TCP/IP. These commands can specify the format of the PV window and its size and position on the screen. This set of commands also includes a few methods for reading and writing data within PreciseVision and for triggering the execution of a vision process. These commands allow any PC application environment to manipulate PreciseVision to look and feel like it is part of the environment without the need for complicated installation of COM objects or distribution issues.

The communication interface uses simple string messages that are passed through an open TCP socket connection. When PreciseVision begins execution, it automatically runs a remote TCP server in a background thread. This thread listens on port (1450) and is dedicated to servicing commands from external applications. This interface can be tested and debugged using any Telnet session connected via the communication port.

Whenever the communication connection is lost, the PV user interface is automatically restored to its normally stand alone mode, i.e. the form title, status, menu and toolbars are all displayed.

Command Definition

Each transmitted command must conform to the following string format:

command [key] arg1 arg2 arg3 ... arg20 {LF}

While in Telnet mode, the command response may be as simple as a {LF} or it may be a string that returns requested information. Please see the command description table below for details.

In general, the format of the response returned for each command is formatted as follows:

errorcode arg1 ... argN {LF}

If no error occurs, the returned "errorcode" will have a value of "0" to indicate success. If an error occurs, a negative error code is returned and "arg1" contains the string representation of the error. For some commands, "arg1 ... argN" contains information returned by PreciseVision.

Supported Commands

The following table describes the legal commands. Please note that the **CMD** name is case sensitive.

CMD	KEY	Argument List	Description & Responses
-----	-----	---------------	-------------------------

getnumresults		<tool>	<p>Retrieves the number of results that exist for the specified tool. The <tool> must be of the form <i>processname.toolname</i>.</p> <p>The information returned by this command is as follows:</p> <p><err> <num_results> where <err>: Standard error code or 0 for success. <num_results>: The number of results available for this tool.</p>
getresults		<tool> <index>	<p>Retrieves the results for a specified tool that was executed as part of a specified process. The <tool> must be of the form <i>processname.toolname</i>.</p> <p>The information returned by this command is as follows:</p> <p><err> <x> <y> <z> <yaw> <pitch> <roll> <objectID> <passed> <value> <info_array> where <err>: Standard error code or 0 for success. <x> <y> <z> <yaw> <pitch> <roll>: Cartesian coordinates for the located object. <objectID>: Optional index that some tools return to identify the specific instance of an object that is located. <passed>: 0 if tool's inspection was successful or -1 if the inspection failed. <value>: Value of the tool property that was tested by the vision inspection process. <info_array>: Please see the information on the specified tool for a description of any additional result values that are returned.</p>
load	image	<file_name>	<p>Loads an image from a specified file into the camera display buffer.</p> <p><file_name>: The full path and name of a image file to be loaded.</p>
load	importproject	<file_name>	<p>Loads a PreciseVision project from a specified file and mergers its contents with the currently loaded project. If the new project contains any processes or tools whose names conflict with items that are already loaded, "_r" is appended to the name of the new item. Also, any camera calibration information that is contained in the new project is ignored.</p> <p><file_name>: The full path and name of the PreciseVision project file to be loaded and</p>

			merged.
load	layout	<file_name>	<p>Loads a window layout given a specified path and file name.</p> <p><file_name>: The full path and name of a compatible PV layout file. This type of file is created when a layout is manually saved.</p>
load	project	<file_name>	<p>Loads a PreciseVision project file from the disk.</p> <p><file_name>: The full path and name of the PreciseVision project file to be loaded. This allows a PC based application to change the project or override the default project loaded when PV starts.</p>
property	set/get	<property> <value>	<p>Reads or writes the value of a specified property of a specified tool. The <property> must be of the form <i>toolname.propertyname</i>.</p> <p>For write operations, <value> defines the new property value that is set.</p> <p>Not all properties are available for reading and/or writing. Please see the vision tool definitions for details on each tool type's properties.</p>
run		<process>	Initiates execution of the specified vision process.
set	displaymode	<mode>	<p>Dictates the contents and visibility of the PV window. The permitted values for <mode> are as follows.</p> <p>0: Resets display mode to normal display. PV returns to stand alone mode with all normal windows, toolbars, menus etc. available for use.</p> <p>1: Displays only the camera window and the current Tool's window. The PV form border, title, and status bars are all hidden.</p> <p>2: Displays only the camera window. The PV form border, title, status bars and all dockable controls are all hidden.</p> <p>3: Minimizes the PV window.</p>
set	layout	<layout_type>	<p>Selects one of the predefined panel layouts to display within the PV window based upon the value of <layout_type>:</p> <p>0: Edit mode 1: Runtime mode 2: Calibration mode</p>
set	position	<xpos> <ypos> <width> <height>	<p>Positions and sizes the PV window relative to the screen.</p> <p><xpos>: X position relative to top left of screen</p>

			<p><ypos>: Y position relative to top left of the screen <width>: width to set window <height>: height to set window</p> <p>All units are in pixels.</p> <p>Note: <width> and <height> are optional. If not specified, only the X,Y position of the window will be altered.</p>
set	topmost	<mode>	<p>Specifies whether the PV window is on top or other windows. The value of <mode> is interpreted as follows:</p> <p>0: Normal (resets topmost property) 1: Keeps window on top.</p> <p>This allows PV to stay on top of another application while the user clicks or drags windows.</p>
set	zoom	<scale_factor>	<p>Selects the Zoom scale factor for the camera window. The <scale_factor> is interpreted as follows:</p> <p>-1: Reset zoom, i.e. no zoom. 0-10: Zoom selections from ¼ - 4x</p>

Appendix C: Multi-Instance Execution

PreciseVision Multi-Instance

For most applications, PreciseVision is connected to a single robot or motion controller. If an application requires PreciseVision to communicate with multiple robots or motion controllers, the Multi-Instance version of PreciseVision should be utilized. This version of the software permits several instances of PreciseVision to be executed concurrently on the same PC.

