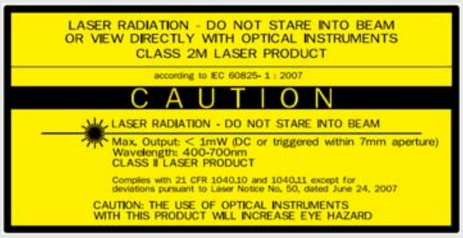
REFERENCE MANUAL

Application Programming IVC-3D

Please read the complete manual before attempting to operate your IVC-3D.

WARNING

IVC-3D is a laser product complying as such to the standards IEC 60825-1 and 21 CFR 1040.10 / 11 (CDRH). It cannot be considered as a standalone unit and must only be used as a part of a laser system, which incorporates additional features depending on the applicable laser class. The IVC-3D product is equipped with a Class II / 2M laser or with a Class IIIb / 3B laser.



LASER RADIATION - DO NOT STARE INTO BEAM
OR VIEW DIRECTLY WITH OPTICAL INSTRUMENTS
CLASS 2M LASER PRODUCT

according to IEC 60825- 1 : 2007

CAUTION

LASER RADIATION - DO NOT STARE INTO BEAM

Max. Output: < 1mW (DC or triggered within 7mm aperture)
Wavelength: 400-700nm
CLASS II LASER PRODUCT

Complies with 21 CFR 1040.10 and 1040.11 except for
deviations pursuant to Laser Notice No. 50, dated June 24, 2007

CAUTION: THE USE OF OPTICAL INSTRUMENTS
WITH THIS PRODUCT WILL INCREASE EYE HAZARD

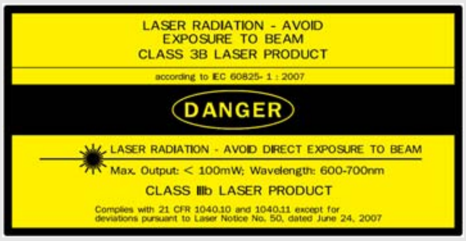
LASER RADIATION – DO NOT STARE INTO BEAM
OR VIEW DIRECTLY WITH OPTICAL INSTRUMENTS
CLASS 2M LASER PRODUCT

According to IEC 60825-1 : 2007

CAUTION

Class II / 2M lasers emit visible radiation in the wavelength range from 400 nm to 700 nm where eye protection is normally afforded by aversion responses including the blink reflex. However, viewing of the output is hazardous if the user employs optical instruments within the beam or suppresses the blink reflex intentionally.

- Do not stare into beam.
- Do not view the laser beam directly with optical instruments like magnifying glasses, telescopes, etc.



LASER RADIATION - AVOID
EXPOSURE TO BEAM
CLASS 3B LASER PRODUCT

according to IEC 60825- 1 : 2007

DANGER

LASER RADIATION - AVOID DIRECT EXPOSURE TO BEAM

Max. Output: < 100mW; Wavelength: 600-700nm

CLASS IIIb LASER PRODUCT

Complies with 21 CFR 1040.10 and 1040.11 except for
deviations pursuant to Laser Notice No. 50, dated June 24, 2007

LASER RADIATION – AVOID
DIRECT EXPOSURE TO BEAM
CLASS 3B LASER PRODUCT
according to IEC 60825-1 : 2007

DANGER

Class IIIb / 3B lasers are considered dangerous to your retina if exposed. This includes looking directly into a reflection from a specular (mirror-like) surface. Viewing diffuse reflections are normally safe. Certification is given on systems that fulfil all safety requirements for 3B laser systems.

- Class IIIb / 3B laser products must bear warning and certification labels.
- During installation and alignment appropriate eye protection must be used.

The IVC-3D is a laser product and operation using procedures other than those specified herein may result in hazardous radiation exposure.

Please read and follow ALL Warning statements throughout this manual.

German versions of the Operating Instructions and Reference manual are available on the CD.

Eine deutsche Version der Bedienungsanleitung und des Referenzhandbuchs finden Sie auf der beigelegten CD.

WARNING

Do not open the IVC-3D

The IVC-3D unit should not be opened, the IVC-3D contains no user serviceable parts inside. Opening the IVC-3D unit may result in hazardous radiation exposure.

Subject to change without prior notice.

Turn off the power to the IVC-3D before maintenance

The power to the IVC-3D must be turned off before any maintenance is performed. Failure to turn this power off when maintaining the unit may result in hazardous radiation exposure.

ISM Radio Frequency Classification - EN55011 – s

Group1, Class A

Warning: Class A equipment is intended for use in an industrial environment. There may be potential difficulties in ensuring electromagnetic compatibility in other environments, due to conducted as well as radiated disturbances.

Explanations:

Group1 – ISM equipment (ISM = Industrial, Scientific and Medical)

Group 1 contains all ISM equipment in which there is intentionally generated and/or used conductively coupled radio-frequency energy which is necessary for the internal functioning of the equipment itself.

Class A equipment is equipment suitable for use in all establishments other than domestic and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

Class A equipment shall meet class A limits.

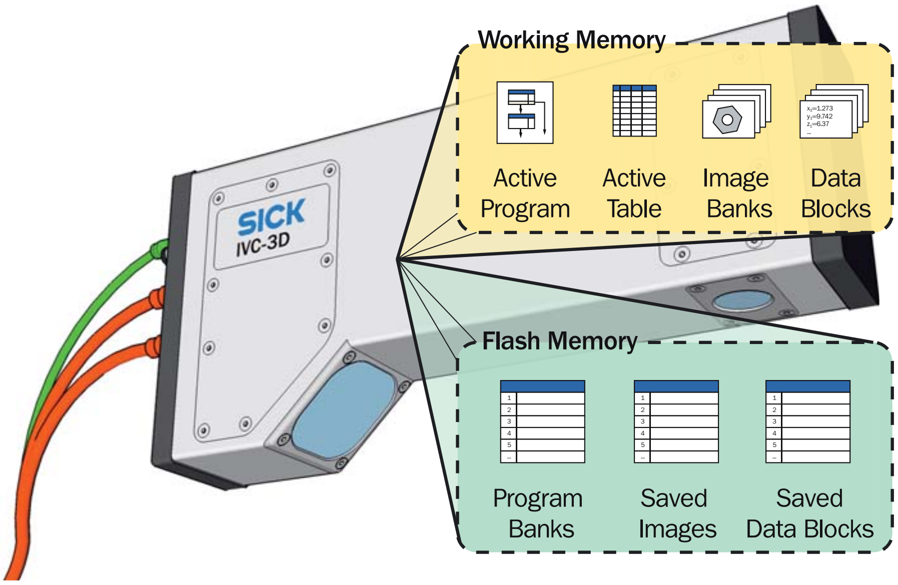
Note: Although class A limits have been derived for industrial and commercial establishments, administrations may allow, with whatever additional measures are necessary, the installation and use of class A ISM equipment in a domestic establishment or in an establishment connected directly to domestic electricity power supplies.

Contents

1 Functional Overview

1.1 IVC-3D Camera

The IVC-3D camera contains a powerful microprocessor that is tailored for image analysis and especially analysis of 3D images. The processor can perform a number of commands – or *tools* – that are used for example for capturing an image, finding an edge in an image or setting one of the camera's output signals.



The camera also has a working memory, which contains the following:

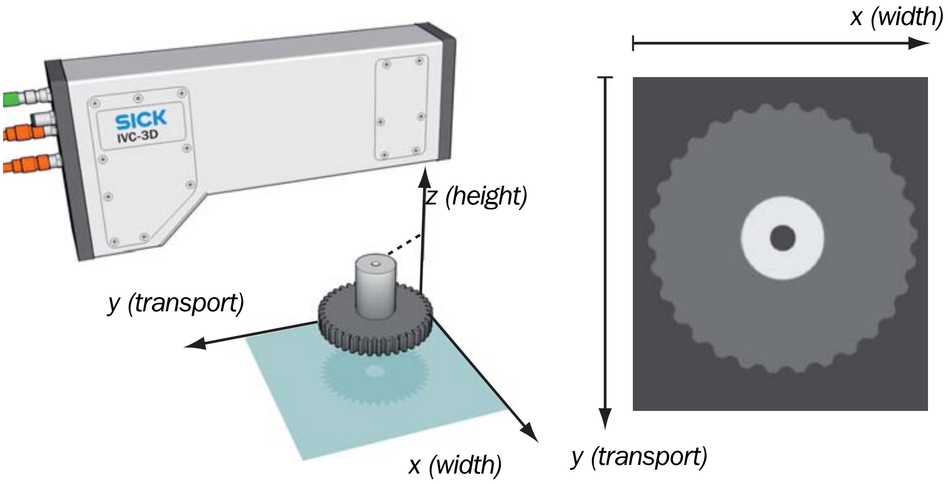
- *Active program*, which is a sequence of commands that are used for analyzing the images.
- *Active table*, which is used for reading and storing values that are used during the analysis.
- A number of *image banks*, which each contains an image captured and processed by the camera. An image bank may contain either a *3D image* or a *profile.*
- *Data blocks*, which are used by some tools for storing or reading additional data. For example, some pattern recognition tools (Teach tools) create and save data in a data block, which can later be used by other tools (Match tools).

In addition, the camera has a flash memory, which is used for permanent storage. The flash memory contains the following:

- *Program banks*, which are used for storing programs and tables that can be loaded into the camera's working memory. A program bank always contains both one program and one table.
- *Saved images,* which can be used for example as a basis when teaching the camera patterns to recognize.
- *Saved data blocks*, containing for example pattern recognition data to be used by Match tools, so that the pattern does not have to be taught before running a program.

1.1.1 3D Images

A 3D image shows the topology of an object, or the distance from the bottom (or reference plane) to a point on the surface of the object. The brighter a pixel is in the image, the higher up that point is on the object.

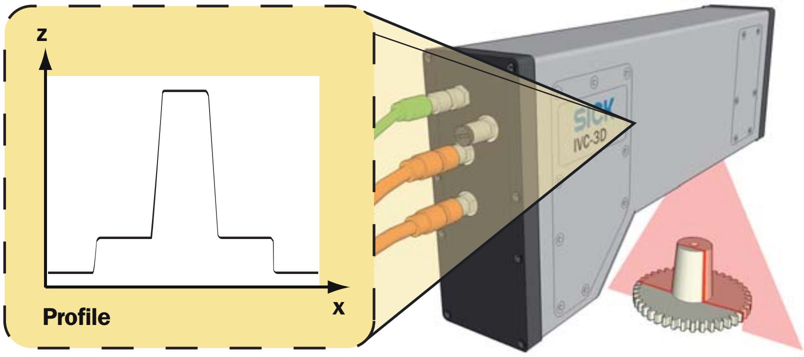


Since each pixel in the 3D image represents a height the pixel values are displayed in millimeters, and not as gray or color values as in ordinary digital images. The resulting height value is measured from a reference plane located at a fixed distance from the camera.

This means that the units of the 3D coordinates in an image are pixels along the x- and y-axis, and millimeters along the z-axis. The coordinates in the 3D image can however easily be converted to millimeters by using a tool in the camera.

1.1.2 Profiles

A 3D image is generated from *profiles*, where each profile represents a cross-section of the object. A profile is created when the object passes under a laser beam, which is reflected as a line on the object. When viewed from an angle, the line shows the contour of the object.



The coordinate system in profiles is the same as in 3D images – that is pixels along the x-axis and millimeters along the z-axis.

1.1.3 Suppressing ambient light

The laser line used to create 3D images has a certain wavelength range, and the IVC-3D has built-in filters that suppress ambient light. However, sunlight and also some standard light sources used at factory floors contain light with the same wavelength range as the laser. For a robust measurement day and night, all over the year, it is recommended to shroud the inspection area from ambient light, especially sunlight.

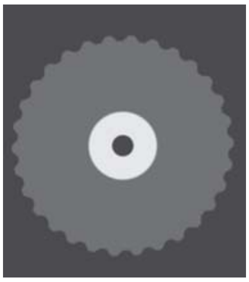
1.1.4 Capturing 3D Images

The camera takes a suitable number of profiles as the object passes under the laser. By knowing the distance that the object moved between two profiles the camera can build a 3D image of the object from the profiles.

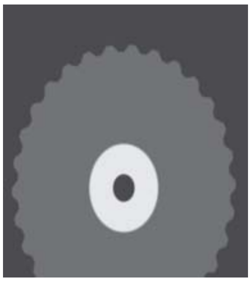
The camera assumes that the distance between the profiles is constant. Therefore it is important to make sure that this is actually the case, in order to generate accurate 3D images. There are two ways to achieve this:

- Make sure that the object is moving with a known and constant speed. The speed is specified in the program, and the camera will then take profiles with a constant time interval.
- Use an *encoder*. In this case, the encoder will trigger the camera to take a profile when the object has moved a certain distance.

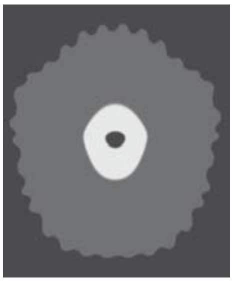
It is strongly recommended to use an encoder if you intend to measure for example the shape or volume of the objects. If no encoder is used, the results of the analysis may be inaccurate if the speed of the objects varies.



Object is moving with the expected speed



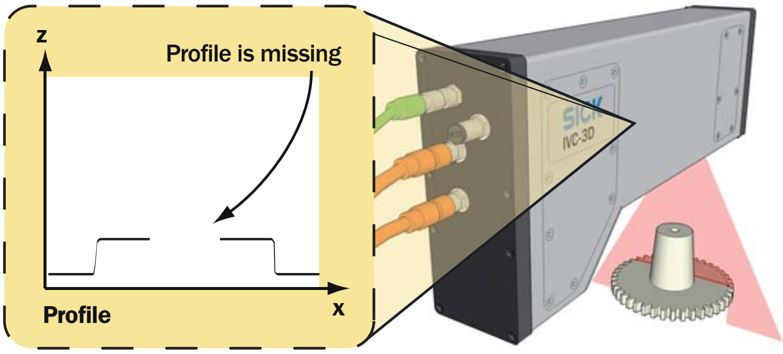
Object is moving slower than expected



The speed of the object is uneven

1.1.5 Missing Data

Sometimes the laser line on the object is hidden by other parts of the object. This makes it impossible for the camera to decide the height of the part of the object that is obscured. In the resulting 3D image, such areas are represented with *missing data*, which is displayed as black or holes when viewing the image.



Normally, the tools that are used for analyzing the 3D images ignore missing data. However, some tools treat missing data as a height value of 0 mm. This may affect the result of the analysis, for example an edge could be detected at a location in the image where there are actually missing data. A list of those tools is found in appendix C in the reference manual.

The camera has a tool for removing missing data from an image and thereby minimizing the impact on the analysis made by such tools. The *Fill Missing Data* tool assumes that the height of the hidden area is same as the area surrounding it, and thus “fills in the hole”.

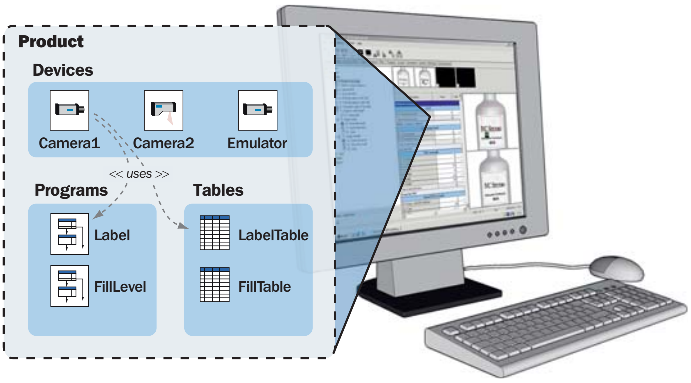
1.2 IVC Studio

IVC Studio is used for developing the programs that are used by the cameras when performing *inspections* – that is, analyzing images. IVC Studio can handle both 2D and 3D cameras.

When you develop a program in IVC Studio, you work with a *product*. A product in IVC Studio is a great help for handling all the *devices* (usually cameras), programs and tables that are needed for a certain inspection.

The product contains a list of the used devices, and copies of all programs and tables that are used by the devices. Normally, each device has one program and one table associated to it, which is also the program and table that are currently in the working memory.

To be able to work with a program in IVC Studio, it must be associated with a device. The device can be either a hardware camera or the Emulator, see below. A program is always executed on a device – and never on the computer. The computer is mainly used for building and modifying the programs on the devices, and to display the results sent from the devices.



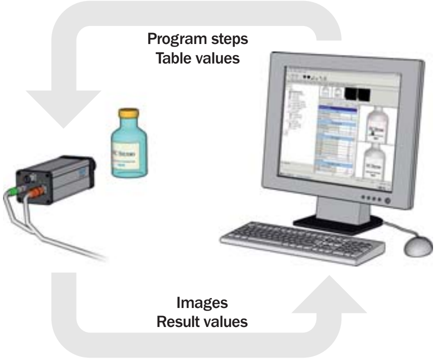
1.2.1 IVC Emulator

The Emulator is a software behaving like an IVC camera, and can be used instead of an IVC camera. The Emulator is available in the IVC Studio development environment, and it makes it possible to develop programs when there is no IVC camera available. The Emulator can emulate both 2D and 3D cameras. The main difference between the Emulator and a camera is that the former uses a predefined set of images stored in an image folder on the PC, whereas the latter views live images.

1.2.2 Programs in Development and Production

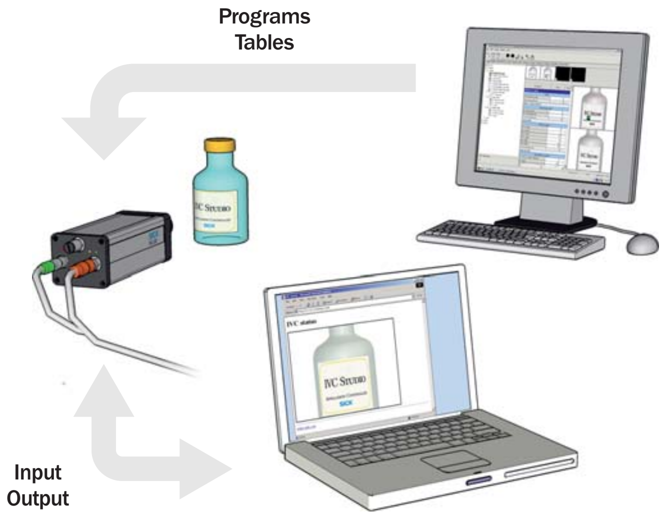
During development, you build the program in IVC Studio but the program is automatically downloaded to the associated device.

When a program (or program step) is executed it is executed in the camera, and the results are sent back to IVC Studio where they are displayed.



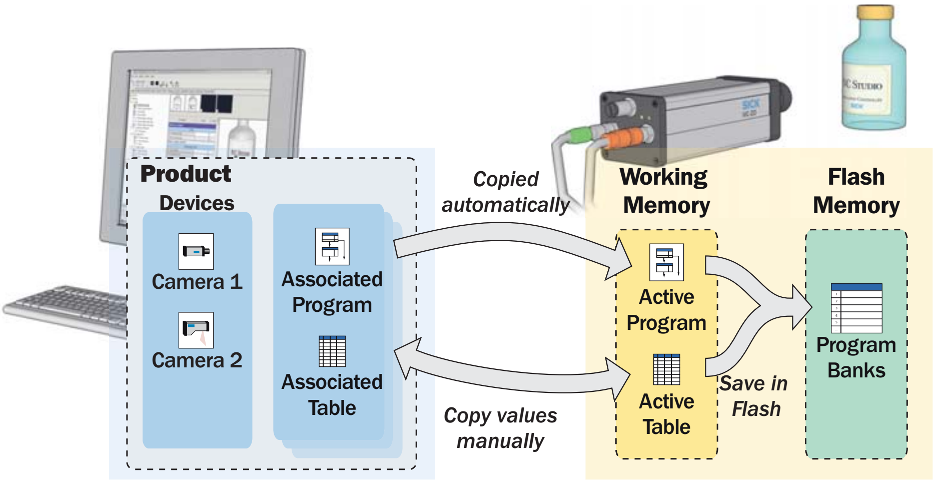
When the development of a program is finished and it is ready to be used, the program (and table) is downloaded to the device and started.

After this it is not necessary to use IVC Studio any more. It may be used to display the results from the program, for example to signal when faults occur. But the device can also be used as a stand-alone unit, where other equipment is used for controlling the device and displaying the output. For example, you could set up a web page on the camera and then monitor the camera from a web browser on any computer on the network.



1.2.3 Saving Programs

When you save a product in IVC Studio, the included programs and tables are saved with the product on the computer. Nothing is saved on the device when you save the product. This is not a problem since the program associated with the device is automatically loaded into the device as soon as the program is started or edited in IVC Studio.



The programs and tables may be stored manually on the device as well. The flash memory in the device contains a number of program banks, each of which can contain a program and a table.

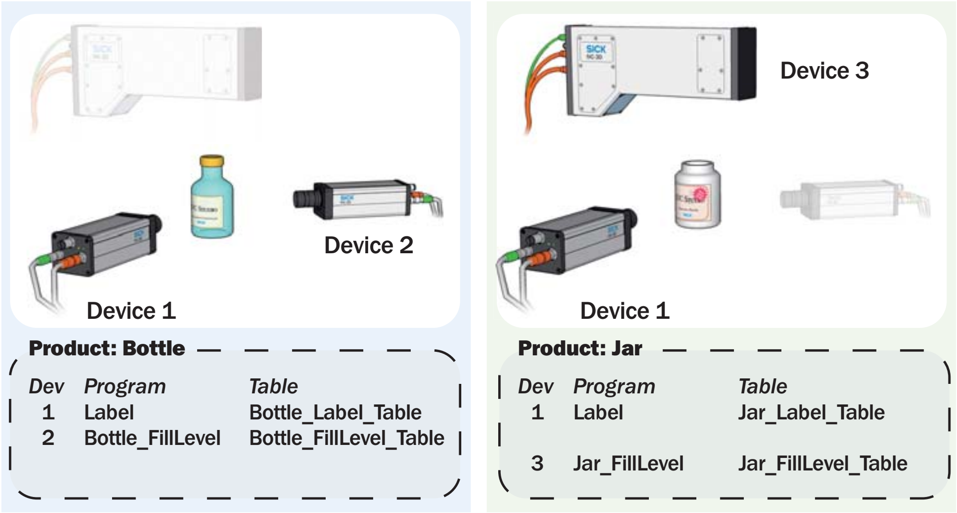
When you store a program in the flash memory, you always store the active program and table, which are currently in the working memory of the device.

A program stored in program bank 0 will automatically be started when the device is powered up.

1.3 Handling Multiple Products

A device may be used in several products, using different programs and tables depending on the product. This makes it easy to use the same camera for performing different inspections. Just create one product for each inspection, and in each product associate the program and table to be used for the specific inspection.

For example, there are three cameras set up by a production line, and we are producing two different items on this production line – a transparent bottle and an opaque jar. For the bottle we can use IVC-2D cameras to inspect both the label on the front and the fill level, but for the jar we need to use an IVC-3D camera to inspect the fill level.



Product: Bottle

Dev	*Program*	*Table*
1	Label	Bottle_Label_Table
2	Bottle_FillLevel	Bottle_FillLevel_Table

Product: Jar

Dev	*Program*	*Table*
1	Label	Jar_Label_Table
3	Jar_FillLevel	Jar_FillLevel_Table

To achieve this we create two products in IVC Studio with the following contents:

Product: Bottle

Device	Program	Table
1	Label	Bottle_Label_Table
2	Bottle_FillLevel	Bottle_FillLevel_Table

Product: Jar

Device	Program	Table
1	Label	Jar_Label_Table
3	Jar_FillLevel	Jar_FillLevel_Table

When switching between producing the two products, we can simply open the product in IVC Studio to load the corresponding programs and tables into the devices. If we would change the design of the label for the bottle, we can just change the values in the table Bottle_Label_Table to suit the new design. If necessary we could also make a copy of the program Label, modify it, and associate the modified program with device 1.

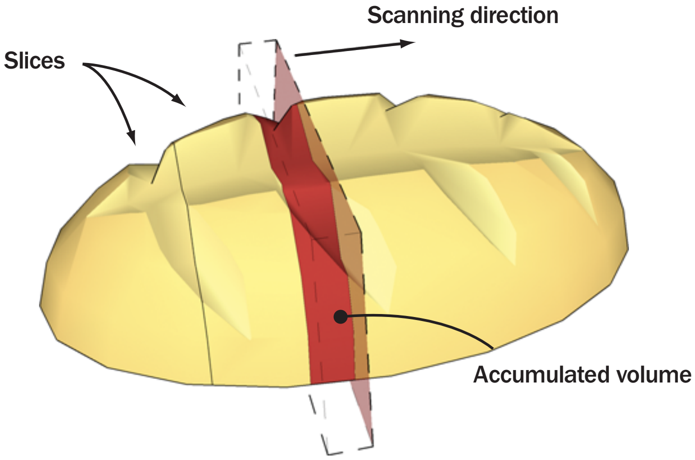
2 Getting Started

In this chapter we will introduce the basics in IVC Studio and learn how to:

- Create a product in IVC Studio in which to write the program
- Write the program - that is adding program steps and setting parameters
- Test and debug the program

As an example we will build a simple program that slices a loaf of bread in a number of pieces of equal volume (or weight if we can assume that the density is constant). One way to achieve this is to:

- Capture a 3D image of the loaf
- Calculate the total volume of the loaf and divide that volume with the desired number of slices to get the volume of each slice
- Move along the 3D image from one end to the other, while calculating the accumulated volume of the part of the loaf that we have covered



When the accumulated volume is equal to (or larger than) the desired volume of a slice, the current position is stored and the accumulated volume is reset. In a real production environment, the camera could control a knife that slices the loaf at the correct places.

When writing a program in IVC Studio you can use either a hardware camera or, if no such is available, the Emulator.

In the following sections it is assumed that a hardware camera is used, and that both the camera and IVC Studio are installed and are working properly. How to install the camera and IVC Studio is described in the installation instruction. To capture 3D images you would also need movement and some kind of trigger for triggering the 3D image grab. It is also strongly recommended to use an encoder for capturing accurate 3D images.

How to use the Emulator is described in section Using IVC Studio in the IVC-3D Reference Manual.

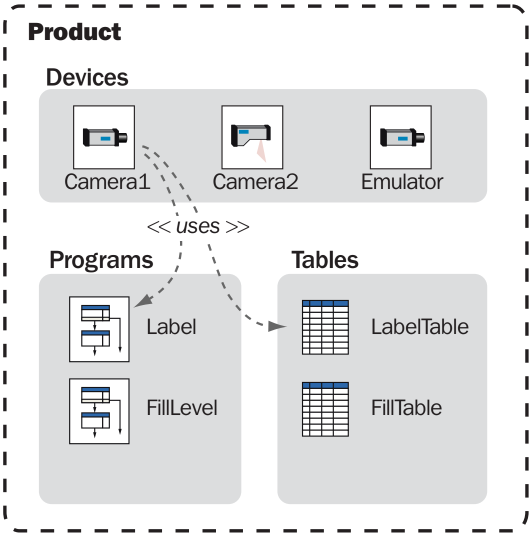
2.1 Creating a Product

Before starting to write the program, we need the following:

- A *product* to work with
- A *device* to use in the product (in this case a camera)
- A *program* written for the device
- A *table* used for the program in the device

A *product* in IVC Studio is a collection of *devices* (usually cameras) that are used for performing an inspection, for example of loafs of bread on a production line. Each device contains one or more *programs* that instruct the device how to perform the inspection.

A *program* is a list of commands, or *tools*, that the device executes one by one, in order to capture images, analyze them and draw conclusions from them. To its help, the program has a *table* that it can read values from and store results in.



2.1.1 Create a Product

The first step is to create the product to work with:

1. Start IVC Studio and log in.

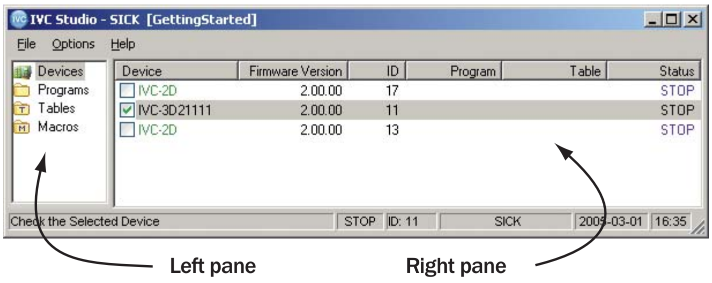
   If you just installed IVC Studio, the default user and password can be found in the installation instruction.

2. Choose File → New Product from the IVC Studio menu bar.

   A new empty product named New Product is opened.

The main window shows the contents of the currently open product. The left pane shows the different categories of objects that the product may contain, that is; devices, programs and tables.

Clicking on one of the categories will display the objects contained in the product. Since the product was just created, all categories are empty, with the exception of Devices, which contains all devices that are available.



Device	Firmware Version	ID	Program	Table	Status
□ IVC-2D	2.00.00	17			STOP
☑ IVC-3D21111	2.00.00	11			STOP
□ IVC-2D	2.00.00	13			STOP

Check the Selected Device | STOP | ID: 11 | SICK | 200[illegible]-03-01 | 16:35

There is also a fourth category that we haven't mentioned yet - *macros*. Macros are basically small programs that you can call from within regular programs. They can be useful for reusing blocks of program steps when writing advanced programs.

2.1.2 Select a Device

The next step is to select the device used for the inspection:

3. Click Devices in the left pane of the main window.

   The camera is displayed in the right pane. If there are more devices that can be used by IVC Studio in your network, those will also be displayed there.
4. Select a device by clicking in the checkbox in front of it in the right pane.

You should always select the devices that you intend to use in your product. IVC Studio periodically updates the information in the device list by polling the devices that are selected in the list.

If no device is selected in the list, IVC Studio will poll every device it can find for information. This slows IVC Studio down and may also affect the performance of devices used in other applications.

2.1.3 Create a Program

We are now ready to create the program we intend to build and to associate it with a device.

The reason for associating the program with a device before building it is that the program is always run on a device and not on the computer. What you see in IVC Studio when running a program are just the results, which are sent from the device. If you did not associate the program with a device, you would not be able to see any result of the program or even test the program.

5. Right-click Programs in the left pane of the main window and choose New Program from the pop-up menu.
6. Fill in a name for the program in the dialog box and click OK.
7. Click Devices in the left pane of the main window.
8. In the right pane, right-click the device that is selected for the product and choose Select Program from the pop-up menu.
9. Select the program in the list in the dialog box and click OK.

2.1.4 Create a Table

There must also be a table associated with the device, so before starting to build the program we must create a table and associate it with the device:

10. Create the table by right-clicking Tables in the left pane, choosing New Table from the pop-up menu and filling in a name in the dialog box.
11. Right-click the device that is selected for the product and choose Select Table from the pop-up menu.
12. In the dialog box, select the table and click OK.
13. Finally, save your changes to the product on the PC by choosing File → Save Product.

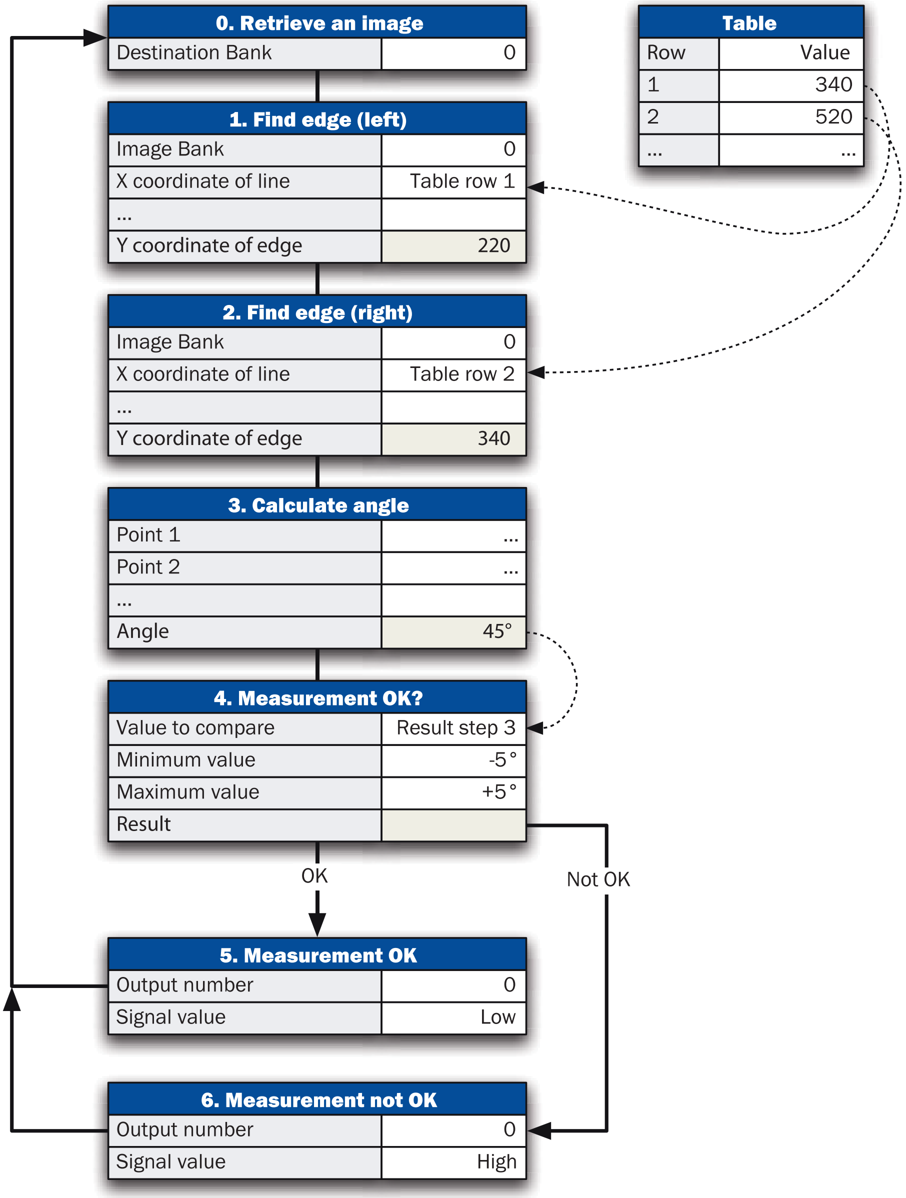
2.2 About Writing Programs

Before starting to write the program, we will take a look at what a program consists of and the programming environment.

2.2.1 Tools

A program is a list of commands – or *tools* – that are performed by the camera. When the program runs, the commands are carried out one by one in the order that they appear in the program list. So when you build a program in IVC Studio, you work with this list of commands.

Most of the tools have a number of input parameters that can be set. For example when capturing an image from a camera, you can specify in which image bank to store the image.



0. Retrieve an image	
Destination Bank	0

1. Find edge (left)	
Image Bank	0
X coordinate of line	Table row 1
...	
Y coordinate of edge	220

2. Find edge (right)	
Image Bank	0
X coordinate of line	Table row 2
...	
Y coordinate of edge	340

3. Calculate angle	
Point 1	...
Point 2	...
...	
Angle	45°

4. Measurement OK?	
Value to compare	Result step 3
Minimum value	-5 °
Maximum value	+5 °
Result	

5. Measurement OK	
Output number	0
Signal value	Low

6. Measurement not OK	
Output number	0
Signal value	High

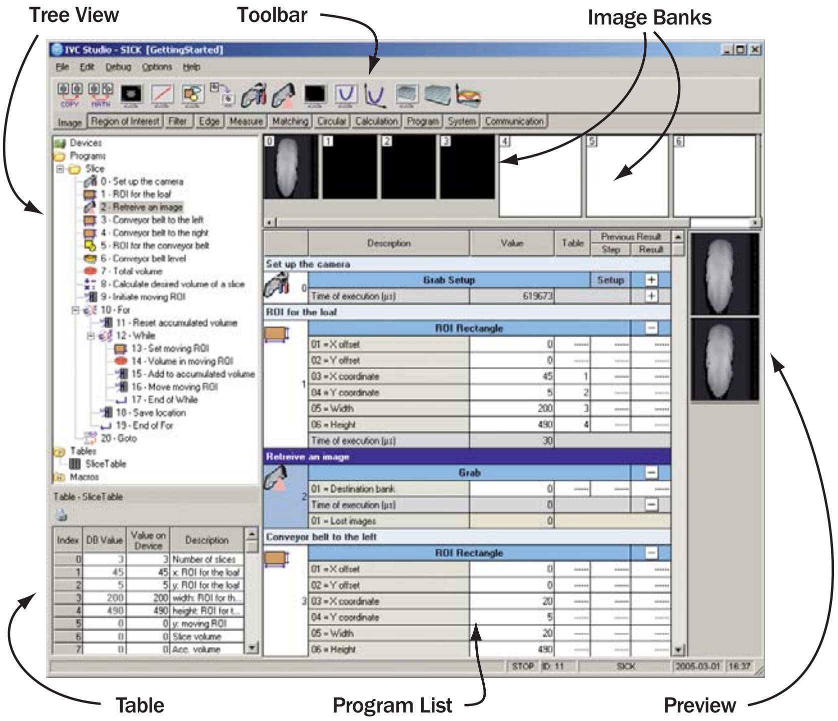
Table	
Row	Value
1	340
2	520
...	...

Many tools also produce results that are available as output parameters. These parameters can be stored in the table or be used directly by other steps in your program.

2.2.2 Programming Window

When you write a program, the main window contains a few additional parts:

- Toolbar – contains the tools that can be used with the device.
- Program List – shows the tools used in the program and the parameters for each tool.
- Table – shows the contents of the device's table.
- Image Banks – shows thumbnails of the images currently in the image banks of the device (if any). The images can be either 3D images or profiles.
- Preview – shows the result of the program step when applied to an image.



Devices
Programs
Slice
0 - Set up the camera
1 - ROI for the loaf
2 - Retreive an image
3 - Conveyor belt to the left
4 - Conveyor belt to the right
5 - ROI for the conveyor belt
6 - Conveyor belt level
7 - Total volume
8 - Calculate desired volume of a slice
9 - Initiate moving ROI
10 - For
11 - Reset accumulated volume
12 - While
13 - Set moving ROI
14 - Volume in moving ROI
15 - Add to accumulated volume
16 - Move moving ROI
17 - End of While
18 - Save location
19 - End of For
20 - Goto
Tables
SliceTable
Macros

Table - SliceTable

Index	DB Value	Value on Device	Description
0	3	3	Number of slices
1	45	45	x: ROI for the loaf
2	5	5	y: ROI for the loaf
3	200	200	width: ROI for th...
4	490	490	height: ROI for t...
5	0	0	y: moving ROI
6	0	0	Slice volume
7	0	0	Acc. volume

	Description	Value	Table	Previous Result	
				Step	Result
Set up the camera					
0	Grab Setup			Setup	+
	Time of execution (µs)	619673			+
ROI for the loaf					
1	ROI Rectangle				−
	01 = X offset	0	-----	-----	-----
	02 = Y offset	0	-----	-----	-----
	03 = X coordinate	45	1	-----	-----
	04 = Y coordinate	5	2	-----	-----
	05 = Width	200	3	-----	-----
	06 = Height	490	4	-----	-----
	Time of execution (µs)	30			
Retreive an image					
2	Grab				−
	01 = Destination bank	0	-----	-----	-----
	Time of execution (µs)	0			−
	01 = Lost images	0			
Conveyor belt to the left					
3	ROI Rectangle				−
	01 = X offset	0	-----	-----	-----
	02 = Y offset	0	-----	-----	-----
	03 = X coordinate	20	-----	-----	-----
	04 = Y coordinate	5	-----	-----	-----
	05 = Width	20	-----	-----	-----
	06 = Height	490	-----	-----	-----

STOP ID: 11 SICK 2005-03-01 16:37

The *toolbar* actually contains several toolbars on which the tools are grouped into categories. You switch between the categories by clicking the tabs at the bottom of the toolbar.

The *program list* shows each step in the program as a table. Each step contains:

- The input parameters that can be set for the tool
- The execution time for the tool when executed
- The result (return values) from the tool

The program list has four columns that are used for specifying parameter values: Value, Table, Step and Result. Which column to use depends on what type of parameter value you want to use; a constant value, a value from the table, or a result from a previous step.

Image banks are used for storing images, just like the table is used for storing values. This can be very useful, for example if you want to modify the image, but need to use the original image later on in the program. Note that the images are stored in the camera, and that the images in the image banks remain there until they are removed or overwritten by other images.

When working with the IVC-3D camera there are two types of image banks: one that contains 3D images and one that contains profiles. Which image banks that are of each type depends on how the camera is configured.

The *preview* window is used by some tools for visualizing the result of the tool. This preview is useful when you develop your program, but is not generated when the program is running. The preview window may also be used for setting parameters for certain tools. This is further described later in this chapter.

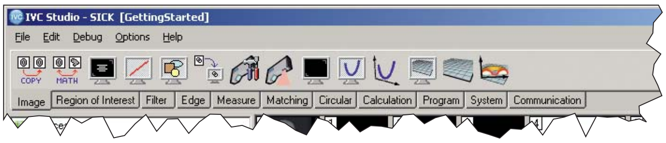
2.3 Adding Program Steps

Now we are ready to start writing our program for measuring and slicing the loaf of bread.

Start by adding the first program step to the program, which should grab a 3D image from the camera:

14. Click on the name of your program in the left pane in the main window.

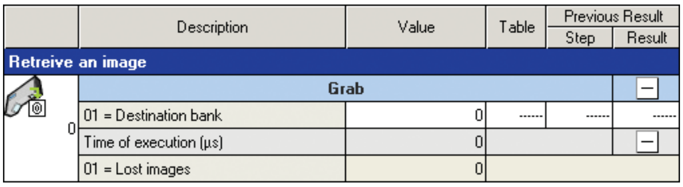
    A toolbar is displayed at the top of the window, which contains a number of tools that can be used with the device. Below the toolbar there is a row of tabs, which are used for switching between different tool categories.



15. Click the Grab tool in the Image category on the toolbar to add the first step to the program.

    The Grab tool is added to the program's folder in the left pane and to the Program List in the right pane.

16. Double-click the blue field at the top of the program step and type a description for the step, for example “Retreive an image”.



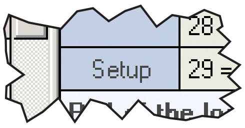
	Description	Value	Table	Previous Result	
				Step	Result
Retreive an image					
	Grab				
0	01 = Destination bank	0	------	------	------
	Time of execution (µs)	0			
	01 = Lost images	0			

The command is now added to our program. Before we can test the program and view the image, we should set up the camera to grab the image that we want.

17. Click the Grab Setup tool on the Image toolbar.
18. In the dialog box that is displayed, choose ...before current step and click OK.

    The Grab Setup step is added to the program list.

19. Add a description to the step, such as “Set up the camera”.
20. Double-click the Setup field that is located in the bottom left corner of the program step in the program list.



The Grab Setup window is now opened.

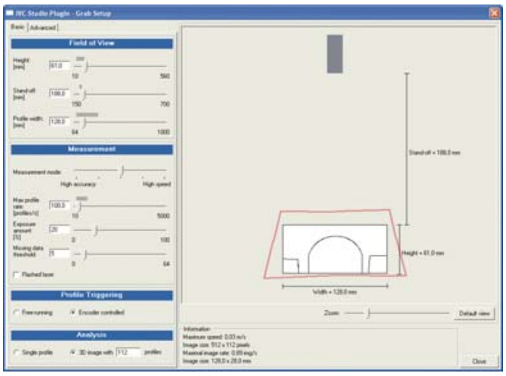
21. In the Grab Setup window, make the following settings:

    Basic tab

Field of view	Adjust the sliders **Height**, **Stand-off** and **Profile width** so that you can view the profile in the preview. You may also have to adjust the **Measurement** settings to improve the quality of the profile.
Profile triggering	Select **Free-running** or **Encoder controlled**, depending on whether or not you have an encoder connected to the camera.
Analysis	Select **3D Image** analysis and fill in the number of profiles per image.

    Advanced tab

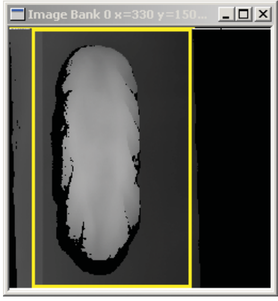
Profile triggering	If you have an encoder, set the number of pulses per millimeter and profile distance.
Image triggering	Select **Free-running** or **Triggered by input signal** depending on whether or not you have a trigger connected to the camera.

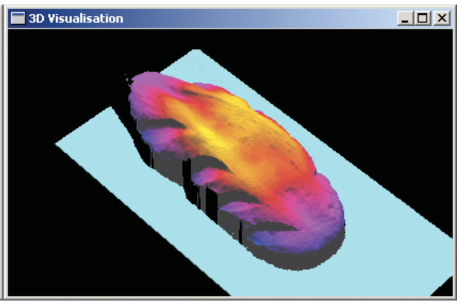


We are now ready to run the program on the camera and view the image that was retrieved.

22. Click the **Grab Setup** step in the program list to select the step.
23. Press F1 to open up the Reference manual for the **Grab Setup** step.
24. Close the manual again and remember to use the F1 button whenever you want to learn more about a tool.
25. Choose **Debug** → **Execute Step** from the IVC Studio menu, or press the **F5** key on the keyboard.
26. Select the **Grab** step in the program list and choose **Debug** → **Execute Step** once more.

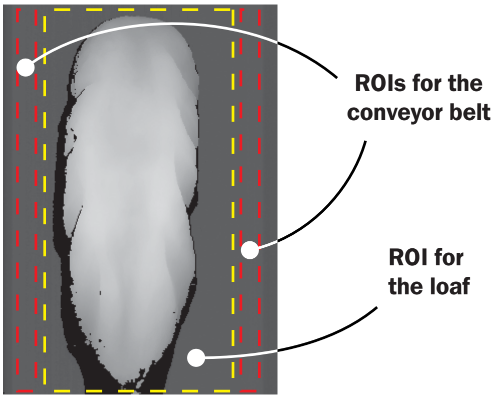
    An image is now retrieved from the camera and stored in image bank 0. Double-click on the image bank to see the 3D image in a larger window, together with a visualization of the image.





The next step is to calculate the total volume of the loaf of bread. In order to do that we need to have the following:

- A Region of Interest (ROI) that defines where in the 3D image the loaf is located
- A surface that defines the conveyor belt on which the loaf is placed. This surface is used as the zero-level when calculating the volume from the height data in the 3D image.



The ROI for the loaf is created by adding a ROI Rectangle tool to the program. We will set the parameters specifying the ROI later.

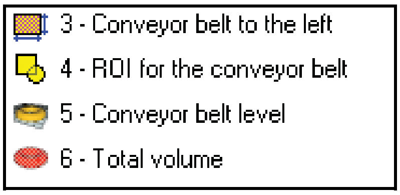
27. Click the **ROI Rectangle** tool on the ROI toolbar.
28. In the dialog box that is displayed, choose **...before current step** and click **OK**.

    The ROI Rectangle step is added to the program list.
29. Add a description to the step, such as “ROI for the loaf”.

The conveyor belt can be found by fitting a surface to areas outside the ROI for the loaf. This can be done with the following steps:

- Two ROI Rectangle tools that specify areas to the left and to the right of the loaf. If the conveyor belt is not exactly planar we can compensate for this by using two areas.
- A ROI Union tool that makes one (discontinuous) ROI out of the two rectangular ROIs.
- A Fit Surface tool that creates a surface from the height data inside the two rectangular ROIs.

30. Add the following program steps at the end of the program and give them suitable descriptions:



3 - Conveyor belt to the left	(ROI Rectangle)
4 - ROI for the conveyor belt	(ROI Union)
5 - Conveyor belt level	(Fit Surface)
6 - Total volume	(Volume)

We will add the second ROI, specifying the surface to the right, after we have set the necessary parameters.

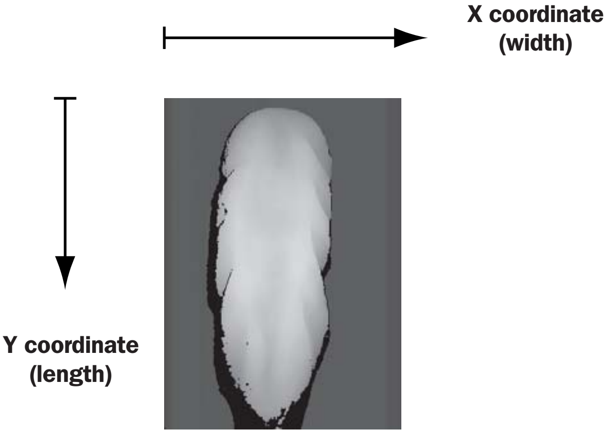
2.4 Setting Parameter Values

The input parameters of the tools can be set in a number of different ways:

- By manually entering a constant value
- By using interactive setup to set constant values
- By retrieving a value from the table
- By using the result from a previous step
- By writing an expression that may combine the methods above

In this section we will look at different ways of setting constant parameter values. Using tables, results from previous steps and expressions will be shown in the following sections.

One important thing when specifying pixel coordinates in images – coordinates are always measured from the top, left corner of the image.



2.4.1 Setting Constant Parameter Values

All the tools that we just added to the program need a number of parameters to be set:

ROI Rectangle • The rectangle that is the region of interest (ROI) in which we expect to find the loaf or the conveyor belt.

ROI Union • Two ROIs to join. A ROI is specified by referring to the program step in which the ROI is created.

Fit Surface • An image bank containing a 3D image, a ROI and the type of surface to fit to the part of the 3D image that is inside the ROI.

Volume • An image bank containing a 3D image, a ROI and a surface to use as zero-level when calculating the volume inside the ROI. Anything in the image below the zero-level is ignored when calculating the volume.

To *set a constant value manually* is really straightforward – just enter the value in the Value column for the parameter:

31. Select the Fit Surface step.
32. Double-click the Value column for the parameter 02=ROI definition step and enter the program step in which you specified the ROI for the conveyor belt, that is the ROI Union step.
33. Set the type of surface to be fitted by double-clicking the Value column for the parameter 03=Surface type and choose Plane surface from the menu.

Interactive setup windows are also used in some tools for entering parameter values. In these windows captured images are used to provide feedback for the settings. Parameters can be set interactively in three different ways:

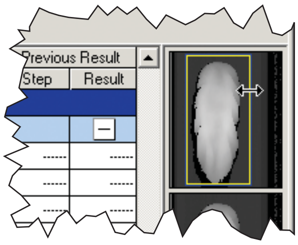
- In the Preview window
- By clicking the button with three dots (...), that is displayed when a parameter is double-clicked
- By double-clicking the Setup field that is displayed at the bottom left corner of certain program steps

The Grab Setup window, which we used earlier to set up the camera, is one example of an interactive setup window.

As another example, it is usually much easier to adjust the size and location of the ROI directly in the image in a preview window than entering coordinates for the rectangle in the Value column:

34. Select the ROI rectangle step “ROI for the loaf”.

    A rectangle is shown in the upper preview window. This is the default ROI that is set for a new ROI rectangle.
35. Move and resize the rectangle in the preview, so that it marks the area where you can see the shape of the loaf of bread.



36. In a similar manner, set the ROI rectangle for the step “Conveyor belt to the left” so that it marks a section of the empty area to the left of the loaf.

If you need a larger window to work in, you can double-click a preview to open it in a separate window. In this window you can fine-tune the parameters settings, for example if there are small details in the image.

Before moving along, we will just add the last ROI Rectangle (for the area to the right of the loaf of bread) and set the rest of the parameters for the steps that we have added this far.

37. Select the “Conveyor belt to the left” step and choose Edit → Copy from the main menu.
38. Choose Edit → Paste and paste the step after the current step.
39. Move the rectangle in the preview window to the right of the loaf of bread.
40. Change the description of the program step to “Conveyor belt to the right”.
41. Set the following parameters for the remaining steps:

ROI Union	01=ROI A definition step	Step number of “Conveyor belt to the left”
	02=ROI B definition step	Step number of “Conveyor belt to the right”
Volume	02=ROI definition step	Step number of “ROI for the loaf”
	03= Surface definition step	Step number of the Fit Surface tool

42. Execute all the steps in the camera by selecting the first ROI Rectangle step (“ROI for the loaf”) and choose Debug → Step by step or press the F8 key until all steps in the program have been executed.

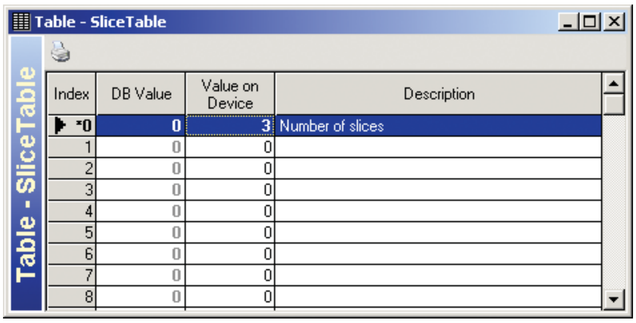
2.4.2 Using Tables and Results from Other Steps

The table is very useful for storing constants and results of calculations that we need to use later.

For example, to calculate the desired volume of a slice of bread we can use the table for setting the number of slices to make, and to store the desired volume of a slice to be used later when we decide where to cut.

43. Double-click in the Value on Device column of an empty row in the table and fill in the number of slices to make. Fill in a description of the value in the Description column of the row, for example “Number of slices”.

    The row is now highlighted in the table, indicating that the value on the device differs from the value in the database.



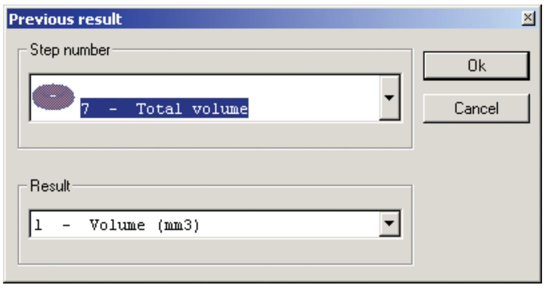
Index	DB Value	Value on Device	Description
*0	0	3	Number of slices
1	0	0	
2	0	0	
3	0	0	
4	0	0	
5	0	0	
6	0	0	
7	0	0	
8	0	0	

44. In the table, right-click the value in the Value on Device column and choose Copy Device Value to the DB to synchronize the value on the PC with the value in the device.
45. Add a Mathematical Operation tool (from the Calculation toolbar) to the program.
46. Set the parameter 03=Mathematical operation to / (Division) and fill in a description.
47. Click in the Table column for the parameter 02=Variable B and type in the number of the table row in which you entered the number of slices.
48. This tool can store the result of the calculation directly in the table, so double-click the Value column of the parameter 04=Table index and fill in the number of an empty row in the table. Remember to fill in a description of the value in the table.

To calculate the desired volume of a slice we also need the total volume, which we calculated in the previous step. We may store the total volume in the table and read the value from there, but we can also retrieve the value directly from the returned values of the step.

49. Double-click the Step column of the parameter 01=Variable A.

    A Previous result dialog box is displayed. Here you can select a result from a program step to use as parameter value.



Step number: 7 - Total volume

Result: 1 - Volume (mm3)

50. Choose the step number of the Volume step and then the first result from that step (there is only one result to choose from) and click OK.

    The number of the step and the result are entered in the Step and Result columns of the 01=Variable A parameter and the current value is displayed in the Value column.

The next step in our problem is to find where to cut the loaf of bread. This can be solved in the following way:

1. Set a thin ROI (1 pixel high) at the beginning of the loaf and set an accumulated volume to 0.
2. Calculate the volume of the thin part of the loaf that is inside the ROI and add this volume to the accumulated volume.
3. Move the ROI 1 pixel at a time and add the volume inside the ROI to the accumulated volume.
4. When the accumulated volume becomes larger than the desired volume of a slice, cut the loaf (or just mark the location) and reset the accumulated volume.

We will use the table for storing both the current location (y-coordinate) of the moving ROI and the accumulated volume.

Since we start at the beginning of the loaf, we can initiate the location of the moving ROI with the y-coordinate of the ROI for the loaf. This value is currently hard-coded into a program step, but if we instead store the coordinates and size of the ROI for the loaf in the table, we can easily read the coordinate we need when initiating the moving ROI.

51. In the program step "ROI for the loaf", copy the values of the parameters 03=X coordinate, 04=Y coordinate, 05=Width and 06=Height and store them in the table. Fill in descriptions for the table values and make in the program step read these values from the table.
52. Add a Write to Table tool (from the System toolbar) to the program and set the following parameters:

01=Value	Row number in the table in which the y-coordinate of the ROI for the loaf is stored.
02=Table index	The table row in which to store the current location of the moving ROI.

We can now reset the accumulated volume, set the moving ROI and calculate the accumulated volume.

53. Add another Write to Table tool and fill in the description "Reset accumulated volume". Set the following parameters:

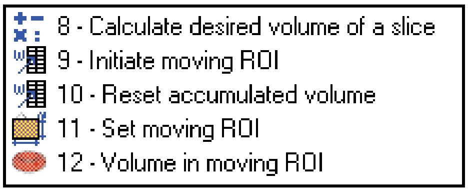
01=Value	0
02=Table index	The row number in the table in which to store the accumulated volume. Remember to fill in a description of the value in the table.

54. Add a ROI Rectangle tool and fill in the description "Set moving ROI". Set the following parameters:

03=X coordinate	The x-coordinate of the ROI for the loaf
04=Y coordinate	The current location of the moving ROI
05=Width	The width of the ROI for the loaf
06=Height	1

55. Add a Volume tool and fill in the description "Volume in moving ROI". Set the following parameters:

02=ROI definition step	Step number of the "Set moving ROI" step
03=Surface definition step	Step number of the Fit Surface tool


8 - Calculate desired volume of a slice
9 - Initiate moving ROI
10 - Reset accumulated volume
11 - Set moving ROI
12 - Volume in moving ROI

2.4.3 Setting Parameter Values with Expressions

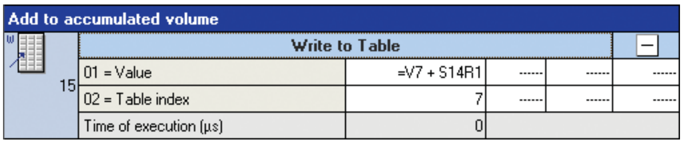
To add the volume inside the moving ROI to the accumulated volume, we need to read the current accumulated volume from the table, perform the addition and then store the new value back to the table. By using an expression we can do all that in one program step.

56. Add another Write to Table tool and fill in the description “Add to accumulated volume”. Set the following parameters:

01=Value `=V<row> + S<step>R1`

where `<row>` is replaced with the table row number in which the accumulated volume is stored, and `<step>` is replaced with the step number of the “Volume in moving ROI” above.

02=Table index The row number in the table in which the accumulated volume is stored (the same as `<row>`).



Add to accumulated volume

15	Write to Table				
	01 = Value	=V7 + S14R1	------	------	------
	02 = Table index	7	------	------	------
	Time of execution (µs)	0			

The value of the parameter 01=Value is an expression that calculates a value each time this step is performed. An expression always begins with an equal sign (=) and may contain:

• Constant values	`360`, `4/7`, etc.
• Table values	`Vn` for the value in row `n`
• Results from other steps	`SmRn` for result `n` of step `m` (for example `S17R2`)
• Parameters (arguments) in other steps	`SmAn` for input parameter `n` of step `m`
• Functions	`sin()`, `abs()`, etc.

Please note that a program using expressions will not necessarily execute faster than (or even as fast as) a program where program steps are used for the same calculations. The expressions need to be parsed each time the program step is executed, which will add some time to the execution time.

Next, we will move the ROI `1` pixel to prepare for the next thin slice of loaf to be added to the accumulated volume. We do that by increasing the location of the moving ROI by `1` – a value that is stored in the table.

57. Select the program step “Add to accumulated volume” and choose Edit → Copy.
58. Paste the step after the selected step. Change the description to “Move moving ROI”.
59. Change the following parameters of the “Move moving ROI” step:

01=Value `=V<row> + 1`

where `<row>` is replaced with the table row number in which the location of the moving ROI is stored.

02=Table index The row number in the table in which the location of the moving ROI is stored (the same as `<row>`).

2.4.4 Using Conditions and Jumps

Since we intend to move the ROI along the entire bread loaf, we need to repeat the last steps. In fact we need two loops in order to solve our problem:

- An inner loop that calculates the accumulated volume until we have a full slice, that is when the accumulated volume is as large or larger than the desired volume for a slice.
- An outer loop that runs from `1` to (the number of slices – `1`) and takes care of the locations where we should cut the bread loaf (there is no need to cut after the last slice).