Each instance of PreciseVision executes completely independently of other instances. In particular, each instance:

1. Connects to its own set of cameras with their own camera calibration data and individual cameras cannot be shared by different instances. Different instances can simultaneously capture images from separate cameras subject to the bandwidth limitations of the PC. In the standard version of PreciseVision, if two or more cameras are connected to a PC, pictures must be sequentially captured and analyzed. In a PC executing multiple instances of PreciseVision, each instance can take a picture at any time without regard to any acquisitions being performed by another instance.
2. Can only connect to a single camera interface type (i.e. Ethernet GigE or USB), but different instances can be connected to different camera interface types.
3. Connects to a single robot or a single motion controller or nothing. This allows multiple robots to share a single PC and permits multiple robots or motion controllers to perform simultaneous frame grabs and vision analysis. If desired, multiple instances can be connected to the same robot or motion controller. In the standard version of PreciseVision, only a single robot or motion controller can be connected to a PC.
4. Loads its own Vision Project and executes its own Vision Processes. This enables each robot to execute either the same Vision Process or independent Vision Processes.
5. Operates with its own set of Preferences. This enables independent control of display options and other parameters.

Software Installation and Activation

The Multi-Instance capability is only supported in PreciseVision 3.0 and later versions. Both the standard and the Multi-Instance software are provided in the same software installation distribution. To load the software and camera drivers, follow the standard software installation instructions detailed in the *Supported Hardware and Software Installation Chapter* of this manual.

The only difference in the installation procedure is the specific software license key that is utilized to activate the software. The "PreciseVision Multi-Instance" key must be installed in place of the standard "PreciseVision" key.

NOTE: When the PrecisionVision Multi-Instance key is installed, it replaces any previously installed standard key. Unfortunately, this will de-activate any 2.x and older versions of PrecisionVision that are still installed on the PC.

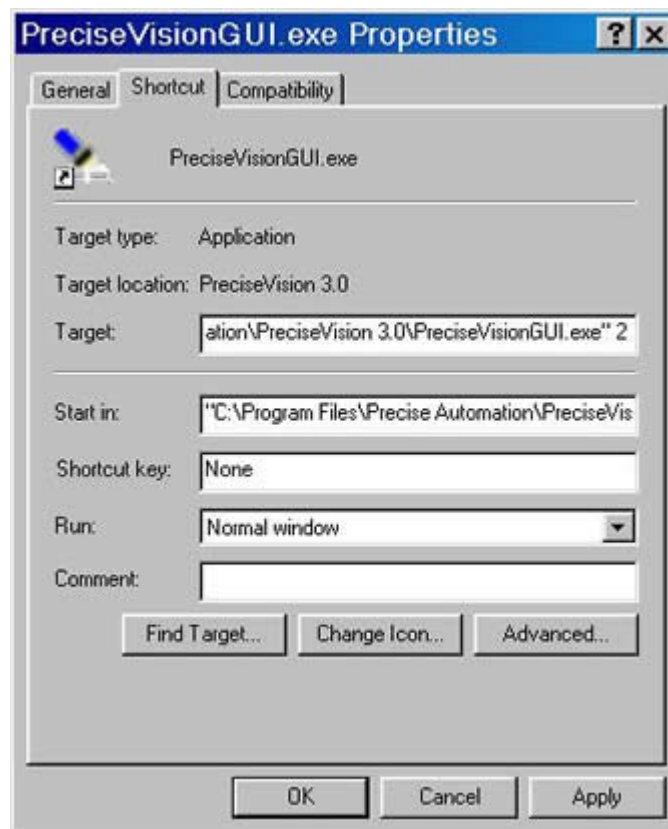
Executing Multiple Instances

Once PrecisionVision 3.0 or later is loaded and the Multi-Instance key is installed, multiple instances can be executed. Each time the *Start > Programs > Precise Automation > PV 3.0 > PrecisionVision* menu item is selected; only the first instance of PrecisionVision is initiated.

To execute instances 2 to N, a command line switch must be specified when starting PrecisionVision. In Windows, the simplest means for accomplishing this is to create a "Shortcut" to PrecisionVision.

1. To create the shortcut, locate the PrecisionVisionGUI.exe file. This is normally stored in *C:\Program Files\Precise Automation\PrecisionVision x.x*.
2. Right click on this file and select *Create Shortcut*.
3. Right click on the new shortcut and select *Properties*.
4. On the Shortcut tab of the Properties page, edit the *Target* to add a number from 2 to N after the ".exe" to specify the instance of PrecisionVision that is to be launched by the Shortcut.

At the conclusion of this process, a typical Shortcut Property page that would launch the second instance of PrecisionVision will look like the following:



PreciseVision

Below is a screen shot that illustrates two instances of PreciseVision Multi-Instance simultaneously executing. Please note that the second instance is recognizable by the "(2)" following "PreciseVision" name in the title bar.