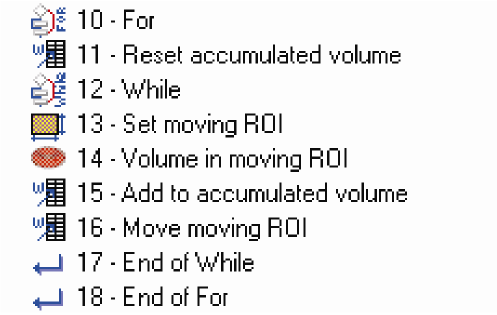
60. Select the “Set moving ROI” step and add a While tool (from the Program toolbar) before the selected step.
61. Add an End tool at the end of the program and fill in the description “End of While”. Set the parameter 01=Start step to the step number of the While tool.
62. For the While tool, set the following parameters:

    01=Control expression =`(V<accVolRow> < V<sliceVolRow>)`

    where `<accVolRow>` is replaced with the table row number in which the accumulated volume is stored, and `<sliceVolRow>` is replaced with the table row number in which the desired volume of a slice is stored .

    02=END step The step number of the “End of While” tool.
63. Select the “Reset accumulated volume” step and add a For tool before the selected step.
64. Add another End tool at the end of the program and fill in the description “End of For”. Set the parameter 01=Start step to the step number of the For tool.
65. For the For tool, set the following parameters:

01=Start value	1
02=End value	The number of slices to make minus 1.
03=Increment	1
02=END step	The step number of the “End of For” tool.



10 - For
11 - Reset accumulated volume
12 - While
13 - Set moving ROI
14 - Volume in moving ROI
15 - Add to accumulated volume
16 - Move moving ROI
17 - End of While
18 - End of For

Now we just have to add a step after the inner loop that registers the location where the bread loaf should be cut. We are going to save the locations in the table, in a number of consecutive table rows.

66. Add a Write to table tool between the two End tools at the end of the program, and fill in the description “Save location”. Set the following parameters:

    01=Value An expression that calculates the value (current location of the moving ROI – 1). This is the value to save since we incremented the location after calculating the accumulated volume.

    02=Table index An expression that calculates the row number of an empty row in the table. The result of the For step can be useful in this case.
67. Add a Goto tool at the end of the program and set this step to jump to step 2.

If we do not add the last Goto step, the program will automatically jump to step 0 when it reaches to the end.

It is usually a good practice to make sure that the program jumps to the right place after reaching the end. This way we can avoid situations where we add steps intended to be run only the first time the program runs, but that are executed every time.

2.5 Testing and Running the Program

How do we know that the program we have written this far is working properly?

One way is to step through the program using Debug → Execute Step and Debug → Step by Step. The result of each step is shown in the preview window and the Value column of each parameter.

68. Use Debug → Execute Step and Debug → Step by Step to step through the program and make sure that it gives the correct result.

Another way is to add some program steps that display the result of the analysis and run the program.

69. Add a Copy image bank tool after the first Grab step.

    We add this step in order to have a copy of the image to draw in. If we draw in the original image the analysis could be affected. Also make sure that the bank is not already used.
70. Add a Draw ROI tool after the Copy image bank tool.

    This step draws the region of interest in the image. Make sure to draw in the image bank with the copy of the image.
71. Add a Draw line tool after the “Save location” step. Set the parameters 01=Start point X, 02=Start point Y, 03=End point X and 04=End point Y so that the tool draws a line across the ROI for the loaf at the location of the cut, which is stored in the table. Make sure to draw in the correct image bank.
72. Add a Display tool after the “End of For” step and set the parameter so that it displays image bank 1.
73. Choose Debug → Run and watch the result in the Display window.

We are now done writing the example program, but there are – at least – two more functions that could be added to the program:

- Making the cuts.

  We could use either the outputs of the camera to directly control a knife that cuts the loaf of bread, or we could have another device that controls the knife and send the locations where to cut to that device using either RS485 or Ethernet.

  Before sending the locations, remember that the values stored in the table have the unit “pixels”. It would probably be a good idea to get the calibrated positions (in millimeters) before passing them on.

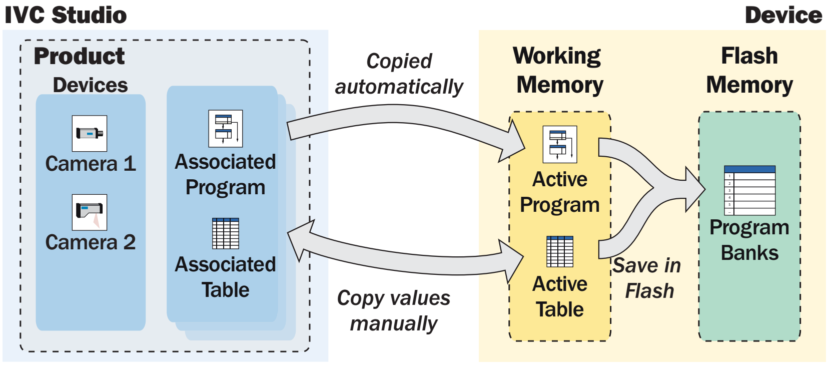
- Improving the precision of the program.

  Every slice – except the last one – will be slightly larger than the desired volume. This is because we are working with a resolution of 1 pixel along the y-axis, and do not make the cut until the accumulated volume is larger than the desired volume. If we add a interpolation calculation that can give us a sub-pixel position where the accumulated volume exceeds the desired volume, the precision of program could be greatly improved.

2.6 Saving the Program

To save the program we have written, use File → Save Product. This will save the program on the PC (along with all other programs and tables in the product), but not on the device. The program is present on the device as well, since it is downloaded to the device as you build it.

But if the power to the device is cut, your program will be lost from the device and has to be downloaded again from the PC. To prevent this from happening, you may save the program in the flash memory on the device.



To download a program to a device without saving it in the flash memory:

1. Open the product containing the program.
2. Make sure the program is associated with the device and that a table is associated as well.
3. Right-click the device in the list of devices and choose Start Program from the pop-up menu.

   The program is downloaded to the device and started. The status of the device is changed from STOP to RUN.

When you save the program in the flash memory on the device, you choose a program bank in which to save the program. You always save the program that is currently in the working memory of the device. The table that is active is also saved with the program.

To save the program on the flash memory of the device:

4. Right-click the device in the list of devices and choose Flash → Write Program in Flash.
5. Select the program bank in which to save the program and click OK.

   The program is now saved in the selected program bank.

If you save a program in program bank 0, this program will start when the device is powered up. If you want the device to run a different program, you can load that program using a PC, either by using an existing product (containing the program to be used), or by downloading the program from the device's flash memory.

2.7 What's Next?

In this chapter we have looked at the basics of how to handle IVC Studio, such as setting up a product and writing a simple program. However, there are many features in IVC Studio and the camera that have not been covered, which makes it possible to write advanced programs for inspections and automation of production. Some of the features are:

- Using the camera as a stand-alone unit
- Using several devices in a product
- Using several programs on a single device

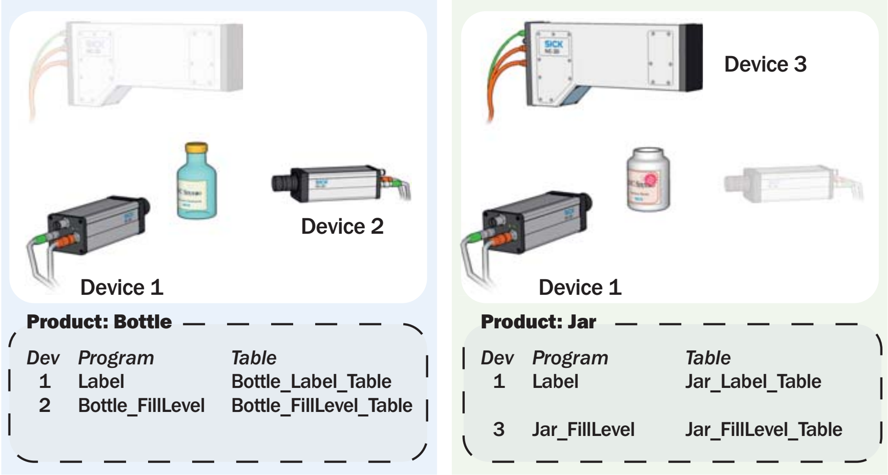
Using Cameras Stand-alone

Once the program is developed it can be downloaded to the device and started. Now the program will run in the device until it is stopped, and it is no longer necessary to use IVC Studio. If the program is also saved in program bank 0 on the flash memory, the program will be started when the device is powered up.

If you want to interact with the device, you can write a program that for example communicates with other equipment via the RS485 port, or set up a web page in the camera that can be used for monitoring and controlling the device in a web browser on a PC.

Using Several Devices

A product may use several devices that each performs a certain inspection. It is also possible to use the same device in several products and let the device run different programs depending on the current product.



Product: Bottle

Dev	Program	Table
1	Label	Bottle_Label_Table
2	Bottle_FillLevel	Bottle_FillLevel_Table

Product: Jar

Dev	Program	Table
1	Label	Jar_Label_Table
3	Jar_FillLevel	Jar_FillLevel_Table

To use several devices in the product, simply select the devices by clicking the checkbox in front of them in the main window.

When the development is finished you can easily download the programs and tables to all included devices at once by right-clicking Devices in the left pane of the main window and choosing Product Transmission. This will also start the programs in the devices.

Using Several Programs

While there can be only one program in the working memory, additional programs can be stored in the flash memory of the device. These programs can either be loaded manually into the working memory, or they can be called from the active program.

- To load a program manually, use IVC Studio to associate the program with the device and then start the program. This requires that the program is available in the product that is open in IVC Studio.

  If the program is not available on the PC, you can retrieve it from the device by right-clicking the device in the list of devices and choosing Flash → Import Program from Flash.
- To call a program stored in flash from the active program, please refer to the Tools section of this manual for information on which tool to use.

  Note that calling a program stored in flash will load both a program and a table into the working memory of the device, replacing the previous program and table there.

3 Using IVC Studio

3.1 Handling Devices

Note: Do not connect to, configure or view live images from a camera that is already used through another PC. A camera can only be connected to one PC at a time. IVC Studio will only detect an Emulator running on the same PC.

3.1.1 Installing and Configuring

Configuring Ethernet

The Ethernet configuration depends on how the device (camera) is connected to the PC.

To configure a device

Choose Options → Configuration from the IVC **Studio** menu bar.
A window containing a tree view is displayed.

Select Ethernet Devices in the tree view.
The Ethernet devices dialog is displayed in the right pane in the window.

Click the Ethernet Device Configuration button.
The Ethernet Device Settings window is displayed, containing a list of available devices.

Select a device from the list.
The current settings of that device are displayed in the right pane.

Double-click the IP number parameter value and change it.

Click Update.

Viewing Live Image

To view a camera image for IVC-2D

Click Devices in the left pane.
The available cameras, devices, are listed in the right pane.

Double-click the device or right-click the device and choose Live Device from the pop-up menu.
A live image is displayed in a pop-up window.

Clicking the handle of the drawer on the right of the image window displays sliders for Shutter, Gain, and Strobe.

To view a camera image for IVC-3D

Select the program currently associated with the device, or create a new program and associate it with the device.

Add a *Grab Setup* tool to the program by clicking on the Grab Setup icon in the Image toolbar.

Double-click the Setup button at the bottom left corner of the program step.

The Grab Setup window is displayed. A live image of the profile is shown in side the white box in the right pane in the window.

Setting Number of Image Banks

To change the number of Image Banks used by the device

Choose Options → Configuration from the IVC Studio menu bar.
A window containing a tree view is displayed.

Select Ethernet Devices in the tree view.
Ethernet devices are displayed in the right pane in the window.

Click the Ethernet Device Configuration button.
The Ethernet Device Settings window is displayed containing a list of available devices.

Select a device from the list.
The current settings of that device are displayed in the right pane.

Change the value of the parameter Image Banks.
For IVC-3D, change the value of the parameter Profile Banks.

Click Update.

Loading Device Firmware

Firmware contains information on the available tools and how they perform. You load new firmware to upgrade IVC Studio with new tools.

To load device firmware

Choose File → Load Device Firmware.

Note:
Do not interrupt the loading of firmware once it has started. Do not disconnect the power or the network connection to the device until the device is shown again in the list of devices in the IVC Studio main window (that is listed with the status RUNNING or STOP)

3.1.2 Starting, Stopping, and Resetting Devices

The device can be in one of three states:

- run
- stop
- error

Resetting the device restarts the processor in the camera. This may be necessary if the device is stalled.

To start running a program in a device

Right-click the device and choose Start Program from the pop-up menu, or press F6. The program keeps running until it is stopped.
To view the result when using an IVC-2D, right-click the device and choose Live Device from the pop-up menu.

To stop a program

Right-click the device and choose Stop Program from the pop-up menu.

To reset a device

Choose Options → Configuration from the IVC Studio menu bar.
A pop-up window containing a tree view appears.
Select Ethernet Devices in the tree view.
Ethernet devices appear in the right panel of the pop-up window.
Click the Ethernet Device Configuration button.
The Ethernet Device Settings window appears containing available devices.
Right-click the device and choose Reset Device from the pop-up menu.

3.1.3 Handling Memory in Camera

Saving camera memory is useful for backup purposes. The camera contains image banks, a data block memory and a Flash memory. For more information on the Flash memory see section Handling Programs on the Camera.

Image banks and data block memory are used for storage during program execution. When starting to develop a new program, it may be useful to refresh the memory in order to make sure that no old data affects the new program. The contents of the image banks can also be saved to disk.

To save the data block memory from the camera to a PC file

Right-click the device and choose Device Management → Save Data Block to File from the pop-up menu.

To save an image bank to disk

Right-click image bank in the active program window and choose Save Image Bank to Disk from the pop-up menu. See section Handling Images for more information on handling image banks.

To reset data block memory	Right-click the device and choose Device Management → Reset Data Block from the pop-up menu.
To reset image banks	Right-click the device and choose Device Management → Reset Banks from the pop-up menu. It is also possible to reset the image banks one by one when a program is open. See chapter Handling Images for more information.
To restore data block memory from a PC file	Right-click the device and choose Device Management → Load Data Block from File from the pop-up menu.

3.1.4 Viewing Device Information

Information is available on the status of devices and errors that have occurred. The information can be refreshed on one or all devices.

To view device information	Right-click the device and choose Device management → Device Information from the pop-up menu. This window contains detailed information about the device, such as hardware and software versions, Ethernet information and the status of the device.
To view the status of running program, inputs and outputs	Right-click the device and choose Device management → Signal Status from the pop-up menu. This window shows the status of inputs and outputs of the device. If a program is running you can also see which program steps that are performed at the moment
To refresh displayed information on a checked device	Choose Options → Refresh from the IVC Studio menu bar or press F5.
To refresh and display information on all devices	Choose Options → Update All from the IVC Studio menu bar or press Ctrl F5.

3.2 Handling the Emulator

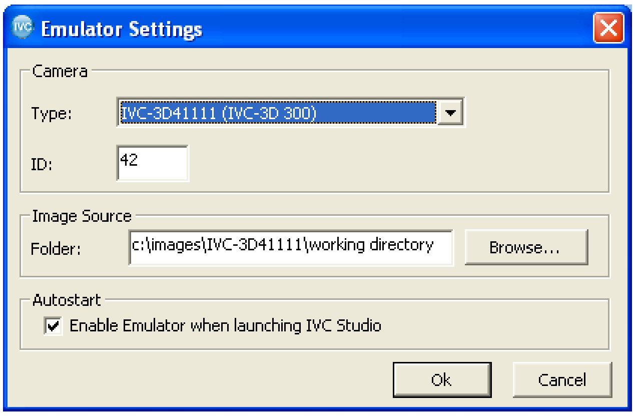
The Emulator is a software program in IVC Studio that behaves like a hardware camera. It makes it possible to write or update programs when there is no hardware camera available. The Emulator can behave as (emulate) both 2D and 3D cameras. Each product in IVC Studio can contain several devices, but only one emulated camera.

The main difference between the Emulator and a camera is that the former uses a predefined set of images stored in a dedicated image folder on the PC, whereas the latter views live images. Not all tools are emulated by the Emulator; these tools are marked with [Not emulated] in the user interface. Interactive setups are not available for non-emulated tools.

The Grab tool functions differently when the Emulator is used. This is described in section Using the Grab and the Grab Setup Tools below.

The execution time of a tool when using the emulator depends on the performance of the PC. This time is not the same as the execution time when the tool is executed on a hardware camera. This means that the field “**Time of execution (us)**” in the step program view cannot be used in a calculation of the expected cycle time for the application when the emulator is used.

From the **Emulator** menu in the menu bar you can enable and disable the Emulator, and change its settings. In the Emulator settings dialog you can choose which camera type to emulate, select which folder to capture pre-recorded images from, and choose to enable the Emulator automatically when starting IVC Studio.



Emulator Settings

Camera

Type: IVC-3D41111 (IVC-3D 300)

ID: 42

Image Source

Folder: c:\images\IVC-3D41111\working directory

Autostart

☑ Enable Emulator when launching IVC Studio

3.2.1 Preparing images for the Emulator

Instead of viewing live images, the Emulator captures pre-recorded images. Before starting the Emulator it is thus necessary to prepare images. This is done by recording images that are captured by a real camera. The images must be saved in the raw format (.raw or .img) for IVC-3D and IVC-2D, or bitmap (.bmp) for IVC-2D, in a version of IVC Studio that supports the Emulator. When saving an image, the Grab Setup parameters are stored in the image file and can be read by the Emulator.

To record images

Use a camera of the same type that you will emulate.

Select or write a program containing a Grab Setup tool defining how to captures images, a Grab tool to capture the images, and a Send to FTP tool to store the images in raw format in a selected folder. The PC receiving the images must have an FTP server running.

To use recorded images in the

Choose **Emulator → Settings**… from the IVC Studio menu bar.

The Emulator settings dialog box is opened.

Emulator

Click Browse… and select a folder containing recorded images. The Emulator camera type must be of the same type that was used when recording the images.

Click OK.

3.2.2 Basics

To enable the Emulator

Choose Emulator → Enable… from the IVC Studio menu bar.

The Emulator settings dialog box is opened.

Select which camera type to emulate from the drop-down list.

Enter a numeric camera ID. The ID must be unique within the Product. Maximum length is 9 digits.

Click Browse… and select a folder containing pre-recorded images. The Emulator camera type must be of the same type that was used when recording the images.

Click OK.

To disable the Emulator

Choose Emulator → Disable from the IVC Studio menu bar.

The Emulator disappears from the list of Devices.

To enable the Emulator automatically

Choose Emulator → Settings… from the IVC Studio menu bar.

The Emulator settings dialog box is opened.

Tick Enable Emulator when launching IVC Studio and click OK.

The Emulator is now automatically enabled when starting IVC Studio.

To change the Emulator settings

Choose Emulator → Settings… from the IVC Studio menu bar.

If Type, ID, **Number of image banks** or **Number of profile banks** is changed, the Emulator will be restarted.

To access the flash disk of the Emulator

The flash disk of the Emulator is found on the PC under My Documents (Documents in Vista) for the current user. The default path to the Emulator flash is:

My Documents\SICKIVP\SmartCameras\IVC Studio x.x\ Emulator\flash

3.2.3 Using the Grab and the Grab Setup Tools

Each time the Grab tool is executed a new image is read from the image source. The name of this image file is displayed as a result parameter of the Grab step, and the Grab Setup parameters saved in the image file are used to update the image banks.

The program thus works as if a Grab Setup step with these settings were executed.

3.2.4 Using Old Images in an Emulated 3D Camera

It is possible to use images that are captured with a version of IVC Studio that does not support the Emulator. The Grab Setup tool then needs to be executed with the same settings as were used when capturing the images, since the images do not contain any setup information.

To use old images in an emulated 3D camera

Choose Emulator → Settings… from the IVC Studio menu bar, select the desired image source folder, and click OK.

Configure a Grab Setup step with the same settings that were used when the images were captured.

Execute the Grab Setup step.

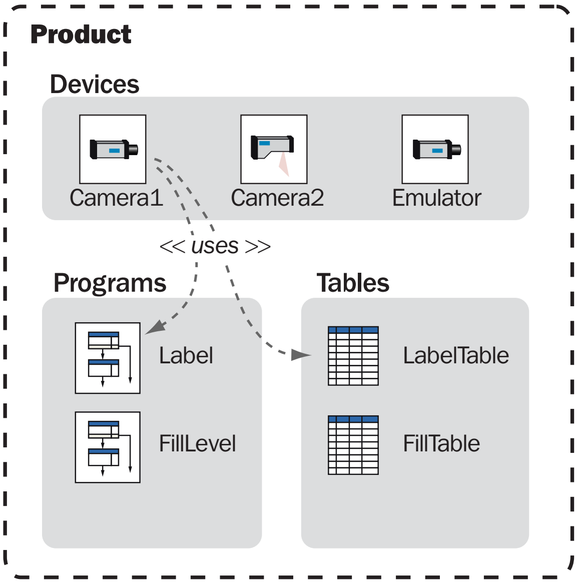
Execute the Grab step.

3.2.5 Using a Non-Emulated Tool in the Emulator

Some tools are not emulated by the Emulator. When executed in the Emulator, they return the default values of all parameters. Interactive setups are not available for non-emulated tools.

3.3 Handling Products

A product in IVC Studio is a collection of devices, programs and tables. A device can be either a hardware camera or an Emulator.



3.3.1 Basics

To create a new product
Choose File → New Product from the IVC Studio menu bar.
An empty product named New Product is opened.

To open a product
Choose File → Open Product… from the IVC Studio menu bar. Select a product in the dialog box and click OK.

To save a product
Choose File → Save Product from the IVC Studio menu bar.
If you try to open another product or to close IVC Studio without saving the presently active product a dialog box appears prompting you to do so.
If the product has not yet been saved, a dialog box is displayed. Type the name of the product and click OK.

To make a copy of the current product
Choose File → Save Product As… from the IVC Studio menu bar. Type the name of the new product and click OK.

To revert to the last saved version of the current product
Choose File → Revert… from the IVC Studio menu bar.

The product files can be stored in two formats; the standard .prd and a new extended format (.prc) that also contains a checksum. The checksum is used to verify the integrity of the product file to ensure that the contents have not been altered, e.g. by a problem in a zip/unzip-procedure.

The new format is not compatible with IVC Studio versions prior to 3.1 SR1. The old format is still supported, and existing files can easily be converted to the new format by using "Save As" in IVC Studio 3.1 SR1 or higher.

3.3.2 Managing Devices Used in a Product

You should always check the devices you are using in order to decrease the execution time. IVC Studio continuously updates the information about the status of all devices in the device list, but if you check the devices you currently use, the list is only updated with information about these, which saves time.

To check/uncheck a device	Select Devices in the left pane and click on the checkbox in front of the device.
To uncheck all devices	Select Devices in the left pane. Right-click a device in the right pane and choose Uncheck All Devices from the pop-up menu.

3.3.3 Associating Programs and Tables with a Device

Both a program and a table have to be associated with the device in order for the program to be able to run.

To associate a program to a device	Right-click the device and choose Select Program from the pop-up menu. Select a program from the pop-up dialog and click OK to associate it with the device.
To associate a table	Right-click the device and choose Select Table from the pop-up menu. Select a table from the pop-up dialog and click OK.
To import a program from another product	Right-click Programs in the tree view and choose Import Program from the pop-up menu.

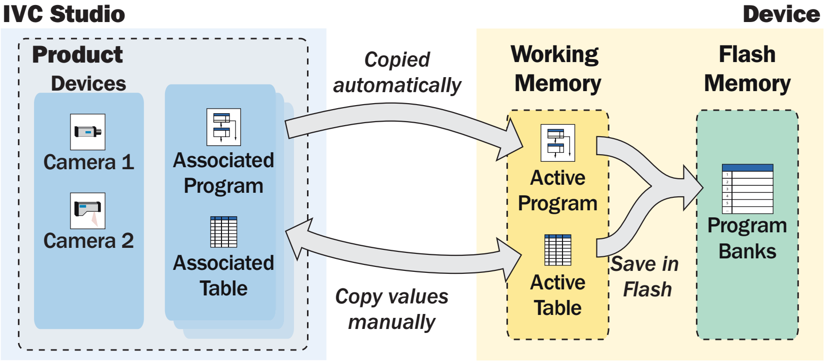
3.3.4 Handling Products

To start all devices in a product	Right-click Devices in the left pane and choose Product Transmission from the pop-up menu.
To stop all devices in a product	Right-click Devices in the left pane and choose Stop Product from the pop-up menu.

3.4 Handling Programs

Programs are developed on a PC. During development a copy of the program is maintained in the device. Programs are always run in the camera, even during development. A camera can contain several programs, but after a shutdown it always runs the one in program bank zero in the Flash memory.

If you don't want to start from scratch when building a program, you may instead import a program used in another product or retrieve a program that is stored in a device. To import a program from another product, the program must first be exported to a file on the computer.



3.4.1 Handling Programs on PC

Basics

To create a new program	Right-click Programs in the tree view and choose New Program from the pop-up menu.
To delete a program	Right-click the program in the tree view and choose Delete Program from the pop-up menu.
To rename a program	Right-click the program in the tree view and choose Rename Program from the pop-up menu. Write the new name in the dialog box that is displayed.
To print a program	Right-click the program in the tree view and choose Print Program from the pop-up menu.
To view program information	Right-click program in the tree view and choose Program Information from the pop-up menu. A pop up window displays information such as program name and dates of creation and last change and who made the latest changes to the program.

Copying, Importing, and Exporting Programs

To make a copy of a program
Right-click the program in the tree view and choose Copy Program from the pop-up menu. Click YES to confirm and name the new program.

To import a program from a file on the PC
Right-click Programs or one of the programs in the tree view in the left pane and choose Import Program from the pop-up menu.

To export a program to a file on the PC
Right-click the program in the tree view and choose Export Program from the pop-up menu.

3.4.2 Handling Programs on the Camera Flash

To write product in flash
Right-click Devices in the left pane and choose Write Product in Flash from the pop-up menu. The currently associated product and table is stored on the camera flash in position 0 for each of the devices in the Device list. No action is performed if the device is not associated with a program in the current product.

To store a program in flash memory on the device
Right-click the device and choose Device Management → Flash → Write Program in Flash from the pop-up menu. Select a memory position in the dialog window and click Save. The table is automatically stored with the program.

To delete programs stored in flash
Right-click the device and choose Device Management → Flash → Delete Stored Program in Flash from the pop-up menu. This deletes the program in the selected position in the flash memory. It is also possible to delete multiple programs by selecting more than one position.

To clear unused memory on flash
When a program is deleted from flash, the flash blocks occupied by the program is not immediately reused but marked as unused (dead). The unused memory will not be reused until there is no more free memory on the device. This is done in order to minimize the wear of the flash memory.

To reuse a block of unused memory, it must first be cleared. Clearing the memory takes some time and may affect the performance of the device. To restore the performance, the unused memory can be cleared manually.

To clear unused memory, right-click the device and choose Device Management → Flash → Clear unused memory from the pop-up menu. In the dialog box that is displayed, click Start and wait for the device to be finished.

To import programs from flash program bank to PC
Right-click the device and choose Device Management → Flash → Import Program From Flash from the pop-up menu. Select a program in the pop-up dialog window and click Save. The associated table is automatically imported with the program.

3.4.3 Handling the Camera Flash

The flash disk of the IVC camera can be used to store programs, images, data blocks and tables. The disk is also used by the web server to store HTML files. The FTP server on the camera allows for external access to the contents of the flash disk.

For details regarding the handling of the flash disk, please refer to in the section **Troubleshooting.**

3.5 Handling Tables

Tables are used to store parameters and other values that a program uses.

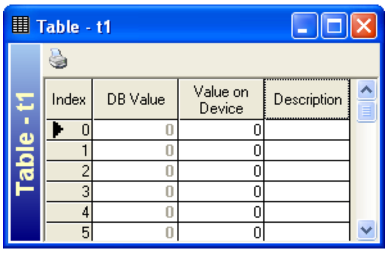


Table - t1

Index	DB Value	Value on Device	Description
0	0	0	
1	0	0	
2	0	0	
3	0	0	
4	0	0	
5	0	0	

- The index column shows a row number in the table.
- The DB Value column shows the value that is currently stored on the PC.
- The Value on Device column shows the current value stored on the device.
- In the description column you can add descriptive names for the values in the table.

The values on the PC and the device are not automatically synchronized. Therefore the values have to be copied manually between the two.

3.5.1 Basics

To create a new table Right-click Tables in the tree view in the left pane and choose New Table from the pop-up menu.

To show the contents of a table Right-click the table in the tree view and choose Show Table from the pop-up menu.

To rename a table Right-click the table in the tree view and choose Rename Table from the pop-up menu.

To delete a table Right-click the table in the tree view and choose Delete Table from the pop-up menu.

3.5.2 Copying, Importing, and Exporting Tables

To make a copy of a table Right-click the table in the tree view and choose Copy Table from the pop-up menu. Click YES to confirm and name the new table.

To import a table from a file on the PC Right-click Tables or a table in the tree view and choose Import Table from the pop-up menu.

To export a table to a file on the PC Right-click the table in the tree view and choose Export Table from the pop-up menu.

To store a table in the flash memory on a device, store the program associated with the table. To import a table from a device, import the associated program. When writing a table to the flash memory on a device, the descriptions are not saved, and are therefore not included when the table is imported from the device.

3.5.3 Handling Table Values

To enter a parameter value in the table
Right-click the table in the tree view in the left pane and choose Show table, or double-click the table in the tree view. A separate table window opens. Double-click the cell in the Value on Device column and enter a value. Close the table window and click YES to save the entered values.

To copy a parameter value from the PC to the device
Right-click the device and choose Show Table from the pop-up menu. Right-click the row in the DB Value column and choose Copy DB Value to the Device from the pop-up menu.

To set parameter comment in the table
Right-click the table in the tree view in the left pane and choose Show table, or double-click the table in the tree view. A separate table window opens. Double-click the cell in the Description column and enter a comment. Close the table window and click YES to save the entered values.

To save the table in the flash memory
Right-click the device and choose Device Management → Flash → Write Program in Flash from the pop-up menu. Select a memory position in the pop-up dialog window and click Save. The table is automatically stored with the program.

3.6 Handling Images

Images are saved in image banks during program execution. The image banks (and their current contents) are displayed in the active program window at the top of the right pane.

Images that are saved to disk on the PC can be loaded back into an image bank. You can also save some images to disk in another file format by choosing Export…, but such files cannot be loaded to the device.

Note that when loading an image to an IVC-3D camera, the camera must have the same settings for field-of-view (FOV) and length as when the image was saved.

To change size of the image bank thumbnails or previews
Place the cursor on border that surrounds the area where the bank thumbnails or previews. The cursor will change to two arrows.

Then click on the border and drag it to resize the thumbnails or previews.

To save an image bank to disk
Right-click the image bank in the active program window and choose Save Image Bank to Disk from the pop-up menu.

To load an image bank from disk
Right-click the image bank in the active program window and choose Load Image Bank from Disk from the pop-up menu.

To save an image bank in a different format (IVC-3D only)
Right-click the image bank in the active program window and choose Export Bitmap to disk or Export Raw to Disk from the pop-up menu.

To reset all banks
Right-click an image bank in the active program window and choose Reset All Banks from the pop-up menu.

To reset a selected bank
Right-click the image bank in the active program window and choose Reset Bank from the pop-up menu.

3.7 IVC Studio Settings

If you are using IVC Studio as an administrator, you can specify whether or not users must log in when starting IVC Studio. By default users do not have to log in.

User names and passwords can be found in the installation instruction.

To enable or disable login when starting IVC Studio

Choose Options → Configuration from the IVC Studio menu bar.
A pop-up window containing a tree view appears.

Select User Access in the tree view.
The User Access settings appear in the right panel of the pop-up window.

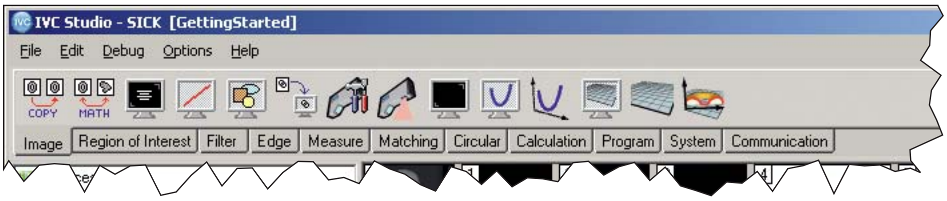
Select the option to let the users to log in when starting IVC Studio.

Deselect the option to let users use IVC Studio without logging in.

3.8 Programming

3.8.1 Adding Program Steps

When a program is selected in the left pane, a toolbar is added to the window. This toolbar contains the tools that are available when writing programs. The tools are organized in a logical order that groups similar tools together. Switch between the groups by clicking on the tabs at the bottom of the toolbar.



To add program steps

To add a program step click the icon for the tool.

To cut or copy steps

Click the program step in either the right pane or in the program list in the left pane and choose Edit→Cut or Edit→Copy.
Note that cut does not remove the step from the program list until it is pasted in its new location.

To select multiple program steps press the Ctrl key as you select steps.

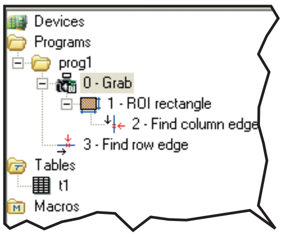
To paste steps

Click the program step in either the right pane or in the program list in the left pane and choose Edit→Paste.

To delete a program step

Click the program step in either the right pane or in the program list in the right pane and choose Delete Step from the pop-up menu.

To increase/decrease tabulation



Tabulation is only used to add readability to the program. It has no effect on the performance or execution of the program. To increase tabulation for a program step right-click it and choose Increase Tabulation from the pop-up menu. To decrease tabulation for a program step right-click it and choose Decrease Tabulation from the pop-up menu.

3.8.2 Setting Parameters

The input parameters can be set in a number of different ways:

- By manually entering a fixed value
- By retrieving a value from the table
- By using the result from a previous step
- By writing an expression that may combine the methods above

To enter parameter value in a program step
Select program step and double-click in the Value column of the parameter. Enter the value and click anywhere outside the changed cell.

To enter a string as a parameter value
Strings must begin with a single quotation mark.
Example: ‘String

To use parameter values from the table
Select the Table column in the program step. Enter the index number of the desired value and click anywhere outside the changed cell. The table value appears in the value column of the program step.

To use results from previous program steps
Select the Step column in the program step. Double-click and choose the number of the previous step and the result you want to use and click OK.

To use parameter expressions
Type the expression in the Value column of the program step. An expression always begins with = directly followed by the expression. Use the following prefixes:
Vn – for table Value in position n.
SnRn – for output Result n from a previous Step.
SnAn – for input Argument from a previous Step.

Example: =V2+S3A2*S3R1 This means that the value of position 2 in the table is added to input parameter 2 in step 3, multiplied with the first output from step 3.

It is also possible to use mathematical functions such as *sin* and *cos*. See Appendix A for more information.

It is usually slower to use expressions than using values directly from the table.

Using Interactive Set-up

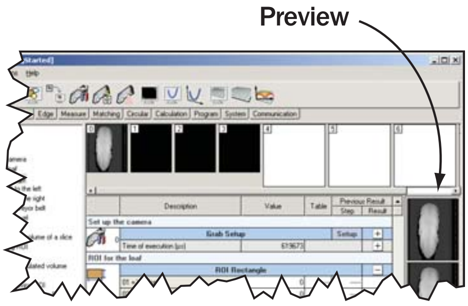
Interactive set-up is a possibility to graphically change parameter values of tools.

Interactive setup may be done in three different ways.

- In the upper preview window
- Some parameter fields, for example the fields for setting threshold values in the Find column edge tool, have a button with three dots following the space to fill in a value.
- Some tools, for example Find line edge, have a setup button.

Upper preview window

Can be used for most geometrical settings.

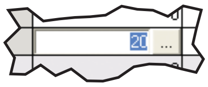


Select a program step containing a geometrical setting and execute it. The top image in the pane to the far right in the window now contains a figure representing the setting. It is possible to move the circle and change the size of it directly in the preview window.

For fine-tuning, double-click the image to display it in a separate window. Note how the values in the parameter field in the program step are updated as you change the settings.

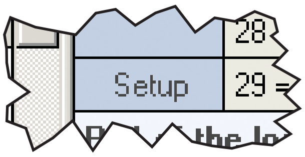
The size of the preview can be changed by clicking and dragging the borders around the previews..

The dotted button



Click the dotted button to open a window enabling interactive setup.

Setup button



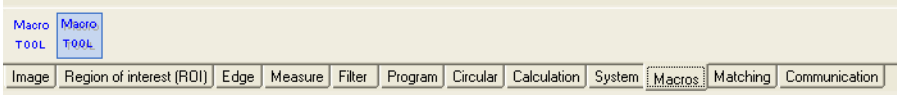
Double-click the Setup button to open a window enabling interactive setup.

3.8.3 Using Macros

Macros are used for operations that are performed frequently and are used by more than one program. It makes programs more readable.

Macros are available from the Macros tab in the tab bar. As they are created the macros are listed as available tools on the toolbar. Default name is Macro TOOL. Use the tool tip to distinguish between the macros.

Note: The execution time of a macro includes the time it takes to run the two tools Start Macro and End Macro. This means that the total execution time of the macro is slightly larger than the sum of the steps in the macro. This difference is more apparent when executing the macro in IVC Studio as then also the communication with the camera is included in the execution time of the macro.



To create a new macro Right-click Macro in the tree view and choose New Macro from the pop-up menu.

To delete a macro Right-click the macro and choose Delete Macro from the pop-up menu.

To make a copy of a macro Right-click the macro and choose Copy Macro from the pop-up menu. Click YES to confirm and name the new macro.

To import a macro Right-click Macro or a macro in the tree view and choose **Import** Macro from the pop-up menu.

To export a macro Right-click the macro in the tree view and choose Export Macro from the pop-up menu.

To print a macro Right-click the macro in the tree view and choose Print Macro from the pop-up menu.

To show information on a macro

Right-click the macro in the tree view and choose Macro Information from the pop-up menu.
A pop up window displays information such as program name and dates of creation and latest change and who made the latest changes to the macro.

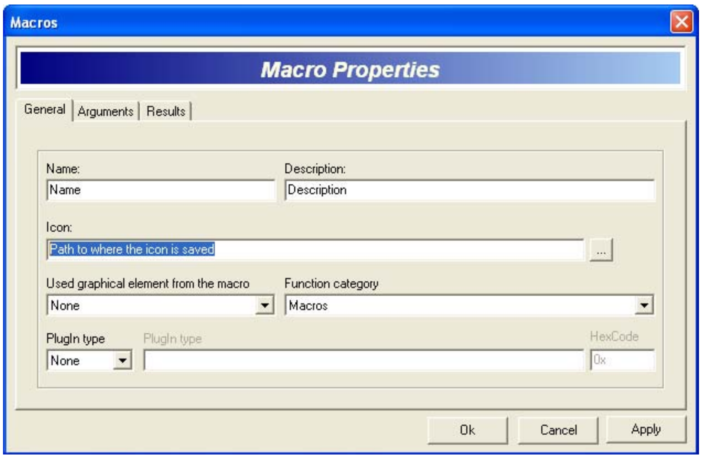
3.8.4 Changing Macro Properties

To change name and description of a macro

Right-click the macro in the tree view and choose Macro Properties from the pop-up menu. This opens the Macro Properties window. Enter macro name and a description in the Name and Description fields and click OK.

To change a macro icon

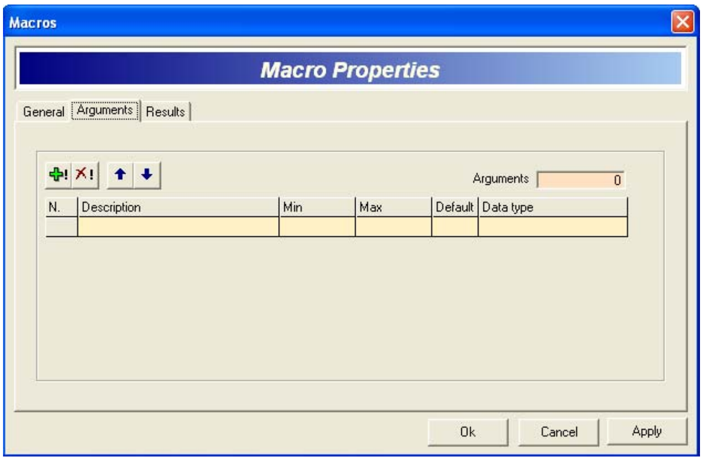
You need an icon with file extension .ico consisting of two images. One 16 x 16 pixels and one 32 x 32 pixels. The smaller is used in the IVC Studio tree view, and the larger in the IVC Studio toolbar.
Right-click the macro in the tree view and choose Macro Properties from the pop-up menu. Enter the path to the icon image in the Icon field, or use the browse button, and click OK.



Name: Name
Description: Description
Icon: Path to where the icon is saved
Used graphical element from the macro: None
Function category: Macros
PlugIn type: None
PlugIn type:
HexCode: 0x

To specify arguments and results

Right-click the macro in the tree view and choose Macro Properties from the pop-up menu. Select one of the tabs Arguments or Results. Add arguments and results by using the +! button.



Arguments: 0

N.	Description	Min	Max	Default	Data type

3.8.5 Running and Debugging Programs

You can run and test the program in two different ways:

- Run the entire program over and over, and view results in the Run window.
- Step through the program or run parts of it, and view the results directly in the Programming window when the program is paused.

You can set breakpoints on program steps where you want the execution to pause, and also disable program steps that you don’t want to be executed. Breakpoints are ignored when running the entire program, - for example when the device is running stand-alone – but disabled program steps will never be executed by the device – even if the device is running without IVC Studio.

When running the entire program, use a ‘Display‘ tool in the program to display parameter values and the contents of an image bank in the Run window. The information in the Run window will be updated each time the ‘Display‘ tool is executed. For more information on the ‘Display’ tool, see the Tools chapter.

To run the entire program from the Programming window	Choose Debug → Run or press F6. The Run window is displayed, and the program will run over and over until it is stopped. Any breakpoints in the program are ignored.
To execute a single program step	Select a step and choose Debug → Execute Step or press F5. If Run debug or Run to cursor is chosen after executing a single step, the program will continue with the selected step.
To execute a program step by step	Select a step and choose Debug → Step by Step or press F8. The selected step is executed and IVC Studio selects the next step as active. If Run debug or Run to cursor is chosen after executing a step, the program will continue with the selected step.
To continue the program up to a selected step	Select the step to stop at and choose Debug → Run to Cursor. When choosing Run to Cursor, the program will stop at any breakpoint that is encountered prior to the selected step.
To continue the program until the next breakpoint	Choose Debug → Run Debug.
To remove a breakpoint	Select the step with a breakpoint in either the tree view or in the program list, and choose Debug → Set Breakpoint.
To continue the program from a certain step	Select the program step to start from and choose Debug → Execute Step or press F5. Then use Run debug or Run to cursor to continue running the program from the last executed step.

Note: If the execution time of a step exceeds the IVC Studio communication timeout (default 2500 ms), an ITF-2 error is displayed in IVC Studio, even though the camera is still executing the step. By pressing F5 or F8 again, the connection to the camera is restored, and the results from the step will be displayed in the step program view.

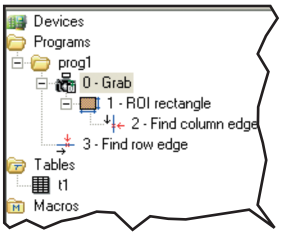
3.9 Efficient Programming

It is important for both efficiency and readability reasons that programs are well structured and well documented. When writing programs in IVC Studio you should consider the tips in this chapter for more efficient programming.

3.9.1 Organizing Programs for Readability and Maintenance

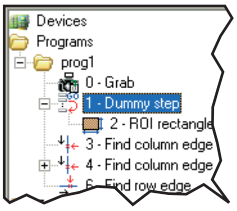
By following these rules your programs become more readable and easier to maintain:

- Divide the program structure into two main parts. One initialization part and one cycle part.
  The initialization part contains everything that is only set once after power-up, for example grabbing parameters, static ROIs, load table from memory, and so on.
  The cycle part is what is executed over and over again until the program is stopped.
- Group sequences of steps to represent a higher-level function than the individual steps. To perform this grouping, there are three standard ways:
  1) tabulation in the program tree



  2) subroutines
  3) macros

- Name step tools more specifically than the tool's original name.
  Example: Rename "Scan rows" to "Scan rows, find upper left edge" or "If go" to "If width too small, go to fail".
- Name the first step in the sequence in accordance with the purpose of the entire high-level function when a sequence of steps is grouped.
  Example: If 12 steps are used to localize a blob and find its uppermost edge pixel, then rename the first step to "Find top edge of blob" and indent the remaining 11 steps.
- Add dummy steps with the only purpose to give a sequence of indented steps a good name, and to retain the possibility to give a more specific name to the first image processing step of the sequence. For example, a 'Goto' tool that only goes to the next step can be used.



3.9.2 Making Debugging Easier

- Display key values of your program/table, using the 'Display' tool, to enable performance tests and fast debugging.
- Display key parameters in different colors and sizes in the displayed bank by using the 'Add Text' tool. For example in simple pass/fail applications you display Pass in green letters or Fail in red letters.
- For graphical feedback, add a 'Draw ROI' step directly after the ROI creation to speed up debugging when you use dynamic ROIs. Dynamic ROIs are ROIs that move around depending on other results in the program.

3.9.3 Organizing Error Handling

Without error handling a program stops if an error occur. Hence it is very important to handle possible errors. Error handling is initiated by the ‘On error goto‘ tool in the Program category. This step can either be added at the beginning of a small program or, for example, at the beginning of each part in a larger program.

3.9.4 Organizing Tables for Readability and Maintenance

- Use a table for all parameters that you may want to change during the installation and use of the application. Divide the table parameters into blocks: User settings, advanced settings, Debug parameters and so on. It is practical to start filling the table with the user settings, as these are visible immediately in the programming environment (no need to scroll the table to find them). Preferably, place a few empty rows in the table between each parameter block to make adjustments easier.
- Give parameters in a table unique names that anyone familiar with IVC Studio and the application can understand.

3.9.5 Optimizing Performance

- Make ROIs as small as possible.
- Use image processing filters only when necessary.
- Avoid displaying results that are not necessary to see.
- Place static ROI definitions outside of the program loops so that they are only executed once. This is only a concern in very time-critical applications.

3.9.6 Providing Image Processing Robustness

- Make sure to provide good lighting conditions.
- Avoid dependence on 50 Hz lamps unless shutter times are very long.
- Mount a band pass filter on the lens if only one color is of interest.

4 Tools

IVC Studio contains more than 100 advanced image processing tools. These tools are available on the toolbar in the programming window, and are grouped into the following categories.

Image The image tool group contains tools that are used for taking a picture to work with, adding graphics to the images and editing the image banks, which is the image memory in the camera.

Region of Interest The region of interest (ROI) tools are used for defining an area in which the other tools should work. These tools speed up the image processing since the entire image is not treated.

Filter The filter tools can be applied to enhance features in the image. Available tools are erode and dilate tools as well as binarize tools for transforming grayscale images to binary.

Edge The edge tools are used to find object edges in the pictures and thereby the coordinates of the objects. It is possible to scan the image from all different directions and also to find multiple edges on one specific line.

Measure This category contains tools that measure area, center of mass, find and measure blobs and measure distance and angle.

Matching The matching tools are used for teaching the camera to recognize an object, and then using this for locating objects in images, counting the number of objects, or for calculating the rotation of objects.

Circular The group of circular tool contains a specific set of tools. These tools make it possible to check perimeters of objects, diameters, the surface and the outer shape of objects.

Calculation Calculation tools are used for example for determining whether or not values are in correct ranges, or calculating the deviation of round objects from circles.

Program The step programming tools are used for defining loops and conditions in programs. Some of the available tools are: For, If, Else, If then goto, If in range goto, Run program, and Subroutine.

The subroutine is a powerful tool when optimizing the program. It increases the overview and readability of your program.

System The system group contains tools for inserting delays in the program, saving values or results to a permanent flash memory, and writing and reading result or parameter values to a memory separate from the actual program (the Table).

Communication The communication tools are used for sending values over RS485 and Ethernet.

Input/Output The tools in the Input/Output group handle reading of digital inputs and setting digital outputs. Tools for encoder handling are also found in this group.

Reader The reader tools are used for reading barcodes in the images.

4.1 Image

Grab Setup

This tool is used for setting up the IVC-3D camera before capturing 3D images or profiles. The following needs to be set in order to retrieve images from the camera:

- Profile triggering and rate
- Field-of-view (FOV) and resolution along the x-axis
- 3D image triggering
- Length and resolution along the y-axis for 3D images

In addition it could be necessary to adjust measurement settings in order to improve the quality of the images.

When this tool is executed, the size of the image banks is adjusted to fit the specified FOV.

When executed on a hardware camera, the device will also start capturing images. Use the 'Grab' tool to move the captured images to an image bank.

There are no parameters that can be set directly in the program step for the 3D Grab Setup tool. Instead there is an interactive set-up that is used for changing the settings. For more information on how to use the interactive set-up, please refer to Grab Setup on page 243.

Input Parameters

None as standard. Use the interactive setup for setting the parameters for the tool.

Exception: See the section **For Advanced Users** below.

Returned Values

None as standard.

Exception: See the section **For Advanced Users** below.

Error Messages

Err. = 7401	Invalid FOV settings. Grab Setup has been set up for another camera type.
Err. = 8610	The interactive Grab Setup must be opened to adjust the FOV settings.

For Advanced Users

By entering a special key code (found in Serial.txt in the installation folder), some of the arguments and results of the tool are made available from the step program. Please note that some arguments depend on each other, and modifying them programmatically in the step program may cause the tool or the interactive setup to malfunction. Proper error handling and testing is important to ensure a robust application.

It is possible to use references to other steps and mathematical expressions in the arguments to the Grab Setup tool, but this is not supported by the interactive setup. It will not be possible to open the interactive setup if references or mathematical expressions are used as arguments.

Grab on Command

This tool is used for triggering the device to start capturing a 3D image. To use this tool in a program, **Trigger by program step** must have been selected for the 'Grab Setup' tool.

After the Grab on command tool has been executed, the image is captured in parallel with the execution of the program. Use the 'Grab' tool to wait for the image to be completed and to move it into an image bank.

The Grab on command tool makes it possible to start the image capturing at a known point in time in the program. It also allows for more complex decision rules for when to take an image, for example when receiving some special command from an external device.

Input Parameters

None

Returned Values

None

Error Messages

Err. = 7403	No 'Grab Setup' tool has been successfully executed.
Err. = 7405	Capturing in progress. The last trigged image has not yet been completed.
Err. = 7406	**Trigged by program step** has not been selected for the 'Grab Setup' tool.

Grab

The Grab tool is used for retrieving the latest captured 3D image or profile and moving it to a specified image bank. The Grab tool functions a bit differently depending on if it is executed in the Emulator or in a hardware camera, and if an encoder is used or not.

Using the Emulator

When using the Emulator as device, images are captured from a predefined set of image files. Executing a ‘Grab’ tool means that the next image in the dedicated image folder is captured. To be able to execute a Grab tool, the FOV settings in the Grab Setup must be adjusted to the FOV settings of the image. This is obtained by executing the Grab Setup tool.

For more information regarding the Emulator, see Handling the Emulator.

Using a hardware camera

The device starts capturing images as soon as a 'Grab Setup' tool is executed. The capturing is done in parallel with the program execution.

A captured image can be retrieved to an image bank as long as the next image has not been completely captured. This means that the device can start capturing the next image before the program has retrieved the previous image.

If more than one image has been captured since the last time a 'Grab' tool was executed, only the latest completed image can be retrieved. All previous images are lost. The number of lost images is returned in the parameter **Lost images**.

If no image has been completely captured since the last time a 'Grab' tool was executed, the 'Grab' tool waits for the image to be completed. The parameter **Time out** specifies the maximum time to wait. If a time-out occurred, **Lost Images** is set to `-1`.

Using an encoder

When using an encoder for triggering profiles, the encoder’s tick count – that is, the number of pulses that the IVC-3D received since the camera was rebooted – is returned in the **Tick count at grab start** parameter. When capturing 3D images, the tick count for the first profile in the image is returned.

Executing a 'Grab setup' tool will remove any captured images from the device before starting to capture new images, and reset the **Lost image** count. The Grab setup tool will only affect the contents of the image banks if they are resized by the tool, otherwise the tool will only remove captured images that are not yet transferred to an image bank.

The result parameter **Tick count at grab stop** can be used in a mathematical expression to identify when the conveyor movement has exceeded its maximum speed. The consequence of this is lost profiles and distorted object proportions in the image. The number of lost profiles can be calculated as:

Lost profiles = ((Stop tick – Start tick)/(Ticks per profile)) - (Profiles per image)

Note: For internal rounding reasons, Lost profiles = 0 or -1 both indicate a normal image acquisition. A suitable indication of exceeded maximum speed is Lost profiles ≥ 1.

Capturing 3D images when testing and developing programs

If you are using an infinite timeout (**Time out** is set to `-1`), and execute a Grab tool in Debug mode (that is, using any of the items on the Debug menu except for Run), the Grab tool will return immediately instead of waiting for an image to be ready.

If the device is capturing overlapping 3D images, it may also place a partial image in the image bank, consisting of the profiles captured so far. To prevent this from happening, set the **Time out** parameter to a value other than `-1` when testing a program capturing overlapping images, and if necessary set the timeout to `-1` when the program is ready to be run stand-alone in the IVC-3D.

Also note that if you use a timeout longer than the timeout set for the communication between the IVC-3D and IVC Studio, executing the Grab tool in Debug mode may result in an ITF Error = 2.

Input Parameters

01 = Destination bank	The image bank where the grabbed image should be placed.
02 = Time out (ms)	Maximum time to wait for the image to be completed. If set to `-1` the tool will never time out.

Returned Values

01 = Lost images	Number of images that have been lost since the last time a 'Grab' or 'Grab Setup' tool was executed. If the image capturing timed out, `-1` is returned.
02 = Tick count at grab start	The encoder tick count at the start of image grabbing. It corresponds to the number of pulses that the IVC-3D received from the encoder since the camera was rebooted. If capturing profiles or images without using an encoder, `-1` is always returned.
03 = File Name	The file name of the acquired image file.
04 = Tick count at grab stop	The encoder tick count at the end of image grabbing. When using the camera in Single profile mode, -1 is always returned.

Error Messages

Err. = 8604	A 2D image cannot be loaded into a 3D camera.
Err. = 8607	It is not possible to load the image. Please open the interactive Grab Setup to (automatically) adjust the FOV settings.
Err. = 8608	The image is not taken with this camera type.
Err. = 8609	Invalid image type.
Err. = 8614	The image is taken with an IVC Studio version earlier than 3.0, and it does not contain any FOV information. The settings in Grab Setup must be adjusted manually to be able to load the image.

Set Laser

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

There can be situations when the laser needs to be forced on or off, for example during maintenance work by the machine operator. This tool allows control of the laser from the step program.

Normally, the enabling/disabling of the laser is controlled by the Grab Setup and Grab tools. This tool will override the internal control of the laser state and can result in images containing only missing data.

From the disabled state, the laser can be enabled either by using the Set Laser tool again (Laser state enabled), or by executing the Grab Setup tool.

Laser safety note:

For laser safety regulation reasons, this software tool can be used in addition to but does not replace the external ICT-R Terminal box accessory for the laser class 3B version of IVC-3D.

Input Parameters

01=Laser state	The state of the laser. **Enabled** – The laser will be activated normally. **Disabled** – The laser will be turned off.

Returned Values

None

Copy Image Bank

This tool is used to make a copy of an image bank. The parameters **Source bank** and **Destination bank** specify which bank to duplicate and where to place the new copy.

Note that the contents of the destination bank are replaced by the new copy. There is no undo function. Replaced data in the destination bank is lost.

Input Parameters

01 = Source bank	This parameter indicates the image bank number to copy from.
02 = Destination bank	This parameter indicates the image bank number where the new copy is placed.

Returned Values

None

Image Bank Operation

This tool is used for copying a region of an image to another image bank. In addition to copying the pixels, you may also calculate new height values for each pixel, based on the height values of the pixels in the image in the source bank and an image already in the destination bank.

The parameters **Source bank** and **Destination bank** specify which banks to use for the operation. The resulting image will be placed in the **Destination bank**.

Note that the image in the destination bank will be replaced by the merged image. There is no undo function. Replaced data in the destination bank is lost.

Input Parameters

01=Source bank The image bank containing the image to copy from.

02=ROI definition step The step number in your program that holds the definition of which region of interest in the image that the operation is performed for.

03=Mathematical operation Specifies which mathematical operation to perform when copying pixels from the ROI of the source image to the destination bank.

`Min (and)` The resulting image will contain the *lowest* of the corresponding pair of pixels from the source and the destination images.

For binary images the corresponding pixels in both images must be white for the resulting pixel to be white. This is equivalent to an AND operation.

`Max (or)` The resulting image will contain the *highest* of the corresponding pair of pixels from the source and the destination images.

For binary images the resulting pixel is white if either the source or destination pixel is white. This is equivalent to an OR operation.

`Diff (xor)` The height of each resulting pixel is calculated by:

> Height at bottom of FOV + absolute value of (height in source image - height in destination image)

Two identical images results in a black image.

For binary images the resulting pixel is white if either the source or destination images are white but not both. This is equivalent to an XOR operation.

`Inv (not)` The height of each resulting pixel is calculated from:

> Height at top of FOV - (height in source - height at bottom of FOV)

For binary images the resulting pixel in the target bank will be white if the source image is black and vice versa. This is equivalent to a NOT operation.

`Copy` Copies every pixel in the ROI of the source image to the destination bank.

04=Destination bank The image bank in which the resulting image is placed. For most of the operations the result is affected by any image that is stored in this bank prior to executing this tool.

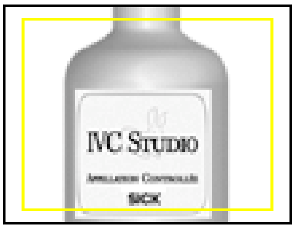
Returned Values

None

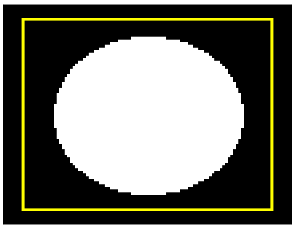
Error Messages

Err. = 7704	The region of interest has parts that are outside the source bank.

Example

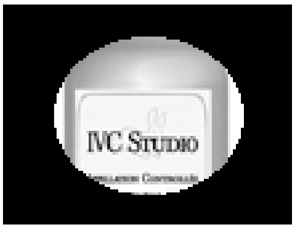


Source

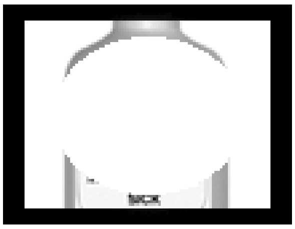


Destination

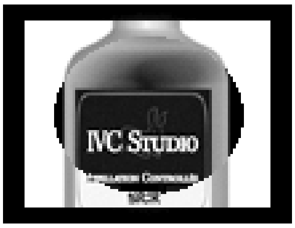
Min (and)



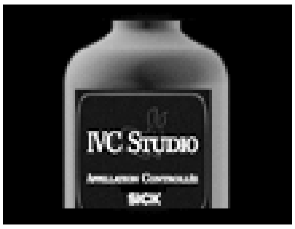
Max (or)



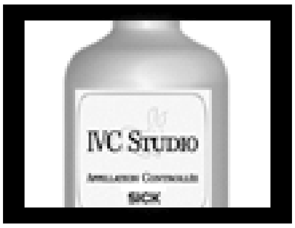
Diff (xor)



Inv (not)



Copy



Add Text

This tool adds a text strip to an image bank. The text itself as well as the background strip can be drawn in the color or gray scale value of your choice.

The text can consist of a text string, a number or both. If the **String type** parameter is set to `Text`, the text string can of course hold numbers, but they will be static. If **String type** is set to `Text and variable` or `Variable`, variable values can be part of the text strip.

When double clicking the values of **String color** or **Background color** parameters, the respective colors can be specified as numbers or chosen from an interactive menu. Possible inputs are numbers between 0 and 255, where 0 through 243 are gray scale values and 244 through 255 are various colors.

Input Parameters

01 = X coordinate The x-coordinate of the upper left corner of the text strip.

02 = Y coordinate The y-coordinate of the upper left corner of the text strip.

03 = String type This parameter specifies whether the text strip is a static text, a variable value or a combination. For the latter case, the variable value will follow the static string with a space in between.

04 = Text This parameter specifies the static text.

05 = Variable This parameter specifies the variable value. Note that the value can be given as a constant value, evaluated by an expression, a table value or be an argument or result from a previous step.

06 = String color The gray scale value or color code that specifies the color of the text. Allowed values are 0 through 255.

07 = Background color The gray scale value or color code that specifies the color of the strip behind the text. The value 254 is transparent.

08 = Size This parameter specifies the size of the font where 1 is the smallest and 8 is the largest font available.

09 = Destination bank The image bank in which to overlay the text.

Returned Values

01 = String length Number of letters in the text strip. Note that the space between the string and the number is included in the count if **String type** is set to `Text and variable`.

02 = Character width The number of pixels each letter is wide.

03 = Character height The text strip height in pixels.

Draw Line

This tool adds a line to an image bank. The line is 2 pixels wide and can be drawn in the color or gray scale level of your choice. The line can for instance be used to separate blobs, to enhance an edge between two known points or simply for visualization. When double clicking the value of the **Color** parameter, the color of the line can be specified as a number or chosen from an interactive menu. Possible inputs are numbers between 0 and 255, where 0 through 243 are gray scale values and 244 through 255 are various colors.

Input Parameters

01 = Start point X	The x-coordinate of the first end point.
02 = Start point Y	The y-coordinate of the first end point.
03 = End point X	The x-coordinate of the second end point.
04 = End point Y	The y-coordinate of the second end point.
05 = Color	The gray scale value or color code that specifies the color of the line. Allowed values are 0 through 255.
06 = Destination bank	The image bank in which to overlay the line.

Returned Values

None

Draw ROI

This tool draws a previously defined ROI in a selected image bank. It is possible to choose if the interior area or the contour of the ROI should be colored. To color the contour set the **Filling** parameter to `False`, to color the whole area set the **Filling** parameter to `True`.

Drawing a ROI in a bank is used for visualization of the current ROI and to control the selected area for next coming processing steps.

Input Parameters

01 = ROI definition step Number of the step with the ROI to show in the selected image bank.

02 = Color Select a color to mark the ROI. Double-click on the input field to choose from a color palette.

02 = Filling
`True` whole area of the ROI will be color with the selected color.
`False` only the contour of the ROI will be color.

03 = Destination bank Number of destination bank in which to draw the selected ROI.

Returned Values

None

Define Curve

This tool is used to define a constant height line.

Such a line can be used as a reference level for cross-section area calculations. Setting a curve with this tool is a lot faster and easier than fitting a curve to height data with the **Curve fit** tool.

Input Parameters

01 = **Height** (mm)	The constant curve height.

Draw Curve

This tool draws a previously defined curve in a user-specified profile bank. The curve values that are outside the bank's range and the values that are outside the region of interest are set as missing data.

Drawing a curve to a bank is mainly intended for visualization purposes.

Input Parameters

01 = ROI definition step	The program step where the ROI was defined.
02 = Curve definition step	The program step where the curve was defined.
03 = Destination bank	Profile bank where the curve is drawn.

Define Surface

This tool is used for defining a surface plane with a constant height. This surface plane can be used for example as a reference level for volume calculations or deviation measurements.

Setting a surface with this tool is much faster than fitting a surface to a 3D image with the 'Fit Surface' tool.

Please note that it is possible to define a surface plane outside the field of view, as specified with the 'Grab Setup' tool, but such a surface will not be visible when drawn in an image bank.

Input Parameters

01 = **Height** (mm)	The height of the surface plane.

Draw Surface

This tool draws a previously defined surface in a selected image bank.

Any parts of the surface that are outside the field-of-view, as defined with the '3D Grab Setup' tool, will be displayed as missing data

Drawing a surface to a bank is mainly intended for visualization purposes.

Input Parameters

01 = ROI definition step	The program step where the ROI was defined.
02 = Surface definition step	The program step where the surface was defined.
03 = Destination bank	Image bank in which the surface is drawn.

Reset Image Banks

This tool sets all pixels in an image bank to a height value of your choice. If the **Number of banks to reset** parameter is greater than one, multiple image banks are reset from left to right starting with **First bank to reset**.

Input Parameters

01 = First bank to reset	This parameter specifies the number of the first image bank to reset.
02 = Number of banks to reset	This specifies how many image banks to reset.
03 = Height (mm)	The height value with which the image banks should be filled.

Returned Values

None

Display

The display tool is used for showing an image bank and a table with ten variable values in a separate Run window when the program is running. The Run window is only displayed when the program is running, and not when stepping through or debugging the program.

Each time the tool is executed, a new row is added to the table in the Run window, showing the current values of the variables. The table can display up to 150 values. For each numerical variable, the mean value and deviation is calculated and displayed at the bottom of the Run window.

If the variable refers to a value stored in the table, the description in the table for that row is used as header of that variable's column. When displaying a value from a previous program step, the name of that result is used as the header. For any other type of variable (numerical value, string or expression) the column has the parameter name (**Variable 1 – 10**) as header.

It is possible to export the values of the variables to file. If the "Export variable values" checkbox is checked when closing the Run window, a save dialog is displayed allowing the user to specify a file name and location. Up to 10.000 of the rows displayed in the Run window are saved to the file. If more than 10.000 rows have been displayed, it is only the 10.000 latest rows that will be saved to file. **N.B.** variables that are longer than 100 characters will be truncated.

If the communication between PC and the device should be interrupted, for instance by pulling the Ethernet cable from the PC, the execution in the device goes on but the updates by the Display tool will be stopped until the connection is re-established.

Double-clicking on a 3D image in the Run window will display a 3D visualization of the image in a separate window. This 3D visualization will be updated as the 3D image in the Run window is updated.

Input Parameters

01 = Source bank	The number of the image bank to display when the program is running.
02 = Binarized color	Specifies a color or gray level to mark out pixels that are ON in an image returned by the 'Binarize' tool.
03 = Variable 1 **04 = Variable 2** … **12 = Variable 10**	The parameters 03–12 specifies the values to be displayed in the table

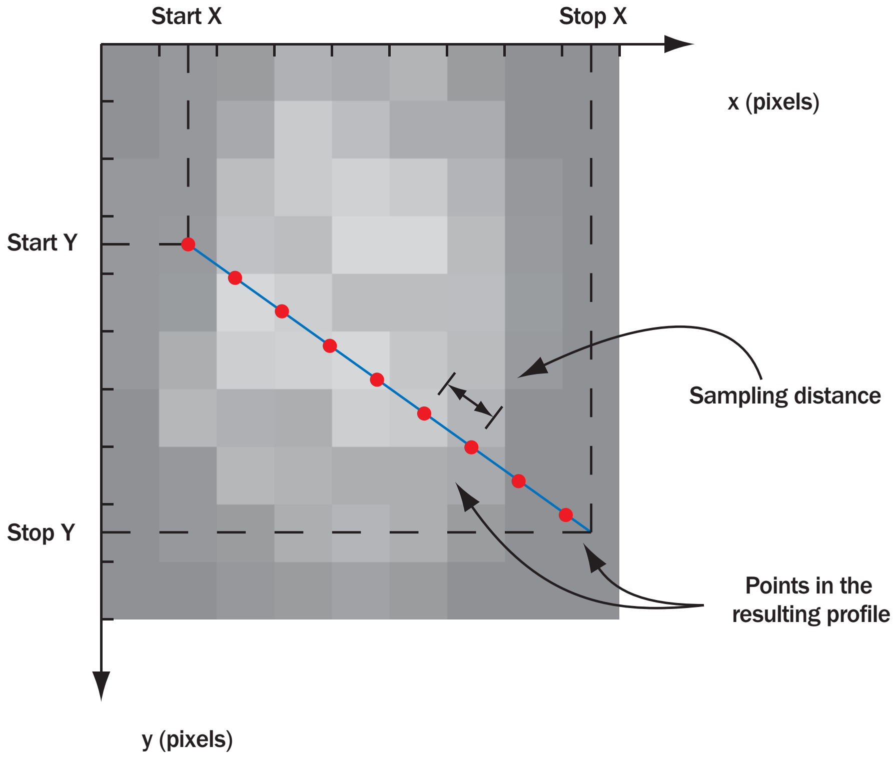
Returned Values

None

Extract Profile

This tool extracts a profile from a 3D image along a line that is specified by the pixel coordinates of the start and end points of the line.

The actual location of the last point in the profile may be slightly different from the specified end point due to the sampling distance. The distance between the last point in the profile and the end point of the line will be at the most half the sampling distance, unless the end point is at the image border, in which case the distance is at the most one sampling distance.



The maximum number of points in the resulting profile is 32768, and if the resulting profile will be longer, an error message is returned.

Input Parameters

01 = Source bank	Bank that contains the image from which to extract a profile.
02 = Start pixel X	`X coordinate of the start pixel.`
03 = Start pixel Y	`Y coordinate of the start pixel.`
04 = End pixel X	`X coordinate of the end pixel.`
05 = End pixel Y	`Y coordinate of the end pixel.`
06 = Sampling distance (mm)	The distance in mm between two points in the resulting profile. Enter `-1` to use the same sampling distance as the source image bank X axis.
07 = Destination Bank	The profile bank where the resulting profile is stored.

Error Messages

Err. = 7703	The resulting profile’s length exceeds the maximum length

Rotate Image

This tool rotates an image by specifying the angle and the center of rotation.

The image can be rotated around its center or around a specified point. The center of rotation is in the latter case specified by the parameters **X center** and **Y center**.

The image can also be moved after rotation, but before being copied to the destination bank. The parameters **X offset** and **Y offset** specifies the distance to move.

The rotated image is displayed in the **Destination image** bank. Note that only the part if the image that *after the rotation* is located within the ROI will be displayed in the destination bank.

The parameter Interpolation method controls how the pixel values are calculated in the destination image. It is possible to choose between bilinear interpolation (gives higher image quality) or nearest neighbor (gives faster execution time).

Input Parameters

01=Source bank	Image bank containing the image to rotate.
02=Destination bank	Image bank in which to display the rotated image.
03=ROI definition step	Step number where the ROI to use was created.
04=Angle	The counter-clockwire rotation angle, in degrees.
05=Rotation around center	`True` The rotation point is in the centre of the ROI and the following two parameters are ignored. `False` The coordinates for the rotation point are set by the following two parameters.
06=X center	The X coordinates for the rotation point. X = 0 is on the left side of the FOV.
07=Y center	The Y coordinates for the rotation point. Y = 0 is at the top of the FOV.
08=X offset	The distance in pixels along the x axis to move the rotated image.
09=Y offset	The distance in pixels along the y axis to move the rotated image.
10=Interpolation method	The interpolation method to use when calculating the pixel values in the destination image.

Returned Values

None

4.2 Region of Interest (ROI)

ROI Rectangle

This tool generates on every type of image a rectangular shaped ROI (Region Of Interest). The ROI is used to define a rectangular limited working area to perform image processing steps or other functions.

To set the position and dimension of the ROI it is possible to type the coordinates of the top left corner of the rectangle and the size specifying the width and the height in pixels. During the setup of the ROI it is also possible to set the size of the ROI and position in the preview using the left mouse button. Double-clicking the image in the preview opens a larger image to set the ROI with the mouse more precisely.

It is possible to define the position of the ROI relative to a previously generated result. This is done by setting an offset of the top left corner of the ROI using the input parameters **X offset** and **Y offset**. The values of the offset must come from a previous step result or from the table.

The ROI is plotted in the current preview.

Input Parameters

01 = X offset	Offset value of the upper left ROI corner in x direction. To set an offset the value must come from the table or as a result from a previously performed program step.
02 = Y offset	Like above but for Y direction.
03 = X coordidate	X coordinate for the top left corner of the ROI.
04 = Y coordinate	Y coordinate for the top left corner of the ROI.
05 = Width	Width of the ROI (in X direction) in pixels.
06 = Height	Height of the ROI (in Y direction) in pixels.

Returned Values

None.

Error Messages

Err. = 148	`Error in ROI` means that parts of the ROI are out of the FOV. Reduce size of ROI. Check X and Y origin. Check offset values. Check Width and Height parameters.

ROI Rotated Rectangle

This tool generates a rectangular shaped ROI (Region Of Interest) that can be rotated. The ROI is used for defining a rectangular limited working area in which to perform image processing or other functions.

To set the position of the ROI the coordinates of the top left corner of the rectangle can be used. It is also possible to define the position of the ROI relative to a previously generated result. This is done by setting an offset of the top left corner of the ROI using the input parameters **X offset** and **Y offset**. The values of the offset must come from a previous step result or from the table.

The size is set in pixels by the parameters **Width** and **Height**.

During the setup of the ROI it is also possible to set the size of the ROI and position in the preview using the left mouse button. Double-clicking the image in the preview opens a larger image to set the ROI with the mouse more precisely.

It is possible to rotate the ROI with respect to the center of the ROI or with chosen coordinates of the rotation center. If the rotation center coordinates are equal to -1 the rotation is done with respect to the center of the ROI. The coordinates of the rotation center could also be outside of the ROI somewhere in the FOV. Note that it is necessary to execute the ROI tool (keyboard key F5) to perform the rotation.

Input Parameters

01 = Source bank	Copy the selected image bank to the preview bank
02 =X offset	Offset value of the upper left ROI corner in x direction. To set an offset the value must come from the table or as a result from a previously performed program step.
03 = Y offset	Like above but for Y direction.
04 = Rotation around center	`True` means that the rotation point is in the centre of the ROI and the following two parameters are ignored. `False` means that the coordinates for the rotation point are set by the following two parameters.
05 = Rotation point X	Set the X coordinates for the rotation point. X = 0 is on the left side of the FOV.
06 = Rotation point Y	Like above but for Y direction. Y = 0 is on the top of the FOV.
07 = X coordinate	X coordinate for the top left corner of the ROI (before rotation).
08 = Y coordinate	Like above but for Y direction (before rotation).
09 = Width	Width of the ROI (in X direction) in pixels (before rotation).
10 = Height	Height of the ROI (in Y direction) in pixels (before rotation).
11 = Angle	Rotation angle with respect to the rotation point. Input values are the rotation angle in degrees. `Positive values` mean counterclockwise rotation. `Negative values` mean clockwise rotation. `Value = 0` means no rotation.
12= Destination bank	Number of destination bank (-1= no display of the ROI in the preview window).

Returned Values

None

Error Messages

Err. = 107	`points out of bank` means that the rotation of the ROI leads out of the FOV. Reduce size of ROI. Check offset values. If using rotation point change coordinates of rotation point.

ROI Circle

This tool generates a circular shaped ROI (Region Of Interest). The ROI defines a circular limited working area in which to perform image processing or other functions.

To set the position and dimension of the ROI it is possible to type the coordinates of the center of the circle and radius length in pixels. During the setup of the ROI it is also possible to set the size of the ROI and position in the preview using the left mouse button. Double-clicking the image in the preview opens a larger image to set the ROI with the mouse more precisely.

It is also possible to define the position of the ROI relative to a previously generated result. This is done by setting an offset to the top left corner of the bounding box of the circle using the input parameters **X offset** and **Y offset**. The values of the offset must come from a previous step result or from the table.

Input Parameters

01 = X offset Offset value of the upper left corner of the bounding box in X direction. To set an offset the value must come from the table or as a result from a previously performed program step.

02 = Y offset Like above but for Y direction.

03 = X center X coordinate of the center of the circle.

04 = Y center Like above but for Y direction.

05 = Radius Length of the circle radius in pixels.

Returned Values

None

Error Messages

Err. = 148 `Error in ROI` means that a part of the ROI is out of the FOV.

Reduce circle radius.

Check offset and center parameters.

ROI Ellipse

This tool generates on every type of image an elliptical shaped ROI (Region Of Interest). The ROI is used to define an elliptic limited working area to perform image processing steps or other functions.

The position and dimension of the ROI can be set by specifying the coordinates in pixels of the center of the ellipse (**X center** and **Y center**) and radius of the axes in X and Y direction (**X radius** and **Y radius**). The ROI can also be set by adjusting the position and dimension in the Preview of the program step. Double-clicking on the preview image opens a larger window with the image to work in.

It is also possible to define the position of the ROI relative to a previously generated result. This is done by setting an offset of the top left corner of the bounding box of the ellipse using the input parameters **X offset** and **Y offset**. The values of the offset must come from a previous step result or from the table.

Input Parameters

01 = X offset Offset value of the upper left corner of the bounding box in X direction. To set an offset the value must come from the table or as a result from a previous program step.

02 = Y offset Offset value of the upper left corner of the bounding box in Y direction. This value must come from the table or be a result from a previous step.

03 = X center X coordinate of the centre of the ellipse.

04 = Y center Y coordinate of the centre of the ellipse

05 = X radius Radius of the axes in X direction in pixels.

06 = Y radius Radius of the axes in Y direction in pixels.

Returned Values

None

Error Messages

Err. = 148 `Error in ROI` means that a part of the ellipse is out of the FOV.

Check radius parameters.

Check center and offset coordinates.

ROI Perimeter

ROI perimeter generates a ROI which shape, position and size is defined by the found contour pixels from the ’Perimeter’ tool. The ’Perimeter’ tool traces the contour of an object and returns the pixels which are found along the contour and this is used as input. The ’Perimeter’ tool is found in the Measure category.

Note: The ROI perimeter tool can only be used after the ’Perimeter’ tool is executed in a previous program step.

With the **Margin** parameter it is possible to expand or shrink the ROI with respect to the original shape. A positive margin value will expand the ROI in each direction by the typed value in pixels. A negative margin will shrink the ROI. If a positive margin value is used make sure that the resulting ROI is not larger than the total FOV of the camera. If a negative margin value is used make sure that the typed value will not produce negative results for the size of the ROI.

The parameter **Filling** controls if the area inside the ROI is colored red (internal) or if only the contour of the ROI (external) is colored red.

Input Parameters

01 = Perimeter definition step	Number of the step with the ’Perimeter’ tool which provides the contour pixels to process the ROI.
02 = Margin	Positive or negative values to expand or shrink the size of the ROI.
03 = Filling	`0=internal` whole area of the ROI will color red. `1=external` only the contour of the ROI is color red.
04 = Destination bank	Number of destination bank to display the ROI. -1= no display of the ROI.

Returned Values

None

Error Messages

Err. = 152	`Error in ROI from perimeter` Check **Margin** values and make sure that the result will not produce negative results or lead outside of the FOV.

ROI Union

This tool unifies two different ROIs from previous program steps to one single ROI.

The two ROIs to be unified are named ROI A and ROI B. The resulting single ROI is the addition of ROI A and ROI B. If it is necessary to display the unified ROI use the ‘Draw ROI’ tool in the Image category.

Input Parameters

01 = ROI A definition step	Reference to program step to select ROI A
02 = ROI B definition step	Reference to program step to select ROI B

Returned Values

None

ROI Intersection

This tool generates a new ROI from the intersection of two different ROIs.
The resulting single ROI is the intersection of ROI A and ROI B. If it is necessary to display the unified ROI use the ‘Draw ROI’ tool in the Image category.

Note that if the selected ROI A and ROI B have no intersection at all this tool will not generate a new ROI. In that case this could be the cause for error messages if input parameter ROI definition from a different tool refers to the result of this tool.

Input Parameters

01 = ROI A definition step	Reference to program step to select ROI A
02 = ROI B definition step	Reference to program step to select ROI B

Returned Values

None

ROI Difference

This tool performs a subtraction between two different ROIs and generates as result a new ROI. The subtraction will be executed as follows:

Resulting ROI = ROI A – ROI B.

If it is necessary to display the unified ROI use the ‘Draw ROI’ tool in the Image category.

Note that if the selected ROI A and ROI B are identical this tool will not generate a new ROI. In that case this could be the cause for error messages if input parameter ROI definition from a different tool refers to the result of this tool.

Input Parameters

01 = ROI A definition step	Reference to program step to select ROI A
02 = ROI B definition step	Reference to program step to select ROI B

Returned Values

None

ROI Interval

This tool creates a profile ROI (Region Of Interest) that specifies the intervals of the profile where other tools can be applied without affecting (or being affected by) the profile outside the intervals. The ROI is used in other tools by referring to the program step in which the ROI was created.

The ROI is created by specifying the x-coordinate where it starts (**X start pixel**) and the width of it (**Width**).

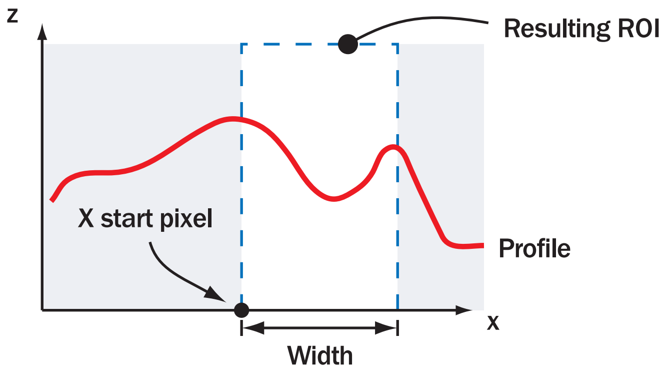


Figure – ROI interval creates a ROI that corresponds to a section of the x-axis.

Input Parameters

01 = X start pixel	X pixel for the starting point of the ROI.
02 = Width	Width of the ROI (in X direction) in pixels.

Returned Values

None.

Error Messages

Err. = 7310

`Error in ROI` means that parts of the ROI are outside of the FOV. In that case:

- Reduce the size of of ROI.
- Check the X origin.
- Check the **Width** parameter.

ROI Height

This tool creates a profile ROI (Region Of Interest) that specifies the intervals of the profile where other tools can be applied without affecting (or being affected by) the profile outside the intervals. The ROI is used in other tools by referring to the program step in which the ROI was created.

The ROI is created by specifying the **Threshold height** and choosing the **Threshold type** parameter. The resulting ROI will contain the parts of the profile where the height values are above or below **Threshold height**, depending on which **Threshold type** that was chosen.

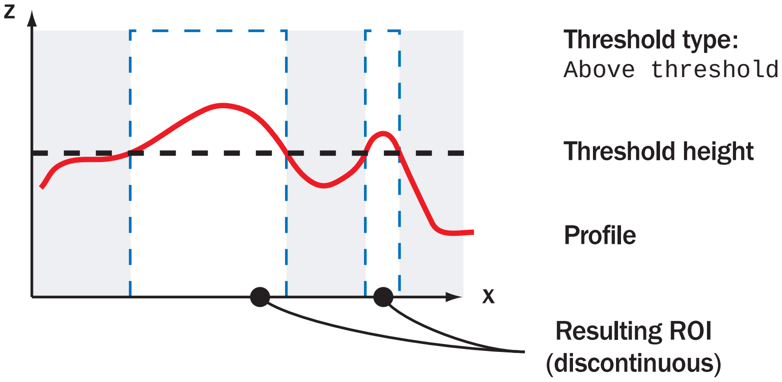


Figure – ROI height creates a ROI that consists of the parts of the x-axis where a profile is above or below a specified threshold.

Input Parameters

01 = Source bank Image bank that contains a profile on which the threshold is applied.

02 = Threshold height (mm) The threshold height with which the profile values are compared.

03 = Threshold type

`Below threshold` Parts of the profile where the height values are *less* than the threshold height are included in the ROI.

`Above threshold` Parts of the profile where the height values are *greater* than the threshold height are included in the ROI.

Returned Values

None.

4.3 Filter

Binarize

This tool creates a binary image based on the image in Source Bank. All pixels inside the specified ROI with height values between a lower and an upper threshold are set to a 'high' value. All other pixels are set to a 'low' value. Return values are the total number of pixels inside the ROI that are in range (within the threshold bounds) and the number of pixels that are out of range (outside the threshold bounds). The resulting binary image is written to the image bank pointed out by the Destination Bank parameter.

This tool is suitable as a pre-processing step to further image processing.

Note: When binarizing an image, all calibrated 3D-data is lost. You cannot measure mm values or volume in the resulting image.

It is recommended to use the interactive setup to customize the parameters. Double click on the Setup button to open the interactive setup window. For more information on the interactive setup, see on page **271**.

Input Parameters

01 = Source bank	Image bank containing the image to binarize.
02 = ROI definition step	Step number where the ROI to use was created.
03 = Lower threshold (mm)	Lower threshold for height value.
04 = Upper threshold (mm)	Upper threshold for height value.
05 = Destination bank	Image bank in which to display the binarized image.

06 = Threshold Mode	Available options are:
	`Manual`
	Set the upper and lower thresholds yourself.
	`Automatic`
	Automatically sets the thresholds. Pixels within the range become white, and the pixels outside the range become black.
	`Automatic inverted`
	Automatically sets the thresholds, but with inverted colors compared to the `Automatic` mode.

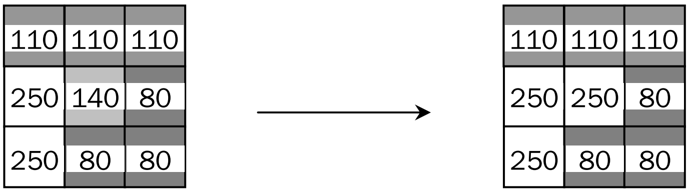
Returned Values

01 = Pixels in range	Total number of found pixels between lower and upper height threshold.
02 = Pixel out of range	Total number of pixels found outside the lower and the upper threshold.
03 = Low threshold (mm)	Lower threshold value. Values lower than the threshold are out of range.
04 = High threshold (mm)	Higher threshold value. Values higher than the threshold are out of range.

Dilate

This tool shifts a 3 by 3 matrix over the image and replaces the value of the center matrix element with highest value out of the surrounding matrix elements. In general this tool erodes dark pixels and can be used to reduce image artifacts due to single dark pixels.

Sometimes it is necessary to repeat this step several times until the desired result is achieved.



110	110	110
250	140	80
250	80	80

Center matrix element
before applying function

110	110	110
250	250	80
250	80	80

Center matrix element
after applying function

Figure – The value of the center matrix element is changed to the highest value out of the surrounding matrix elements.

Input Parameters

01 = Source bank	Image bank containing the image to dilate.
02 = ROI definition step	Step number where the ROI to use was created.
03 = Destination bank	Image bank in which to display the dilated image.

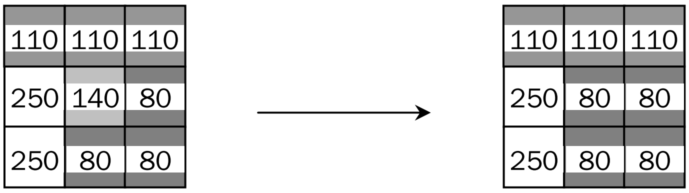
Returned Values

None

Erode

This tool shifts a 3 by 3 matrix over the image and replaces the value of the center matrix element with lowest value out of the surrounding matrix elements. In general this tool erodes pixels with high values (bright or high) and can be used to reduce image artifacts due to single white pixels.

Sometimes it is necessary to repeat this step several times until the desired result is achieved.



110	110	110
250	140	80
250	80	80

Center matrix element
before applying function

110	110	110
250	80	80
250	80	80

Center matrix element
after applying function

Figure – The value of the center matrix element is changed to the lowest value out of the surrounding matrix elements.

Input Parameters

01 = Source bank	Image bank containing the image to erode.
02 = ROI definition step	Step number where the ROI to use was created.
03 = Destination bank	Image bank in which to display the eroded image.

Returned Values

None

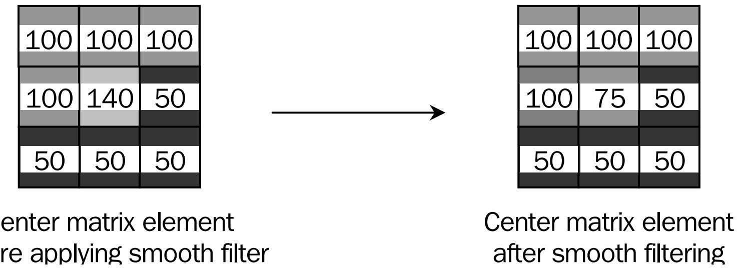
Filter

This tool offers the following three filter types:

1. Smooth
2. Edge
3. Median

Smooth

The Smooth filter shifts a 3 by 3 matrix over the image. The value in the matrix center will be replaced by the mean value out of the surrounding 8 matrix elements, as shown in the following figure:



100	100	100
100	140	50
50	50	50

100	100	100
100	75	50
50	50	50

Center matrix element before applying smooth filter
Center matrix element after smooth filtering

Figure – The value of the center matrix element will be replaced by the mean value out of the surrounding 8 matrix elements.

Edge

The Edge filter is based on a sobel filter in x and y direction and detects edges in the image.

Median

The Median filter is similar to the Smooth filter, but the value in the matrix center is replaced by the median value of the surrounding elements, instead of the mean value.

The result of the median filter is an image where noise and small details (single pixels) are removed but edges are preserved.

Note that the both filter types operate only inside the selected ROI. The results are displayed in a user defined image bank.

Input Parameters

01 = Source bank	Image bank containing the image to be filtered.	
02 = ROI definition step	Step number where the ROI to use was created.	
03 = Filter type	`Smooth`	Smooth the part of the image inside the ROI.
	`Edge`	Detects edges of the image part inside the ROI.
	`Median`	Smooth the part of the image inside the ROI.
04 = Destination bank	The image bank in which to display the filtered image.	

Returned Values

None

Filter Profile

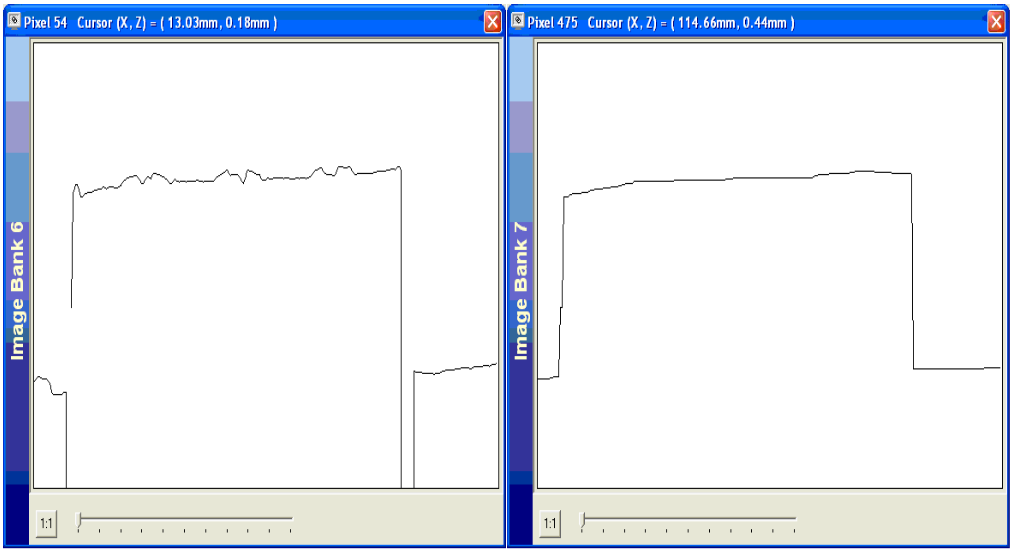
The Filter Profile tool is used to generate a new profile with smoothed or enhanced detail features compared to the original one. A typical use is to decrease local peaks to the level of the environment.

There are three filter modes: **Smooth, Edge and Median.**

The **smooth filter** will apply a normalized averaging using a rectangular filter kernel. This mode is very fast due to the rectangular filter kernel (typical execution time is in the order of 0.1 ms). This speed is independent from the filter kernel size. The normalization is done so that missing data and data outside the provided ROI will not affect the result of the filtering. This also means that the filter behaves nicely near the ends of the profile also for very large kernels.

The **median filter** is slower than the smooth filter. Still the execution time is typically around 3 ms per profile. Median filters may be preferred when filtering objects where many different heights are represented. On the other hand, the smoothing filter may perform well also here if complemented with a suitable range-based ROI. Which one to choose is ultimately application specific.

The **edge filter** performs a normalized convolution with a rectangular shaped differential operator which returns the derivative of the original profile. The derivative is offset by the center of the FOV since IVC profiles cannot assume negative values. The tool currently does not output the numeric value of this offset but it can be found either by looking at the result from derivation of a constant signal or by using the option **FOV Center** in the Profile Difference tool.


Pixel 54 Cursor (X, Z) = (13.03mm, 0.18mm)
Image Bank 6
1:1
Pixel 475 Cursor (X, Z) = (114.66mm, 0.44mm)
Image Bank 7
1:1

The Original profile (left) Median-filtered profile (right). The Median filter removes details.

Input Parameters

01 = Source bank	Profile bank on which the filter is applied
02 = ROI definition step	The Profile ROI defining what parts of the source bank will contribute to the result. The input data will be masked by this ROI before filtering. It is suggested to use the tool ROI Height to define the ROI. This gives a powerful method to eliminate range values that

should be disregarded.

03 = Filter type Specifies which type of filter to use:
Smooth will perform a normalized averaging using a rectangular kernel. Values outside the ROI will not affect the result at all. The same holds for ‘missing data’. Notice however that if the profile has been obtained using the Extract Profile tool, it may contain values that are outside the expected field of view due to interpolation. It is therefore suitable to use the ROI Height tool whenever extracted profiles are considered.
Median will perform a median filtering while disregarding all values outside the ROI and missing data.
Edge will perform a derivation of the profile by normalized convolution with a rectangular differential operator. The result will be the result of this convolution + a fix offset which corresponds to the height of the center of the FOV. This is added to put the output profile within the allowed range of values.

04 = Filter size Determines the size of the filter kernel in pixels. This determines the size of the supporting region of the profile for each output pixel. Any value from 1 to 500 is allowed and the total kernel size is 2*radius +1. The value has no significant effect on execution time.

05 = Destination bank Image bank in which the resulting profile is stored

06 = Fill missing data If **true**, target profile points outside the ROI or with no corresponding valid source data will also get an output value. This value is calculated in exactly the same way as all other target values.

If **false**, all values outside the ROI and all values corresponding to missing data in the input will be set to ‘missing data’ in the result.

Setting this option to true may be useful in cases where a “golden part” is used to learn a background pattern where any missing data should be disregarded.

Returned Values

None

Error Messages

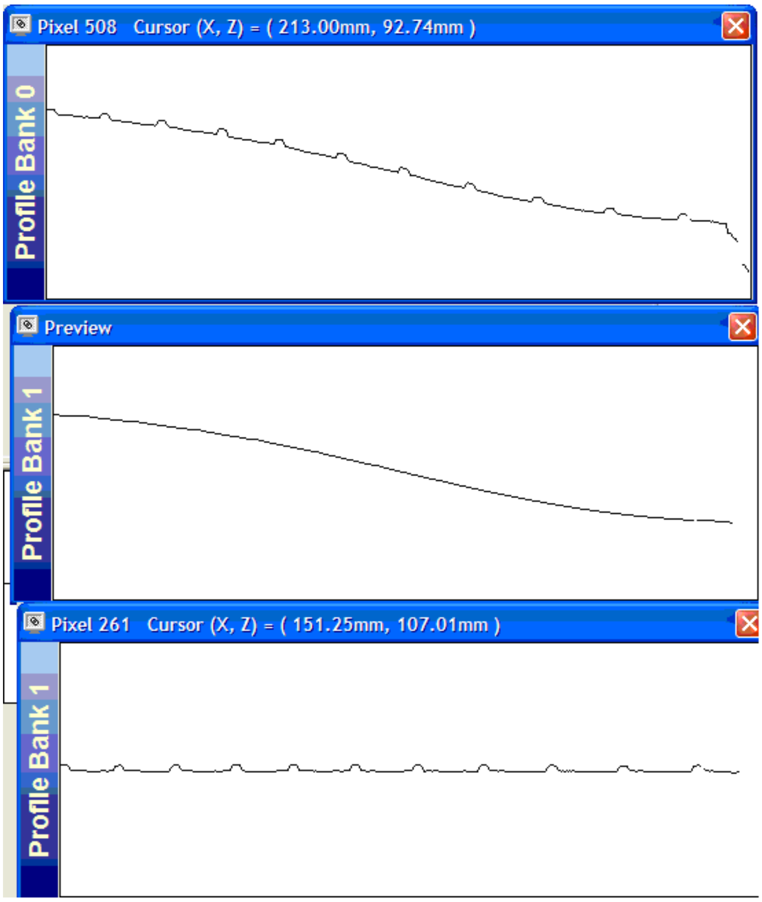
Err. = 7704 The region of interest has parts that are outside the source bank.

Profile Difference

The Profile Difference tool subtracts one profile bank from another. It uses a ROI to define on which height values to work. All values which are not part of the ROI will be left untouched. Since the IVC-3D expects profile values to be within a certain range corresponding to the current FOV, there is a user-configurable offset to place the output values within a suitable range. The default setting for the offset is **FOV Center**. This is suitable for profiles with minor fluctuations. If the profile in the Destination bank contains large negative spikes, the **FOV Top** setting is recommended, and for large positive spikes, the **FOV Bottom** is recommended. Finally, the option **Absolute** is available for situations where none of the above settings are applicable. It is then possible to specify the exact offset in mm to use.

The tool calculates the difference according to the following formula:

Destination Bank := Source Bank – Destination Bank + Offset Z.


Pixel 508 Cursor (X, Z) = (213.00mm, 92.74mm)
Profile Bank 0
Preview
Profile Bank 1
Pixel 261 Cursor (X, Z) = (151.25mm, 107.01mm)
Profile Bank 1

The bottom profile is the difference between the two upper profiles.

Input Parameters

01 = Source bank Profile bank on which the filter is applied

02 = ROI definition step Defines the region of interest in which the subtraction shall be done. All values outside this ROI will be left untouched by the tool. If you wish these values to be set to missing data you can use an Image Operation tool of type Copy within the ROI to an empty profile bank.

03 = Offset Type Specifies the type of offset to add to the resulting profile. There are four options:
Absolute The value in the parameter **Offset Z (mm)** is

	added to the resulting profile. **FOV Bottom** The bottom level of the current FOV is added. **FOV Center** The center level of the current FOV is added. This is the default setting. **FOV Top** The top level of the current FOV is added.
04 = **Offset Z** (mm)	Defines how many mm to add to the resulting difference before writing the result in the destination bank. This parameter is only used if the **Offset Type** is set to **Absolute**.
05 = **Destination bank**	The profile bank containing the profile to be subtracted and the bank where the resulting difference profile will be put.

Returned Values

01 = **Offset Used**	The tool returns the mm value actually used as offset. This is convenient if the actual mm difference value shall be used later in the step program (by a result reference). To get the actual difference in mm in any specific point, use the tool Get Calibrated Point and subtract the Used Offset from the obtained Z value.

Error Messages

Err. = 7704	The region of interest has parts that are outside the source bank.

Fill Missing Data

This tool removes missing data from a selected part of a 3D image or profile, by interpolating the height values from areas surrounding the missing data.

Only the pixels within the ROI are affected in the output but values outside the ROI are used for interpolation. If the ROI only contains missing data, this tool does nothing. Data can not be created from scratch.

Typically, this tool is used for preparing 3D images for use with tools that treats missing data as a height value. For example, if an image containing missing data is used in the 'Find Row' tool, the missing data could be interpreted as an edge. For a list of tools that treats missing data as height values, please refer to appendix C.

The tool is mainly designed to fill small areas of missing data but will work for areas of any size.

Input Parameters

01 = Source bank	Image bank containing the 3D image or profile.
02 = ROI definition step	The program step where the ROI was defined.
03 = Destination bank	Image bank in which to store the resulting interpolated surface or curve.

Error Messages

Err. = 7704	The region of interest has parts that are outside the source bank.

Detail Extraction

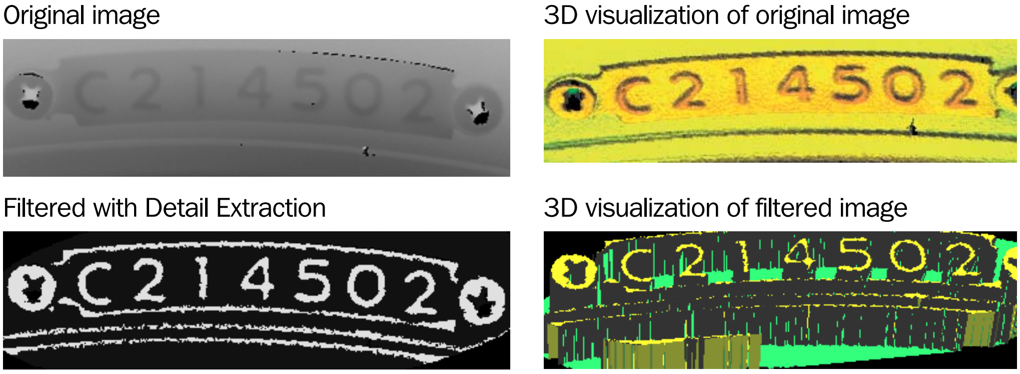
The Detail extraction tool finds image details that “stick out” from the background. In 3D images, embossed (raised) details or de-bossed (lowered) details are enhanced, for example embossed text on tires, or embossed or engraved text on forged metal objects.

It is recommended to use the interactive setup to customize the parameters. Double-click on the Setup button to open the interactive setup window. For more information on the interactive setup, see **Detail Extraction Setup**

on page **278**.

The result from the tool is a new image where only two height values are represented – `high` for details (top of the FOV) and `low` for background (bottom of the FOV).

Note: The actual height values in the resulting image will be different from the original image and therefore it is not relevant to measure the height or volume in such an image. Missing data in the image will still be missing data in the output image.



Original image

3D visualization of original image

Filtered with Detail Extraction

3D visualization of filtered image

Figure –Filtering a 3D image with the Detail extraction tool

In the **Operator Type** parameter you set how the deviation search should be carried out.

Note: Pixels near the edges of the ROI will be affected by pixels outside the ROI.

Input Parameters

01 = Source Bank Image bank containing the image to be filtered

02 = ROI Definition Step Previous program step defining the ROI to be used by this tool

03 = Operator Type Defines which set of neighbouring points to consider when locating deviating points:

- `Horizontal` Compare the current point to the horizontal neighbours.
- `Vertical` Compare the current point to the vertical neighbours.
- `Four points` Compare the current point to the horizontal and vertical neighbours.
- `Eight points` Compare the current point to the horizontal, the vertical and the diagonal neighbours.
- `Full Region(slow)` All pixels inside the operator radius are considered.

04 = Threshold (mm) The minimum height difference between the pixel and the background that is required to consider the pixel a detail.

05 = Operator Radius	The radius within which the Operator Type operates. It determines how far from the current point the considered neighbour points can be.
06 = Destination Bank	Image bank in which to store the filtered image.
07 = Deviation Type	Specifies whether the details to look for are higher (`Raised`), lower (`Lowered`) or both higher and lower (`Raised` + `Lowered`) than the background. **Note:** If the Operator Type parameter is set to `Full region`, the `Raised` + `Lowered` option is not available.

Returned Values

01 = Number of Detail Pixels	The total number of detail pixels found.

4.4 Edge

Find Row Edge

This tool scans a defined row and outputs the first found pixel with a height value that is within the defined height value thresholds. The return value is the column number of the first found pixel. This column number is the x-coordinate of the found pixel and the y-coordinate is the row number set with the input parameter **Row**.

This tool requires a non-rotated rectangle ROI from a previous step. Note that only ROIs that are generated by the 'ROI rectangle' tool can be used. Do not use ROIs created by any other ROI tool.

Only the pixels along the row inside the ROI will be considered.

The **Row** parameter can be set in the preview image by using the left mouse button and drop the line from the top border of the FOV to the desired position.

It is possible to select scan direction along the row by the parameter **Analysis direction.** If you select analysis direction from left to right (`Left -> Right`) the found column corresponds to the first found pixel from the left side of the ROI.

The height value thresholds are set by the parameters **Min height** and **Max height**. To set the thresholds with a slider, double-click the input field for the height value threshold and click the appearing button. This opens a larger image. Use the left mouse button to move the slider.

All pixels inside the ROI with height values within the two thresholds are colored blue.

Input Parameters

01 = Source bank	Image bank containing the image to be processed.	
02 = Row	Row number for the row to be scanned. 0 = top of FOV	
03 = Analysis direction	Scan direction.	
	`Left -> Right`	beginning from the left side of the ROI.
	`Right -> Left`	beginning from the right side of the ROI.
04 = Min height (mm)	Low height value threshold.	
05 = Max height (mm)	High height value threshold.	
06 = ROI definition step	Step number where the ROI to use was created. Note that only ROIs generated by the 'ROI rectangle' tool can be used.	

Returned Values

01= Column	Returns the number of the column where the found pixel is located. This could be used as the X-coordinate of the found pixel.

Error Messages

Err. = 107	`Error: points out of bank` Check if the specified ROI is generated by a 'ROI rectangle' tool.
Err. = 108	`Error in Find row edge` Check if selected row is inside the ROI.

Find Column Edge

This tool scans a defined column and outputs the first found pixel with a height value that is within the defined height value thresholds. The return value is the number of the corresponding row of the first found pixel. This row number is the y-coordinate of the found pixel and the x-coordinate is the column number set with the input parameter **Column**.

This tool requires a non-rotated rectangular ROI from a previous step. Note that only ROIs that are generated by the 'ROI Rectangle' tool can be used. Do not use ROIs created by any other ROI tool.

Only the pixels along the row inside the ROI are considered.

The **Column** parameter can be set in the preview window by using the left mouse button and drop the line from the top border of the FOV to the desired position.

It is possible to define **Analysis direction** to have either the column at the bottom of the ROI as starting point (`Down -> up`) or the top column (`Up -> down`). Selecting **Analysis direction** `Down -> up` outputs the row of the first found pixel beginning from the bottom of the ROI.

The height value thresholds are set by the parameters **Min height** and **Max height**. To set the thresholds with a slider, double-click the input field for the height value threshold and click again on an appearing button that opens a larger image. Use the left mouse button to move the slider. It is also possible to adjust the column position in this window.

All pixels inside the ROI with height values within the two thresholds are colored blue.

Input Parameters

01 = Source bank	Image bank containing the image to be processed.
02 = Column	Column number for the row which will be considered. 0 = left border of FOV
03 = Analysis direction	Direction of the analysis. `Down -> up` beginning from the bottom of the ROI `Up -> down` beginning from the top of the ROI.
04 = Min height (mm)	Low height value threshold.
05 = Max height (mm)	High height value threshold.
06 = ROI definition step	Step number where the ROI to use was created. Note that ONLY ROIs generated by the 'ROI rectangle' tool can be used.

Returned Values

01 = Row	Returns the number of the row where the found pixel is located. This could be used as the Y-coordinate of the found pixel.

Error Messages

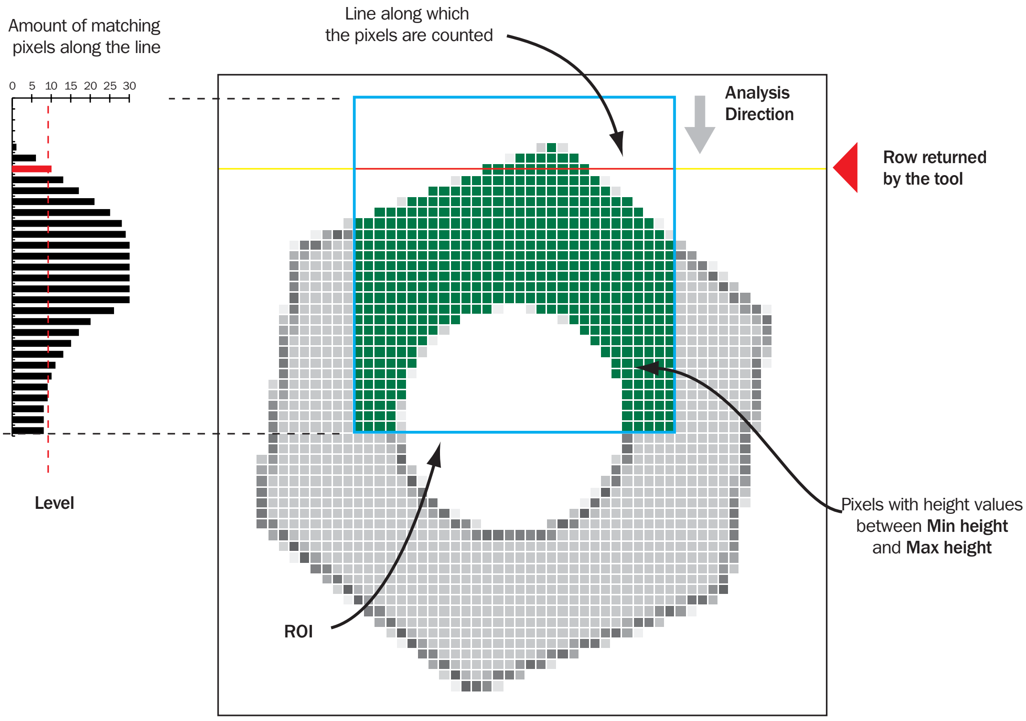
Err. = 104	`Error: points out of bank` Check if the specified ROI is generated by a 'ROI rectangle' tool. Check if the specified column is inside the ROI.

Find Row

This tool scans an image along a horizontal line to find a row that contains pixels with height values that are in a specified range. Only the part of the image that is inside a ROI is scanned.

The returned value is the y-coordinate of the found row. In the preview window, the found row is marked with a yellow line.

The tool will “find” a row (and stop scanning the image) when the row contains a certain amount of pixels with height values within the range. This amount is specified by the parameter **Level**, and can be used for making the tool less sensitive for noise in the image.


Amount of matching pixels along the line
0 5 10 15 20 25 30
Level
Line along which the pixels are counted
Analysis Direction
Row returned by the tool
Pixels with height values between **Min height** and **Max height**
ROI

The parameter **Type of transition** is used for choosing whether the tool should stop scanning when the amount of matching pixels in the line rises above the amount set in **Level** (pixels > level), or when it sinks below the amount set in **Level** (pixels < level).

The lower and upper limits of the range of height values are set by the parameters **Min height** and **Max height**. These parameters can be set in an interactive setup window, which is opened by clicking the button that is displayed when double-clicking the Value field of the parameters. In the interactive setup window, all pixels inside the ROI with height values within the range are colored blue.

The image is scanned either from the top of the ROI to the bottom, or from the bottom to the top depending on the setting of the parameter **Analysis direction**.

This tool requires a non-rotated rectangular ROI. The parameter **ROI definition step** points out the program step in which the ROI is created. Note that only ROIs created with the 'ROI Rectangle' tool are allowed. Do not use a ROI created by another ROI tool.

For some applications it is useful to combine this tool with the 'Find Column' tool to detect the column as well. In some cases the column and the row could be used to establish the x- and y-coordinates of the found pixel.

Input Parameters

01 = Source bank	Image bank containing the image to analyze.
02 = Analysis direction	Direction of the analysis. `Down→up` beginning from the bottom of the ROI. `Up→down` beginning from the top of the ROI.
03 = Min height (mm)	Lower height value threshold.
04 = Max height (mm)	Upper height value threshold.
05 = Level	Amount of pixels with height values in between **Min height** and **Max height**. Default setting = 2
06 = Type of transition	`Pixels > level` Stop when the amount of matching pixels in the line *rises above* **Level**. `Pixels < level` Stop when the amount of matching pixels in the line *sinks below* **Level**.
07 = ROI definition step	Selected ROI from a previous program step. Note that only ROIs created with the 'ROI rectangle' tool are allowed.

Returned Values

01 = Row	Y-coordinate of the found row.

Error Messages

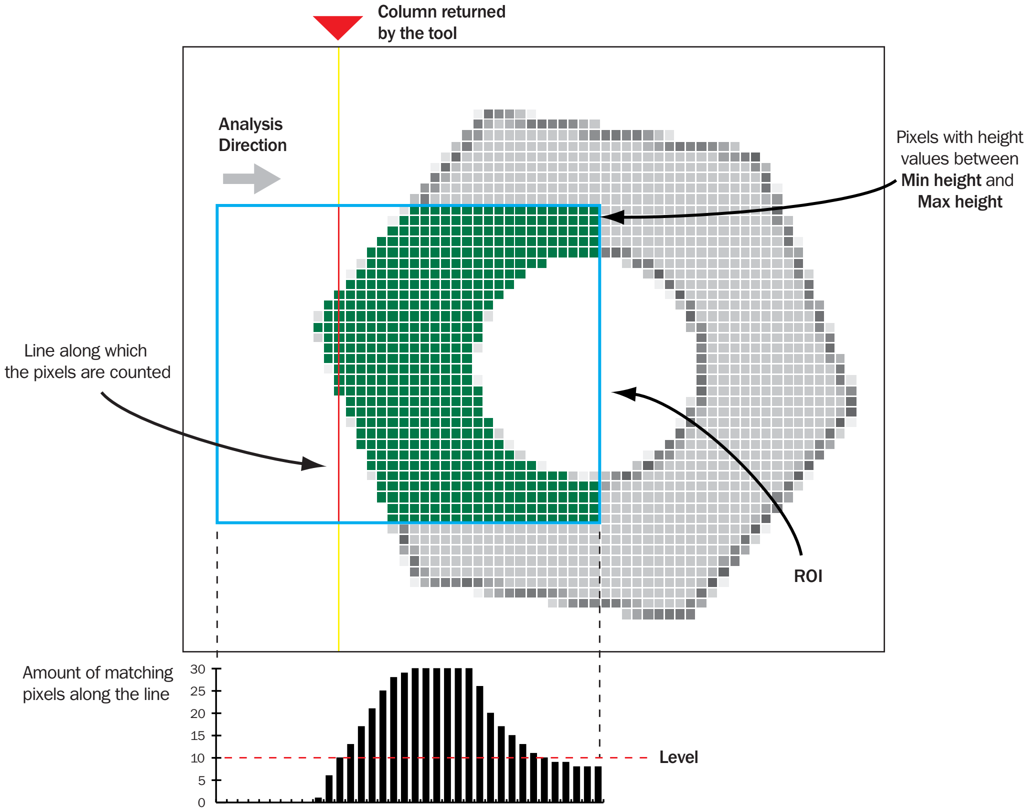
Err. 107	`Error: points out of bank` Check that the ROI is generated by the 'ROI rectangle' tool and not by a different ROI tool.

Find Column

This tool scans an image along a vertical line to find a column that contains pixels with height values that are in a specified range. Only the part of the image that is inside a ROI is scanned.

The returned value is the x-coordinate of the found column. In the preview window, the found column is marked with a yellow line.

The tool will “find” a column (and stop scanning the image) when the column contains a certain amount of pixels with height values within the range. This amount is specified by the parameter **Level**, and can be used for making the tool less sensitive for noise in the image.


Column returned by the tool
Analysis Direction
Pixels with height values between Min height and Max height
Line along which the pixels are counted
ROI
Amount of matching pixels along the line
30
25
20
15
10
5
0
Level

The parameter **Type of transition** is used for choosing whether the tool should stop scanning when the amount of matching pixels in the column rises above the amount set in **Level** (pixels > level), or when it sinks below the amount set in **Level** (pixels < level).

The lower and upper limits of the range of height values are set by the parameters **Max height** and **Min height**. These parameters can be set in an interactive setup window, which is opened by clicking the button that is displayed when double-clicking the Value field of the parameters. In the interactive setup window, all pixels inside the ROI with height values within the range are colored blue.

The image is scanned either from the left edge of the ROI to the right, or from the right to the left depending on the setting of the parameter **Analysis direction**.

This tool requires a non-rotated rectangular ROI. The parameter **ROI definition step** points out the program step in which the ROI is created. Note that only ROIs created with the 'ROI Rectangle' tool are allowed. Do not use a ROI created by another ROI tool.

For some applications it is useful to combine this tool with the 'Find Row' tool to detect the row as well. In some cases the column and the row could be used to establish the x- and y-coordinates of the found pixel.

Input Parameters

01 = Source bank Image bank containing the image to analyze.

02 = Analysis direction Direction of the analysis.

`L – R` beginning from the left side of the ROI.
`R – L` beginning from the right side of the ROI.

03 = Min height (mm) Lower height value threshold.

04 = Max height (mm) Upper height value threshold.

05 = Level Amount of pixels with height values in between **Min height** and **Max height.**

Default setting: 2

06 = Type of transition `Pixels` > `level` Stop when the amount of matching pixels in the column *rises above* **Level.**

`Pixels` < `level` Stop when the amount of matching pixels in the column *sinks below* **Level.**

07 = ROI definition step Selected ROI from a previously program step. Note that only ROIs generated by the 'ROI rectangle' tool can be used.

Returned Values

01 = Column X-coordinate of the found column.

Error Messages

Err. 107 `Error: points out of bank`

Check that the ROI is generated by the 'ROI rectangle' tool and not by a different ROI tool.

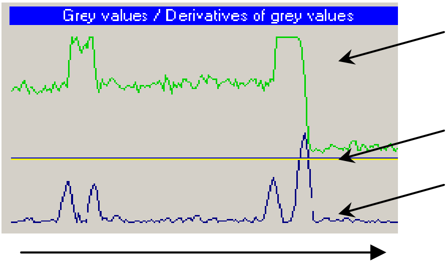
Find Line Edge

This tool finds edges on a user defined straight line by evaluating how the height changes along the line. There is an interactive setup and it is recommended to use it to set the parameters. Double-click the Setup button to open the interactive setup. For more information on the interactive setup please refer to on page 260.

There are two evaluation methods to detect transitions/changes in the height.

Evaluation Method 1: Detect Relative Change in Height

Beginning at the starting point of the line this method detects the first change in height that is above the user defined value. The evaluation is based on the derivation of the histogram along the line. If the first absolute value of the derivation, average out of 4 pixels, is greater or equal to the user defined threshold the function terminates. In that case the function returns the coordinates of the first found pixel (**X transition**, **Y transition**).



Height value along the line

User defined threshold of the minimal required change in height

Absolute derivative of the height (shows amount of height changes along the line)

Direction of evaluation

Figure – Evaluation method 1: Detect relative change in height

The figure above shows an example of evaluation method 1. The pixel with the first absolute relative change in height (in direction of evaluation) that is greater or equal to the threshold is detected. In this case the amount of the last change is ≥ than the threshold. The red circle indicates the detected point on the blue line. This point corresponds to the location of the returned X and Y pixel coordinates. Red circle displayed in this example only.

Evaluation Method 2: Detect Absolute Change in Height

Beginning at the starting point of the line this method detects if the height enters a user defined region of height values. The evaluation is based on the absolute values in the histogram along the line. The region of height values is defined by upper and lower thresholds. In this mode the function returns each transition into the region of height values. Note following convention: If the height value of the starting point of the line is already in the region of height values the starting point itself is a detected point as well. In this mode the function writes the found pixel coordinates of detected transitions into the table.

The figure below shows an example of evaluation method 2. The red circles indicate the detected points in the histogram (green line). Note that only one transition of the height into the selected region of height values is detected. This is due to the fact that the location of the detected points depends on the direction of evaluation. The red circles correspond to the location of the returned X and Y coordinates. Red circles displayed in this example only.

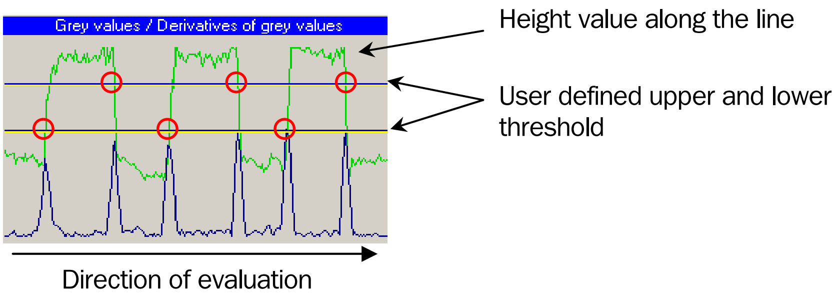


Figure – Evaluation method 2: Detect absolute change in height

The evaluation method and the geometrical definition of the line parameters are selected by the input parameter **Type**. The following types are available:

Type	Evaluation method	Line parameters
`Single & Cartesian`	1	Cartesian coordinates for start and end point of line.
`Single & Interval`	1	Cartesian coordinates for start point and relative values delta X and delta Y for end point of line.
`Single & Polar`	1	Cartesian coordinates for start point and distance and angle (anti clockwise with respect to x-axes) for end point of line.
`Multiple & Cartesian`	2	Cartesian coordinates for start and end point of line.
`Multiple & Interval`	2	Cartesian coordinates for start point and relative values delta X and delta Y for end point of line.
`Multiple & Polar`	2	Cartesian coordinates for start point and distance and angle (anti clockwise with respect to x-axes) for end point of line.

To reduce the influence of noise the input parameter **Average pixels** can be set to make an average of the height values in up to 10 pixels in line direction. This avoids faulty results due to the influence on single pixels. This option is available with evaluation method 2: Detect an absolute change in height only.

Input Parameters

01 = Source bank	Selected image bank for the processing of this function.
02 = Type	Selects evaluation method and geometric definition of line parameters (see table above).
03 = Start point X	X coordinate for start point of line.
04 = Start point Y	Y coordinate for start point of line.
05 = End point X, width, L	If **Type** is `Cartesian`: X coordinate for end point of line. If **Type** is `Interval`: Relative distance delta X to end point of line. If **Type** is `Polar`: Absolute distance to end point of line.
06 = End point Y, height, angle	If **Type** is `Cartesian`: Y coordinate for end point of line. If **Type** is `Interval`: Relative distance delta Y to end point of line. If **Type** is `Polar`: Angle with respect to x-axes.
07 = Min height (mm)	Lower height threshold value (method 2). Derivative threshold (method 1).
08 = Max height (mm)	Upper height threshold value (method 2). Derivative threshold (method 1).
09 = Average pixels	Available with evaluation method 2 only. Allows to average over up to 10 pixels in the line direction.
10 = Table index	Works only for evaluation method 2. Start index in table to write the found pixel coordinates of transitions in the table.
11 = Max stored transitions	Works only for evaluation method 2. Upper limit for stored transitions in the table. Counts from first found pixel.
12 = Destination bank	Number of the destination bank in which to display source bank, line and found points. Make sure that Destination bank is different from Source bank.

Returned Values

01 = Found transitions	Total number of found transitions.
02 = X transition	X coordinate of the first found pixel. Set to 0 if no transitions were found.
03 = Y transition	Y coordinate of the first found pixel. Set to 0 if no transitions were found.

Error Messages

Err. = 10	Error in Parameter 10. Value has to be less than 11.

Find Subpixel Edge

This tool scans the height values along a user defined line and detects a change of height values that is at least of the amount of a user defined threshold. Evaluation begins at the start point of line and returns the coordinates of the first found edge with subpixel resolution. All evaluation types use a relative threshold and Cartesian coordinates for start and end point of the line.

Double-clicking on the input field for **Threshold** and double-clicking again on the button that appears opens a larger image. In this new window you can set the threshold for the required relative changes of height values by using a slider on the left side. The first found edge along the line is marked with a green dot in the image.

Input Parameters

01 = Source bank	Image bank containing the image to be processed
02 = Type	Always set to `Cartesian`.
03 = Start point X	X coordinate for start point of line.
04 = Start point Y	Y coordinate for start point of line.
05 = End point X, width, L	X coordinate for end point of line, delta X, distance.
06 = End point Y, height, angle	Y coordinate for end point of line, delta Y, angle.
07 = Threshold (mm)	Threshold for required relative change in height to detect an edge.
08 = Destination Bank	Image bank in which to draw the line that was searched along, and lines for the returned X and Y coordinates.

Returned Values

01 = X transition	X coordinate of the found edge with subpixel resolution.
02 = Y transition	Y coordinate of the found edge with subpixel resolution.

Find Multiple Edges

This tool evaluates the variation of height values and detects edges along a user defined line. In general two evaluation types are available.

- **Relative** Detects pixels with a height value variation above a relative height value threshold. Additional it's possible to select the type of transition to detect only transitions from high to low height values, from low to high height values or any transition.
- **Absolute** Detects pixels with a height value variation above or below two absolute height value thresholds.

For each evaluation type there exist specific input parameters to optimize the edge detection. The definition of these input parameters is shown in the figures below.

The evaluation starts at start point of line and continues along the line to end point of line. The tool writes the X and Y coordinates of the detected pixels into a user defined row in the table. Additionally the tool returns the total number of found transitions along the line.

Double-click the input field for the height value thresholds and click the button to set the upper and lower thresholds for the height values with a slider. Additionally it is possible to set length and position of the line with the left mouse button. All found edges along the line with transitions from low to high height values are marked with a blue cross and transitions from high to low height values with a red cross.

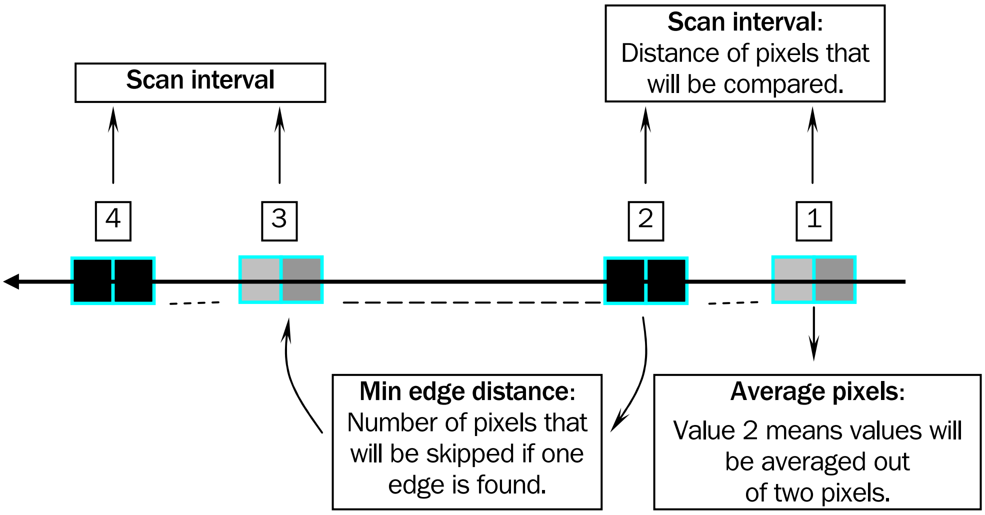
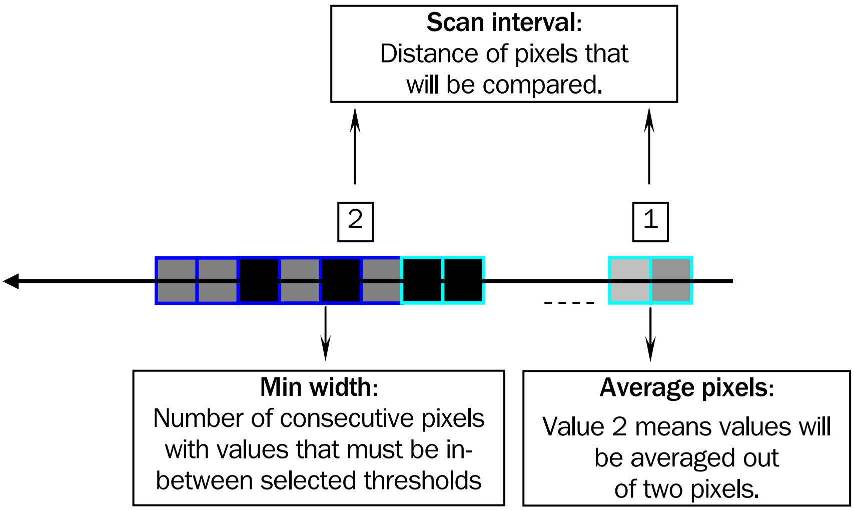

Scan interval
Scan interval: Distance of pixels that will be compared.
4
3
2
1
Min edge distance: Number of pixels that will be skipped if one edge is found.
Average pixels: Value 2 means values will be averaged out of two pixels.

Figure – Edge finding with evaluation type Relative, which detects a relative change of height values. Note that the Min edge distance value should be greater than the Scan interval value to avoid misplaced results.


Scan interval:
Distance of pixels that will be compared.
2
1

Min width:
Number of consecutive pixels with values that must be in-between selected thresholds
Average pixels:
Value 2 means values will be averaged out of two pixels.

Figure – Edge finding with evaluation type Absolute, which detects an absolute change of height values.

Input Parameters

01 = Source bank	Image bank containing the image to be processed.

02 = Type	Selected type of threshold and transition type:
	`Bright -> dark`
	Relative threshold and only transitions from high to low height values will be detected.
	`Dark -> bright`
	Relative threshold and only transitions from low to high height values will be detected.
	`Any relative transition`
	Relative threshold and any transition will be detected
	`Absolute`
	Absolute threshold and any transitions above or below the two thresholds will be detected.

03 = Start point X	X coordinate for start point of line.
04 = Start point Y	Y coordinate for start point of line.
05 = End point X	X coordinate for end point of line.
06 = End point Y	Y coordinate for end point of line.
07 = Min height (mm)	Lower height value threshold. Using any evaluation type with relative threshold this value is the required changes in height values.
08 = Max height (mm)	Upper height value threshold. Available only with evaluation type absolute threshold. Note that this value will be ignored when using evaluation type relative threshold.

09 = Average pixels	Number of averaged pixels for height value.
10 = Min edge distance / Min width	**Min edge distance** Number of pixels that will be skipped if a transition is found. Used with evaluation type relative threshold. **Min width** Number of consecutive pixels that must have height values between lower and upper threshold. Used with evaluation type absolute threshold.
11 = Scan interval	Distance of compared pixels (in pixels).
12 = Table index	Start index in table to write the found coordinates.
13 = Max stored transitions	Upper limit for number of stored transition coordinates in table. Note that only transitions up to this number will be marked with a cross in the image bank. If **Max stored transitions = 0** no found transition will be marked in the image.
14 = Destination bank	Number of the image bank in which to display the circle (ellipse) with red marked crosses to indicate found transitions.

Returned Values

01 = Found transitions	Total number of found edges.

Error Messages

Error 135	The line is too short.
Error 136	The line is too long.

Find Mean of Edges

This tool performs a linear fit on certain pixels in the image. Return values are the mean position on the fitted line and the deviation from the line of the found pixels.

The pixels for the fit are generated by a height value evaluation either along selected columns or selected rows. Beginning at the starting point of the column or row the first pixel showing a change in height that is at least of the amount of a user defined value is indicated. In general the direction of evaluation is either along the columns or the rows and is selected by an input parameter.

This tool requires a rectangular non-rotated ROI from a previously performed step. Note that only ROIs generated by the 'ROI Rectangle' tool can be used. Do not use ROIs from any other ROI tool. Only the columns or rows inside the ROI are considered.

To speed up processing time it is possible to select how many columns or rows inside the ROI that should be evaluated. The input parameter **Scan interval** in pixel defines the equidistant gap between each column or row in pixels. The precision of the linear fit is increased with the number of columns or rows.

After the height value evaluation is performed further conditions select the pixels that are considered for the linear fit. To ignore a single outlier it is possible to allow a maximum distance from the next found neighbor pixel. To ignore connected pixels it is possible to define a cluster build with a minimum number of connected pixels. Clusters of this size and a distance of more than the allowed maximum distance to the next cluster are ignored for the fit.

Double clicking the input field for the **Threshold** parameter and double clicking an appearing button opens a larger image. This new window allows setting of the **Threshold** parameter and displays the found pixels and the fitted line in the image.

The tool returns the coefficients of the equation for the line that represents the edge. The equation is on the form y = kx+m.

Input Parameters

01 = Source bank	Image bank containing the image to be processed.
02 = ROI definition step	Step number where the ROI to use was created. Note that only ROIs generated by the 'ROI rectangle' tool can be used.

03 = Analysis direction	Direction of the evaluation to generate pixels for the fit. The choices are:
	`Left -> right`
	`Down -> up`
	`Right -> left`
	`Up -> down`

04 = Scan interval	Define gap between equidistant spaced columns or rows in pixels. To evaluate each column (row) type in 0.
05 = Threshold (mm)	Amount of the minimum required change in height.
06 = Pixel distance	Maximum allowed distance in pixel from next found neighbor pixel.
07 = Average pixels	Allows to average height values over up to 16 pixels along the scan direction.
08 = Min connected transitions	Defines minimum required number of connected pixels with the allowed distance from next neighbor pixel (combination with the input parameter Pixel distance).
09 = Destination bank	Number of the destination bank in which to display source bank, selected pixels and fitted line. Make sure that Destination bank is different from Source bank.

Returned Values

01 = Mean of transition	Returns the mean X respectively Y coordinate of all fitted pixels (depends on the evaluation direction).
02 = Max derivation of regression	Maximum distance from the fitted line in pixel (depends on the evaluation direction).
03 = Points out of tolerance (%)	Percentage of the found pixels which will not be considered for the linear fit
04 = Lines without transition (%)	Percentage of evaluated columns (rows) without the required transitions in height.
05 = Slope	This is the slope of the line, i.e. the value of k in the line equation.
06 = Y-intercept	Indicates where the line crosses the Y-axis, i.e. the value of m in the line equation.

Example

The following example is for IVC-2D, but the principle is the same when using IVC-3D. The only difference is that the threshold is a height value in millimeters instead of a gray level value.

The figure below shows an example to Find mean line and margin. Note that red circles are ignored and are not considered for the linear fit. Chosen input parameters: Tolerance in pixel = 5 and Filter in steps on isolated points = 3. Due to the fact that all pixels with a distance of more than 5 pixels to the next found neighbor pixel are ignored (indicated with A in the figure). Additionally all clusters with less than 4 connected pixels and a distance of more than 5 pixels to the next found neighbor pixel are ignored as well (indicated with B in the figure).

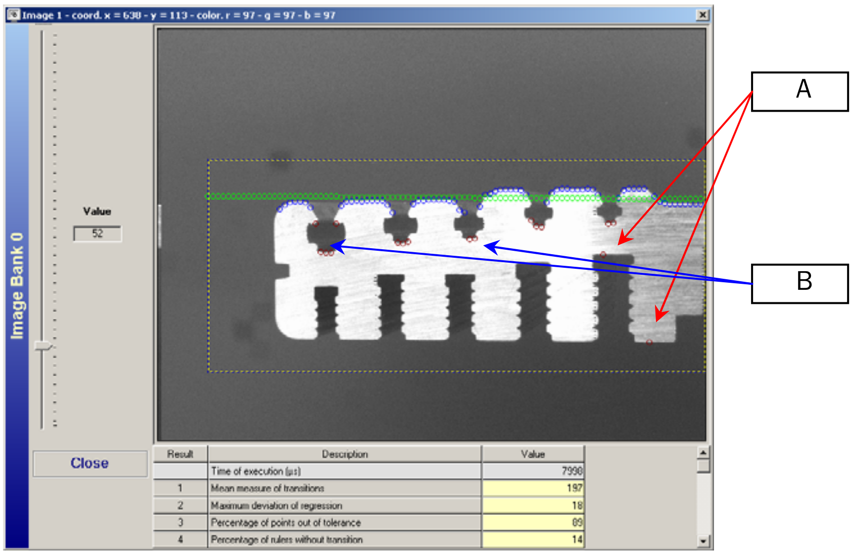


Image 1 - coord. x = 630 - y = 113 - color. r = 97 - g = 97 - b = 97

Result	Description	Value
	Time of execution (µs)	7990
1	Mean measure of transitions	197
2	Maximum deviation of regression	18
3	Percentage of points out of tolerance	89
4	Percentage of rulers without transition	14

Figure – Evaluation direction is from top to bottom. Dashed yellow box indicates selected ROI. Blue circles: found pixels which will be considered for the linear fit, red circles: found pixels but ignored and not considered for the linear fit, green circles: fitted mean line. The table below the image shows the result parameters.

Find Circle Edges

This tool evaluates the variation of height values and detects edges along the circumference of a circle or ellipse. In general two evaluation types are available.

- Relative evaluation: This type detects pixels with a height variation above a relative height value threshold.
- Absolute evaluation: This type detects pixels with a height variation above or below two absolute height value thresholds.

Each evaluation type has specific input parameters to optimize the edge detection. The definition of these input parameters is shown in the figures below.

The evaluation starts at the horizontal axis of the circle (ellipse) and continues counter clockwise along the circumference.

The tool writes the X and Y coordinates of the detected pixels into a user defined row in the table. Additionally the tool returns the total number of indicated pixels and sets an error flag to control the correct execution.

To set the thresholds with a slider, double-click the input field for the height value threshold and click the appearing button that opens a larger image. Use the left mouse button to move the slider. It is also possible to set the shape and position of the circle (ellipse) with the left mouse button in this window. All found edges on the circumference are marked with red crosses.

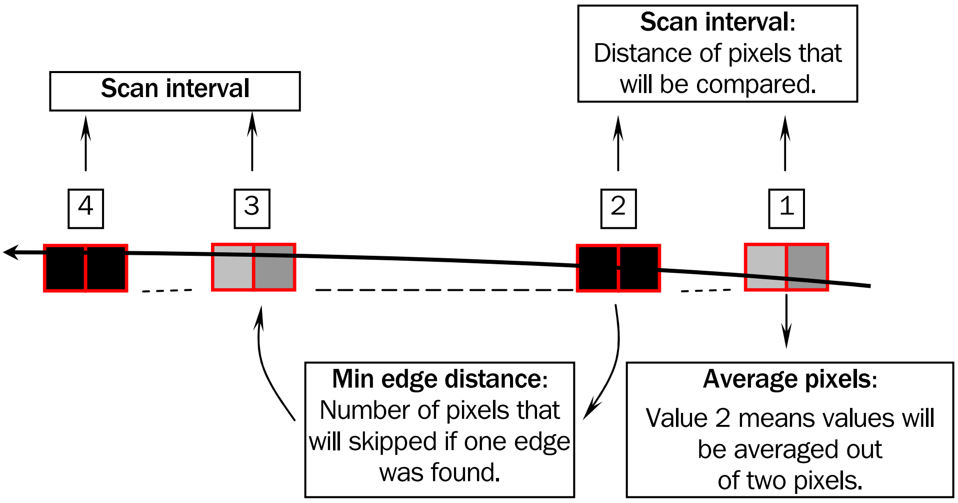

Scan interval:
Distance of pixels that will be compared.
Scan interval
4
3
2
1
Min edge distance:
Number of pixels that will skipped if one edge was found.
Average pixels:
Value 2 means values will be averaged out of two pixels.

Figure – Edge finding using relative evaluation.
A relative change of height values is detected. Note that the Min edge distance value should be greater than the Scan interval value to avoid misplaced results.

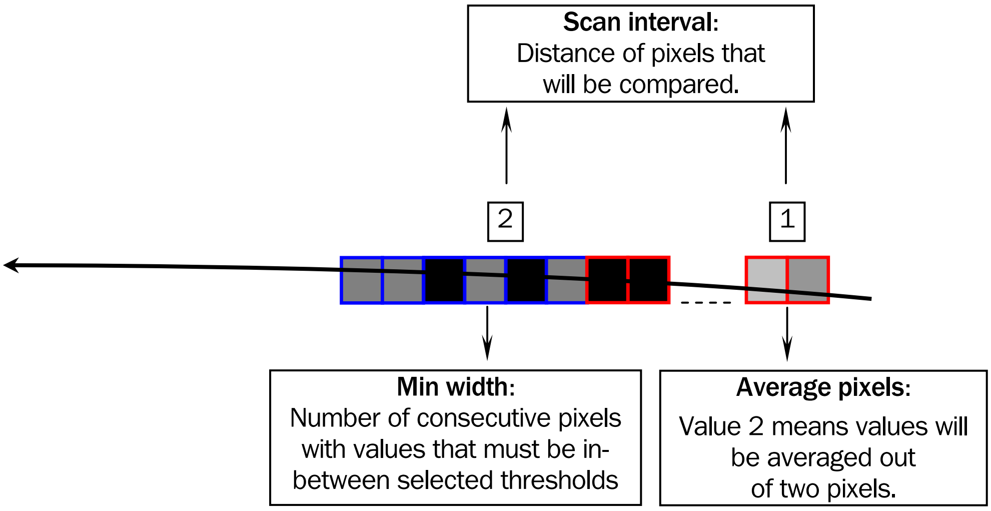

Scan interval:
Distance of pixels that will be compared.
2
1
Min width:
Number of consecutive pixels with values that must be in-between selected thresholds
Average pixels:
Value 2 means values will be averaged out of two pixels.

Figure – Edge finding using Absolute evaluation.

Input Parameters

01 = Source bank Selected image bank for the processing of this function

02 = Type Selected type of threshold

`Absolute` sensitive to absolute variations of height values.

`Relative` sensitive to relative variations of height values (Input parameter **Max height** will be ignored)

03 = X center X coordinate of the circle or ellipse center.

04 = Y center Y coordinate of the circle or ellipse center.

05 = X radius Value of the radius in X direction.

06 = Y radius Value of the radius in Y direction.

07 = Min height (mm) Lower height value threshold.
When using evaluation type `Relative`, this value is the required change in height values.

08 = Max height (mm) Upper height value threshold.
Note that this value will be ignored when using evaluation type `Relative` threshold.

09 = Type of transition Only available with evaluation type `Relative`. Note that this value will be ignored when using evaluation type absolute threshold.

Defines direction of evaluated height value transitions.

1 = transitions from lower to higher.
–1 = transitions from higher to lower.
0 = transitions in both directions.

10 = Scan interval Distance of compared pixels (in pixels).

11 = Average pixels Number of averaged pixels for height value.

12 = Min edge distance Only available with evaluation type `Relative`. Note that this value will be ignored when using evaluation type `Absolute`.

Number of pixels that will be skipped if a transition is found.

13 = Min width Only available with evaluation type `Absolute`. Note that this value will be ignored when using evaluation type `Relative`.

Number of consecutive pixels that must have height values between lower and upper threshold.

14 = Table Index Start index in table to write the found coordinates.

15 = Max stored transitions Upper limit for number of stored transition coordinates in table.

16 = Destination bank Number of image bank to display the circle (ellipse) with red marked crosses to indicate found transitions.

Returned Values

01 = Error flag Flag = 0 if the function was executed correctly.

02 = Found edges Total number of found transitions.

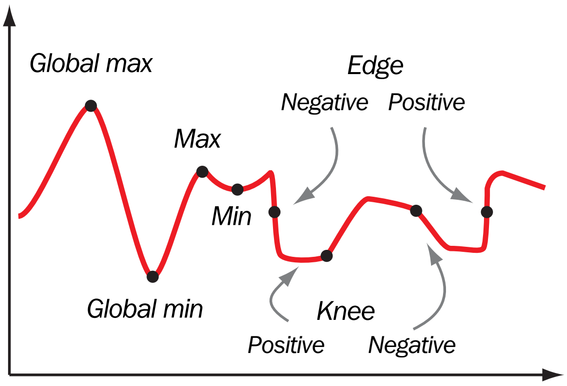
Find Profile Points

This tool analyzes a selected part of a profile and finds every point that either is a local maximum or minimum, an edge or a knee. The section of the profile to analyze is specified with a region of interest.

This tool has an interactive setup in which you can set the input parameters and immediately see how the result is affected by the changes. The interactive setup is opened by double-clicking the Setup button.

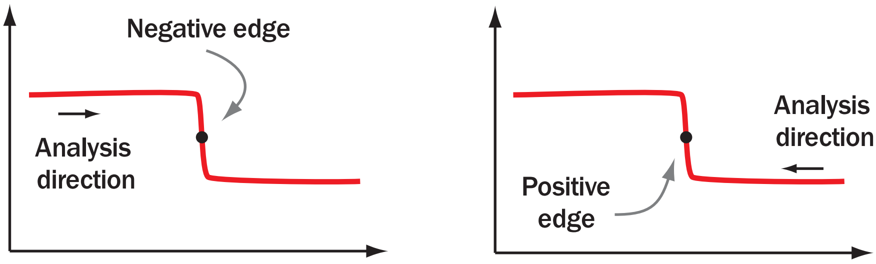
The tool can only handle profiles of length up to 2048 pixels. If the profile to analyze is a result from the 'Extract Profile' tool, ensure that the length of the profile does not exceed 2048 pixels.

The parameter **Type** specifies which type of points to search for.



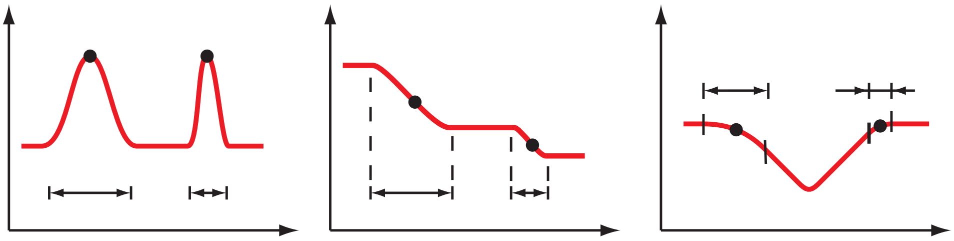
Different types of point that can be searched for.

The search direction for this tool is defined by **Analysis direction.** When searching for edges, this parameter also affects the types of points found since a `Negative edge` is considered to be a `Positive edge` when the profile is searched the other way.



Analysis directions when searching for edges.

The **Size** and **Strength** parameters can be used for filtering out small deviations in the profile. The **Size** parameter specifies the smallest size of the deviation along the x-axis.

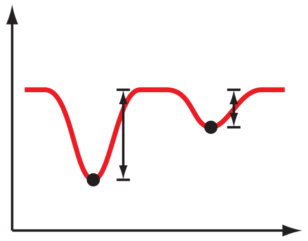


Size of maximum *Size of edge* *Size of knee*

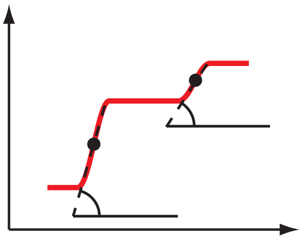
Similarly, the **Strength** parameter specifies the smallest strength of the deviation. The strength value is a measure of how much the profile varies:

- A large minimum or maximum is stronger than a small one

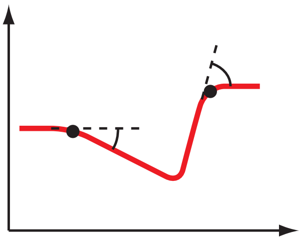
- A steep edge is stronger than a flat edge
- A sharp knee is stronger than a dull knee



Strength of minimum



Strength of edge



Strength of knee

For each found point, the x coordinate and the strength value are stored in the table, starting at row **Table index.** Each found point will thus occupy two rows in the table. The number of points stored in the table can be limited by setting the **Max stored points** parameter.

Input Parameters

01 = Source bank	Image bank containing the profile to analyze.
02 = ROI definition step	The program step where the ROI was defined.

03 = Analysis direction	The direction in which the analysis shall be performed:
	`Left -> right`
	`Right -> left`

04 = Type	The type of points to find:
	`Global Min`
	`Global Max`
	`Min`
	`Max`
	`Positive edge`
	`Negative edge`
	`Positive knee`
	`Negative knee`

05 = Size	The approximate size of the deviation in pixels along the x-axis; width of edge, width of maximum, etc. Allowed values are 1 through 128.
06 = Min strength	Minimum strength for deviations to be detected. A high maximum, low minimum, steep edge or sharp knee corresponds to high strength. Allowed values are 0 through 100.
07 = Table index	Position in the table where the results – x coordinate and strength – are stored.
08 = Max stored points	Maximum number of points that the tool will find
10 = Backwards compatible	See note below.

Returned Values

01 = Found points	The number of points that were found and stored in the table.

Error Messages

Err. = 7704	The region of interest has parts that are outside the source bank. This error is also returned if the ROI ends past pixel

2048 of the profile.

Important note:

Changed behaviour since IVC 3.2 release:

1. The tool could sometimes miss valid points above the min strength value, even if the max number of points had not been reached.
2. Previously, the tool returned the first valid found points, but could miss stronger points farther along the profile. Now, the tool is changed to return the points with the largest strengths, still sorted in the order of occurrence according to the search direction.

A new parameter called **Backwards Compatibility** is added to the tool. If this parameter is set to false, the correct behaviour as described above is enabled, and if it is set to true the previous behaviour is retained.

4.5 Measure

Centroid

This tool finds all pixels inside a ROI with height values between a lower and an upper threshold. The tool returns the coordinates of the center of gravity (centroid) of the found pixels area.

Double-click the input field for lower and upper threshold and double-click the appearing button. This opens an interactive window. This new window allows setting lower and upper threshold with a slider and shows the image with the found pixels colored.

Note: If no pixels with height values between **Min height** and **Max height** are found inside the ROI, the resulting coordinates of the centroid are (0,0).

Input Parameters

01 = Source bank	Selected image bank for the processing of this tool.
02 = ROI definition step	Select ROI from a previously program step.
03 = Min height (mm)	Threshold for lower height value.
04 = Max height (mm)	Threshold for upper height value.
05 = Destination bank	Number of the image bank in which to show the image with colored pixels and calculated centroid.

Returned Values

01 = X center	X coordinate of calculated center of gravity.
02 = Y center	Y coordinate of calculated center of gravity.

Single Blob Analysis

This tool counts all connected pixels with height values between a lower and an upper threshold beginning at a defined starting point in the image. It is possible to mark all found pixels with a color. Return values are the total number of found pixels and the centroid coordinates of the found pixels.

The lower and upper threshold for the height values can be set with a slider in an interactive setup window, which also shows the image with the found pixels marked with the selected color. To open the interactive window, double-click on the input field for lower or upper threshold and double-click again on the button that is displayed by the field.

Note: If the starting point is at a place at which the height value is not in between **Min height** and **Max height**, the resulting centroid is (0,0) and the number of counted pixels is of course 0.

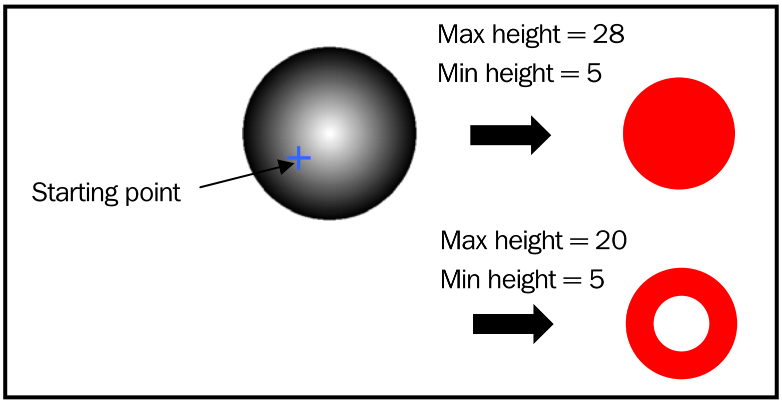
Input Parameters

01 = Source bank	Image bank containing the image to analyze.
02 = Start point X	X coordinate to start evaluation of height values.
03 = Start point Y	Y coordinate to start evaluation of height values.
04 = Min height (mm)	Threshold for lower height value.
05 = Max height (mm)	Threshold for upper height value.
06 = Color	Select color to mark found pixels. Double-clicking opens a color table.
07 = Destination bank	Number of image bank to show image with colored pixels and calculated centroid.

Returned Values

01 = Found pixels	Total number of found pixels between lower and upper threshold.
02 = X center	X coordinate of calculated centroid.
03 = Y center	Y coordinate of calculated centroid.

Example



Area

This tool calculates how many pixels inside a ROI that have a height value between a lower and an upper threshold. All found pixels inside the lower and upper threshold are defined as “pixels in range” and all pixels outside this region of height values are defined as “pixels out of range”. Return values are the total number of pixels in range (within the region of height values) and pixels out of range (outside the region of height values).

Double-click the input field for **Min height** and **Max height** and click the appearing button to set the height values with a slider. All pixels inside the ROI with height values in between the two thresholds are colored according to the parameter **Color for marking pixels in range** and the pixels outside the thresholds are not affected.

Input Parameters

01 = Source bank	Selected image bank for the processing of this tool
02 = ROI definition step	Select ROI from a previous program step.
03 = Min height (mm)	Threshold for lower height value.
04 = Max height (mm)	Threshold for upper height value.
05 = Color for marking pixels in range	The pixels inside the ROI that are between the two thresholds are marked with this color

Returned Values

01 = Pixels in range	Total number of found pixels between the lower and upper threshold.
02 = Pixels out of range	Total number of found pixels outside the lower and upper threshold.

Perimeter

This tool traces the contour of a blob. It requires an input starting point which should be located inside or to the left of the blob. The contour of the blob must be completely inside the image. The coordinates of the input starting point are usually a result from a previously executed step, for example of the Edge category. Beginning at the starting point this tool starts searching from left to right for the nearest edge on the horizontal line through this point. The search is done in a binarized image which set by the thresholds **Min height** and **Max height**. When the edge is found the perimeter is traced along the object.

Double-click on the input field for the height value thresholds and double-click again on the appearing button. This opens an interactive window. This new window allows setting the upper and lower thresholds for the height values with a slider. The found contour pixels are displayed in red color in the image.

This tool is useful for generating object specific ROIs in combination with the 'ROI perimeter' tool.

Notes:

1. The input starting point is not necessarily on the found contour (see examples below).
2. If the input starting point is outside of the blob, this tool finds white blobs best if the starting point is at the left of the blob and black blobs best, if the starting point is on the right of the blob. However, it is strongly recommended not to use any starting point outside of the contour.

Input Parameters

01 = Source bank	Selected image bank for the processing of this tool.
02 = Start point X	X coordinate of starting point to trace contour. Normally this value is a result value form a previously executed step of the Edge category.
03 = Start point Y	Y coordinate of starting point to trace contour. Normally this value is a result value form a previously executed step of the Edge category.
04 = Min height (mm)	Threshold for lower height value of allowed contour pixels.
05 = Max height (mm)	Threshold for upper height value of allowed contour pixels.
06 = Destination bank	Number of image bank to plot the found contour pixels.

Returned Values

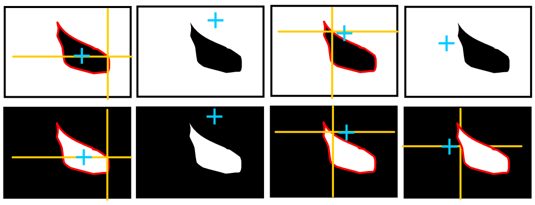
01 = Error flag	Flag = 0 if the tool was executed correctly Flag = -1 if no contour was found or in case of an error.
02 = Perimeter length	Total number of pixels along the perimeter of the traced contour. The upper limit is 2500 pixels.

Error Messages

Err. = 119	Parts of the contour are out of the FOV or no start point to trace the contour was found. Check thresholds for height values.
Err. = 118	Number of found contour pixels is less then 20. Check thresholds for height values.

Examples

+input starting point
+contour starting point



Line Intersection

This tool calculates the intersection, cross point, of two straight lines. Each line is defined by the coordinates of two points. Return values are the coordinates of the lines cross point.

Note: Cross points can be outside of the FOV but are still calculated correctly.

An error occurs if two points for one line coincide or in cases of parallel lines. In these cases the step terminates with an error and the returned coordinates are set to 0.

Input Parameters

01 = Line A start point X	X coordinate one on line A.
02 = Line A start point Y	Y coordinate one on line A.
03 = Line A end point X	X coordinate two on line A.
04 = Line A end point Y	Y coordinate two on line A.
05 = Line B start point X	X coordinate one on line B.
06 = Line B start point Y	Y coordinate one on line B.
07 = Line B end point X	X coordinate two on line B.
08 = Line B end point Y	Y coordinate two on line B.

Returned Values

01 = X intersection	X coordinate of cross point
02 = Y intersection	Y coordinate of cross point

Errors

Err. 112	No cross point found. Check that selected points for one line are different. Check that lines are not parallel.

Distance and Angle

This tool calculates the distance and the angle between two points. Return values are the absolute value of the distance and the angle.

Notes:

1. The definition of the geometrical interpretation of the angle means that the direction of rotation is counterclockwise in respect to the corresponding X-axis going through the first point.
2. If both points are identical, both result values are 0.

This tool is useful for example for generating offset parameters in a ROI tool.

Input Parameters

01 = Start point X	X coordinate of the first point.
02 = Start point Y	Y coordinate of the first point.
03 = End point X	X coordinate of the second point.
04 = End point Y	Y coordinate of the second point.

Returned Values

01 = Distance	Absolute value of the distance between the points in pixels.
02 = Line angle	Angle between the points in degrees ( ).

Example

Geometrical interpretation of the angle between two points.

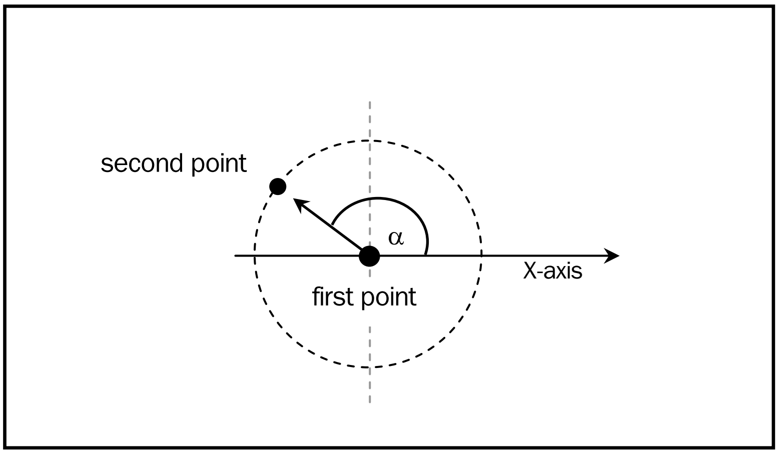


Figure – Geometrical interpretation of the angel between points.

Curve Intersection

This tool finds all intersection points between two curves. The supported curve types are lines, second-degree curves (parabolas) and circles.

The coordinates of the intersection points are written to the table, starting with x_1 at **Table index**, and y_1 at **Table index**+1, then x_2 and so on. A maximum of 4 intersection points can be found, as in the case of a parabola intersecting with a circle.

Note that the found points are not displayed in the previews in IVC Studio.

Input Parameters

01 = Curve A definition step	The program step where the curve A is defined.
02 = Curve B definition step	The program step where the curve B is defined.
03 = Table index	The table row in which to start storing the coordinates of the calculated intersections.

Returned Values

01 = Number of intersections	The number of found intersections

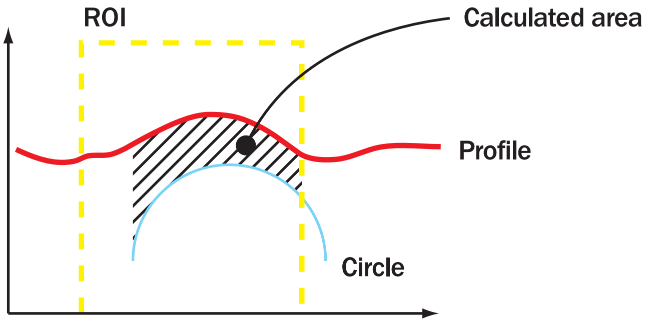
Cross-Section Area

This tool calculates the cross-section area of a profile within a region of interest, using a previously defined curve as zero level.

Only points on the profile above the zero-level reference curve are included in the calculation. Points that contain missing data are also excluded so it may be necessary to use the 'Fill Missing Data' tool before using this tool.

The zero-level reference curves can be created for example with the 'Define Curve' or 'Fit Circle to Profile' tools.

Note that when using a circle as zero-height reference, only the part of the profile that is within the width of the circle is included in the calculation, even if the ROI may specify a larger area.



Calculating the cross-section area with a circle as zero-level curve.

The returned area is always in square millimeters, so it may be necessary to convert the result into another unit if the result is to be displayed. Use a 'Mathematical Operation' or 'Mathematical Expression' tool to perform such a conversion.

Input Parameters

01 = Source bank	Image bank that contains the profile.
02 = ROI definition step	The program step where the ROI was defined.
03 = Curve definition step	The program step where the zero-level curve was defined.

Returned Values

01 = Area (mm^2)	The calculated area.

Error Messages

Err. = 7704	The region of interest has parts that are outside the source bank.

Volume

This tool calculates the volume of a 3D object within a region of interest, using a previously defined surface as zero level.

Any pixels that miss data will not be included in the volume calculation. Consider interpolating missing data before using this tool.

The volume is given in cubic millimeters and may sometimes need conversion if the value is to be presented to a user. Use the math tools to perform such a conversion.

Input Parameters

01 = Source bank	Image bank that contains a 3D image of the object whose volume will be calculated.
02 = ROI definition step	Program step where the ROI was defined.
03 = Surface definition step	Program step where the zero-level surface was defined.

Returned Values

01 = Volume (mm^3)	The calculated volume.

Distance

This tool calculates the distance between two points, given their calibrated x, y and z coordinates.

To convert the coordinates of a pixel in a 3D image into calibrated x, y and z coordinates, the 'Get Calibrated Point' tool can be used.

Input Parameters

01 = X1 (mm)	The calibrated X coordinate of the first point.
02 = Y1 (mm)	The calibrated Y coordinate of the first point.
03 = Z1 (mm)	The calibrated Z coordinate of the first point.
04 = X2 (mm)	The calibrated X coordinate of the second point.
05 = Y2 (mm)	The calibrated Y coordinate of the second point.
06 = Z2 (mm)	The calibrated Z coordinate of the second point.

Returned Values

01 = Distance (mm)	The Euclidian distance between point 1 and point 2

Deviation

This tool finds the maximum and the mean values of the absolute deviation along the z-axis between a selected part of a 3D image and a surface.

The part of the 3D image to analyze is specified by the region of interest in **ROI definition step**, and the surface to use as reference is specified in **Surface definition step**.

If necessary, an **Outlier distance** can be used for removing noise in the 3D image. The points that deviate more than **Outlier distance** from the surface are discarded, and the mean and max deviation is based on the remaining points only.

If **Outlier distance** is set to zero, every point in the 3D image will be included in the calculations. Note that this tool usually runs faster when **Outlier distance** is set to 0.

The deviation can be used for measuring defects on plane surfaces. It can also be used for measuring the quality of the result from the 'Fit Surface' tool.

Input Parameters

01 = Source bank	Image bank containing the 3D image to be compared with a surface
02 = ROI definition step	The program step where the ROI was defined.
03 = Surface definition step	The program step where the surface was defined.
04 = Outlier distance (mm)	The maximum distance between a point in the 3D image and the surface.

Returned Values

01 = Mean deviation (mm)	The mean deviation from the reference surface.
02 = Max deviation (mm)	The maximum deviation from the reference surface.

Error Messages

Err. = 7807	There are no valid values in the specified ROI. Use a different ROI or decrease **Outlier distance.**

Blob Finder

This tool finds regions of connected pixels, called blobs, based on their values. The values of the blobs are defined with an upper and a lower threshold.

It is recommended to use the interactive setup to customize the parameters. Double-click on the Setup button to open the interactive setup window. For more information on the interactive setup, see Blob Finder Setup on page 272.

Input Parameters

01 = Source bank
Image bank containing the image to be processed by this tool.

02 = ROI definition step
The number of a previous program step where an arbitrarily shaped ROI has been generated. This may be a ROI rectangle, circle, union or even a blob analyzer step.

03 = Destination Bank
Image bank in which the found blobs are rendered if **Generate blob image** is `enabled`.

04 = Generate Blob Image
If `enabled`, generates a blob image in the destination bank. A blob image is an image where all blobs are white (high) and all other pixels are black (low). The image can be used as input to other program steps for any kind of processing. Note that the actual values of the pixels in the image have no meaning in terms of mm after blob binarization.

05 = Threshold Low (mm)
Sets the minimum height threshold limit. Pixels lower than this value are ignored.

06 = Threshold High (mm)
Sets the maximum height threshold limit. Pixels higher than this value are ignored.

07 = Threshold Mode
Choose to look for lowered objects, raised objects or to manually set the limits.

08 = Min Blob Area (pixels)
Lower area limits for a found blob. Smaller blobs are ignored.

09 = Max Blob Area (pixels)
Upper area limits for a found blob. Larger blobs are ignored.

10 = Timeout (ms)
Sets the maximum time the tool is searching for blobs. If this time limit is exceeded and the tool has not yet scanned the entire ROI for blobs, the result found so far will be returned. Note that the actual elapsed time will be somewhat longer than the timeout time since the Blob finder needs to perform some cleaning up operations before returning.

11 = Ignore Edge Blobs
If `enabled`, blobs on the edge of the ROI are ignored.
If `disabled`, edge blobs are included, but only the part of the blob inside the ROI is considered.

12 = Fill Holes in Blobs	If `enabled`, a blob is defined as all pixels inside its external perimeter. Internal holes are then considered part of the blob. If `disabled`, holes will be kept and the blob will only consist of pixels with original values in range.
13 = Sort By	Blobs can be sorted according to: - `Area` - `Horizontal position` (of centroid) - `Vertical position` (of centroid) - `Distance to sorting point` - `None` (unsorted) This option is used together with **Sorting order** to determine in which order to store the blobs. For example, if sorting the blobs by area in descending order, the largest blob is numbered 0, the second largest is number 1m etc. If you want to find only the largest blob you can thus sort by descending area and only analyze the first blob (with index 0).
14 = Sorting Order	Choose `Ascending` (smallest first) or `Descending` (largest first). Use in conjunction with **Sort by** to determine in which order to store the blobs.
15 = Sorting Point X	X position of sorting point. Only used when sorting by `Distance to sorting point` in the **Sort by** option.
16 = Sorting Point Y	Y position of sorting point. Only used when sorting by `Distance to sorting point` in the **Sort by** option.
17 = Table Index	Blob centroid and blob area can be stored in the table. Defines where in the table to start saving blobs.
18 = Max Blobs in Table	Maximum number of blobs to store in the table. All blobs are stored internally and can be accessed by the Blob analyzer tool even if no blobs are stored in the table. Note, however, if you use the interactive setup to configure your blob finder step, you will need to use the table to store blobs if you want to display the list of blobs beneath the preview window.

Returned Values

01 = Number of Found Blobs	The amount of blobs found.
02 = Low Threshold Used (mm)	The lower threshold used when looking for blobs.
03 = High Threshold Used (mm)	The upper threshold used when looking for blobs.

Blob Analyzer

This tool analyzes the blobs found by the ‘Blob Finder’ tool. The Blob analyzer analyzes one blob at a time and is typically used in a for loop. A range of different analysis methods can be used as described below.

Note: To use the Blob Analyser the step program must contain a ‘Blob Finder’ step, and a valid Blob Index number must be pointed out by the ‘Blob Finder’ step number and the Blob Index parameter.

It is recommended to use the interactive setup to customize the parameters. Double-click on the Setup button to open the interactive setup window. For more information on the interactive setup, see **Blob Analyzer Setup** on page **275**.

Input Parameters

01 = Blob Finder Step Number The step number of the used ‘Blob Finder’.

02 = Blob Index The number of the blob to analyze. Valid values are 0 to the number of found blobs -1 Note that the first blob has number 0.

03 = Destination Bank Image bank where the analysis results are visualized.

04 = Visualize Results If `enabled`, the results are visualized in the destination bank.
If `disabled`, the results are not visualized.

05 = Display Centroids Determines if the blob centroid is displayed (with a + sign) or not.

06 = Orientation Method The method to compute the blob orientation: `none`, `Area based` or `Boundary based`. See the **Compute bounding box** parameter for more information.

07 = Compute Bounding Box Determines if a bounding box is computed or not. If `Enabled`, the **Orientation Method** parameter determines how to orient the bounding box:
If the orientation method is `None`, only the XY-aligned bounding box is returned.
If the orientation method is `Area based` or `Boundary based`, a graphical representation of the bounding box is generated in the destination bank.

08 = Compute Diameters If `Enabled`, computes the maximum, the minimum and the average diameters for the found blobs. Currently no visualization (`Enabled + Visualized`) is available for diameters.

09 = Angular Resolution (degrees) An advanced feature which determines what resolution that will be used when computing the orientation in `Boundary based` mode The default value of `1` (degree) is a reasonable value for most applications. Increasing the value makes the analysis a bit faster at the cost of lower angular resolution.

10 = Compute Perimeter If `Enabled`, calculates the perimeter length of the blob in pixels. Select `Enabled + Visualized` to vizualize the result.

11 = Create Blob ROI Creates a ROI of the blob. The blob ROI can be referenced by other tools by giving the Blob Analyzer step number as ROI Definition step.

12 = Source Bank Only used when computing blob volume or height. Determines which image to use as input to the measurement.

13 = Surface Definition Step Only used when computing blob volume or height. Determines which surface definition step to use as reference in computing the volume or the height.

14 = Compute Volume If `enabled`, the blob volume (mm3) between the data in **Source Bank** and the surface in **Surface Definition Step** is computed. That is, the height difference between each blob pixel and the reference surface at that point is multiplied by the pixel area and accumulated to a volume.

15 = Compute Height If `enabled`, the blob height (mm) is computed. The blob height is the distance between the reference surface (from the **Surface Definition Step**) and the image data. The measurement uses the **Height Percentile** parameter to determine what pixel values to consider.

16 = Height Percentile (%) Determines what pixel values to be used when computing a blob height. If set to 95%, the top 5% of the pixels are removed. The height is then determined by finding the maximum deviation from the reference surface.

Returned Values

01 = Blob Area (pixels) The number of pixels in the blob.

02 = Left Edge of Blob The horizontal position of the leftmost pixel of the blob That is, the left edge of the blob in pixels along the X-axis.

03 = Top Edge of Blob The vertical position of the topmost pixel of the blob. That is, the top edge of the blob in pixels along the Y-axis.

04 = Blob Width (pixels) The total width of the blob, defined as the rightmost pixel - the leftmost pixel + 1.

05 = Blob Length (pixels) The total length of the blob, defined as the bottommost pixel - the topmost pixel + 1.

06 = Blob Centroid X The x-coordinate of the blob centroid (area-based mass centre).

07 = Blob Centroid Y The y-coordinate of the blob centroid (area-based mass centre).

08 = Blob Orientation (degrees) The orientation angle of the blob in degrees. `0` means that the blob is horizontally aligned. The angle increases counter clock-wise. The valid range is `0-180` degrees.

09 = Blob Ovality A measure of how oval (non-isotropic) a blob is. A perfect circle (or square) has the value `1` whereas a straight line has a very low value. Valid range is `0-1`.

10 = Max Diameter of Blob (pixels)
The largest diameter found in the blob, where diameter is defined as the distance between the two most distant points on a line through the blob centroid.

11 = Min Diameter of Blob (pixels)
The smallest diameter found in the blob.

12 = Average Diameter of Blob (pixels)
The average of the diameters found in the blob.

13 = Blob Perimeter Length (pixels)
The length of the external perimeter of the blob (in pixels). If the blob has internal holes, their perimeters are not considered as part of the perimeter.
`Note:` Perimeters are difficult to measure and are affected by a lot of factors. Make sure that the value returned by this measure is relevant to your application.

14 = Bounding Box Centre X
The horizontal position of the centre of a rotated bounding box. Rotated bounding boxes are obtained when enabling the **Compute Bounding Box** option and use an orientation mode different from `None`. Note that if you use orientation mode `None`, the bounding box will be defined by the left edge, the top edge, the width and the length of the blob.

15 = Bounding Box Centre Y
The vertical position of the centre of a rotated bounding box.

16 = Bounding Box Width (pixels)
The width of the bounding box (along the major axis of the blob).

17 = Bounding Box Length (pixels)
The length of the bounding box (along the minor axis of the blob).

18 = Blob Volume (mm3)
The volume between the reference surface and the image data in **Source Bank** inside the blob region.

19 = Blob Height above Surface (mm)
The maximum blob height above the reference surface after removing the 100 minus the height percentile % topmost pixels of the blob.

Co-Planarity

This tool calculates the angle between the normal vectors of two planes. It's typically used to see if two surfaces are co-planar (parallel) or not.

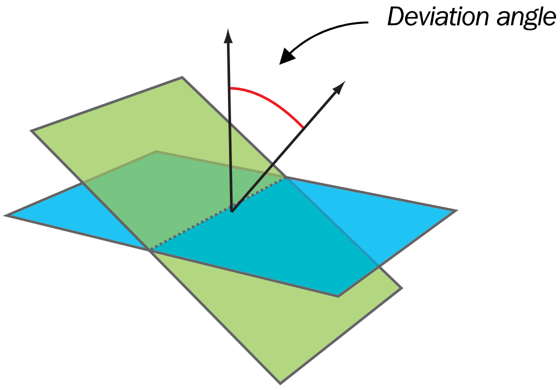


Figure – The deviation angle between two fitted planes.

Notes: The two planes are fitted to the data pointed out by the Source Bank 1 and 2, and the ROI definition Step 1 and 2.

Input Parameters

01 = Source Bank 1	Image bank containing the first image to be processed.
02 = ROI Definition Step 1	Previous program step defining the first ROI to be used by this tool.
03 = Source Bank 2	Image bank containing the second image to be processed.
04 = ROI Definition Step 2	Previous program step defining the second ROI to be used by this tool.
05 = Outlier Distance (mm)	The maximum distance between a point in the 3D image and the surface.

Returned Values

01 = Deviation Angle (degrees)	The angle between the two planes.

4.6 Matching

Shape Locator

The Shape Locator tool finds a reference shape in an image. The reference shape is created from a reference image and is then located (searched for by matching) in live images.

Matching shapes or parts of shapes is complicated and it is essential to have a good set of input parameters for this tool to compute a result in reasonable time. This tool has an interactive setup to help you create reference shapes and fine tune input parameters so that the locating algorithm will work as fast and efficient as possible. For more information on the interactive setup, see Shape Locator Interactive Setup on page 251.

The section **Locating Shapes (tips and** tricks) on page 256 describes the algorithm used when searching for shapes, and the section **Examples on workflows** on page 258 shows some examples on how to use the suite of tools together in an efficient way.

The tool will return information about the first shape (according to the selected sorting order). If a table index is specified, information about all found shapes is stored in the table beginning at the specified index. For each shape, five entries are written in the table: x position of the reference point, y position of the reference point, rotation angle, scale and finally score of the located shape.

The coordinates of the reference point are given in pixels in the destination image. The rotation and scale are given relative to the reference image.

Reference shapes can also be created in runtime using the ‘Add Shape Runtime’ tool.

The supplementary tools Get Shape on page 136, Transform Image on page 137 and Transform ROI on page 139 can be used to traverse the list of found shapes.

Input Parameters

01 = Source bank The image bank where to search for matching shapes.

02 = Data block The slot in the memory where the reference shape is stored.

03 = Search full image Controls if the whole image shall be used to search for the shape, or if the ROI parameters shall be used to limit the search area.

04 = ROI X coordinate The x coordinate of the upper left corner of the region to search for matching shapes.

05 = ROI Y coordinate The y coordinate of the upper left corner of the region to search for matching shapes.

06 = ROI width The width of the region to search.

07 = ROI height The height of the region to search.

08 = Allow scale Search for shapes with another scale compared to the reference shape. Shapes with a scale variation of ±20% can be found.

09 = Allow rotation Search for shapes with another rotation angle compared to the reference shape.

10 = Rotation tolerance (degrees) The greatest angle the search for a match should be performed for.
Example: 180 means ±180 degrees, i.e. full rotation.

11 = Max number of The maximum number of shapes that the tool shall search

shapes	for in the live image. The shapes with the highest score are selected if there are more shapes in the image. Maximum value is 32.
12 = Min score	The tool will only return shapes with a score above or equal to this value.
13 = Overlap distance (pixels)	Threshold in pixels determining when two close matches shall be considered to belong to the same shape. A higher value will in many cases help to reduce the execution time.
14 = Sort by	Defines how the returned shapes shall be sorted. The default sort order is with the highest score first in descending order.
15 = Sort order	Defines if the sort order shall be ascending or descending.
16 = Table index	The start position for result output to the table. The value -1 indicates that no values shall be written to the table.
17 = Timeout (ms)	Sets the maximum time the tool is searching for shapes. If this time limit is exceeded, the result found so far will be returned. The status code will indicate if the tool has exceeded the timeout. A value of -1 will let the algorithm run to completion without any timeout limitation.
18 = Visualization	Type of result visualization in the destination bank; No visualization, First shape (according to specified sorting order), All shapes.
19 = Destination bank	The image bank where matched shapes are visualized. The value -1 indicates that no visualization is performed. This will help to reduce the execution time.
20 = Sorting point X	The x coordinate of the sorting point. This value is only used when the **Sort by** parameter is set to **Sorting Point**.
21 = Sorting point Y	The y coordinate of the sorting point. This value is only used when the **Sort by** parameter is set to **Sorting Point**.

Returned Values

01 = Search status	The status of the execution of the shape locator.
02 = Number of shapes	The total number of found shapes of satisfactory similarity to the reference shape.
03 = Ref. point X coordinate	The x coordinate of the point that corresponds to the reference point in the reference shape.
04 = Ref. point Y coordinate	The y coordinate of the point that corresponds to the reference point in the reference shape.
05 = Angle (degrees)	The angle of the found shape in the coordinate system defined in the reference image.
06 = Scale	The scale of the found shape compared to the scale of the shape defined in the reference image.
07 = Score	A measure of the resemblance of the shape found and the reference shape. The score has an interval of 0 through 100, but it does not represent the similarity in percent.

Note: The results 3 through 7 refer to the first located shape according to the specified sorting order.

SEARCH STATUS

0	All OK
8823	No shape found.
8824	Failure when writing results to the table.
8825	The reference point of one or more shapes is located outside the image.
8828	Failure when visualizing results.
8833	Search aborted due to timeout. The resulting shape may be less accurate.

ERROR CODES

7704	The ROI is partly or completely outside the image.
8828	Error in visualization of the located shape(-s)

Add Shape Runtime

When creating reference objects in runtime, i.e. during the execution of the step program, the Add Shape Runtime tool is used. The tool defines a reference shape that can later be compared to other shapes with the 'Shape Locator' tool. The ‘Add Shape Runtime’ tool has no interactive setup and it is intended to be used for on-line teaching. The interactive setup of the 'Shape Locator' tool contains the same functionality as the ‘Add Shape Runtime’ tool and has a user interface used to manually create reference shapes. For details on parameters and optimization of the algorithm, please refer to Add/Edit Shape Interactive Setup on page 254.

Input Parameters

01 = Source bank The image bank holding an image of the reference shape.

02 = ROI definition step An arbitrary shaped Teach ROI from a previous program step.

03 = Data block The number of the slot in the memory (RAM) where information of the reference shape will be stored temporarily.

04 = Edge strength The edge strength is the image contrast needed for defining shape edges. A higher value gives fewer edges in the shape. Valid range 0-100

05 = Robustness vs. Speed This setting controls the tradeoff between execution time and robustness when running the Shape Locator tool. A high value prioritizes a short execution time. Valid range 0-4

06 = Accuracy vs. Speed This setting controls the tradeoff between execution time and the accuracy with which the shape is located when running the Shape Locator tool. A high value prioritizes a short execution time. Valid range 0-4

07 = Ref. point X coordinate The x coordinate of the reference point.

08 = Ref. point Y coordinate The y coordinate of the reference point.

09 = Destination bank The image bank where a visualization of the edges of the reference shape shall be made. If set to -1 no visualization will be made.

ERROR CODES

7704 The ROI is partly or completely outside the image.

8800 Initialization of the shape locating algorithm failed.

8838 The ROI Perimeter must have the parameter **Filling** set to **0=Internal**. Otherwise, the ROI will only contain the pixels on the circumference of the perimeter.

Get Shape

The Get Shape tool is used together with the Shape Locator tool to retrieve information about a located shape.

The tool refers to a previous Shape Locator step and the zero-based index of a located shape. It is possible to visualize the position of the specified shape if a destination bank is specified. Note that only the green edges of the shape are drawn in the destination bank. The actual live image must be copied separately to the image bank before calling this tool.

Input Parameters

01 = Shape locator step The Shape Locator step that was used to find shapes.

02 = Shape index The zero-based index of the shape to retrieve information about.

03 = Visualization Determines how the result shall be visualized in the destination bank.

04 = Destination bank The image bank where the result shall be visualized. Set to -1 if no visualization is used.

Returned Values

01 = Status code The status of the execution of the 'Shape Locator' step.

02 = Ref. point X coordinate The x coordinate of the point that corresponds to the reference point in the reference shape.

03 = Ref. point Y coordinate The y coordinate of the point that corresponds to the reference point in the reference shape.

04 = Angle (degrees) The angle of the found shape in the coordinate system defined in the reference image.

05 = Scale The scale of the found shape compared to the scale of the shape defined in the reference image.

06 = Score A measure of the resemblance of the shape found and the reference shape. The score has an interval of 0 through 100, but it does not represent the similarity in percent.

SEARCH STATUS

The result Search status can have one of the following values

0 All OK

8825 The reference point of the shape is located outside the image.

ERROR CODES

8810 The referenced step is not a Shape Locator step.

8812 The index of the shape is not valid, e.g. larger than the number of located shapes.

8813 No results found from the Shape Locator tool. This can happen if the execution of the Shape Locator tool failed for some reason.

8833 Timeout in the shape locating algorithm

Transform Image

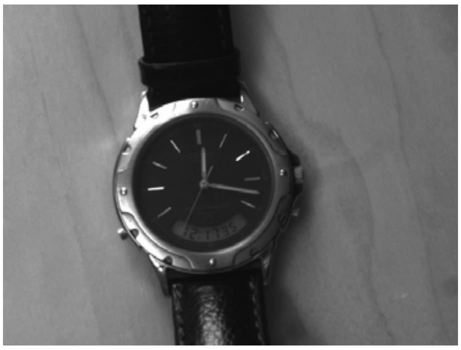
The Transform Image tool is used together with the Shape Locator tool. This tool transforms the image from the source bank so that the located shape is moved to the same position as the reference shape had in the reference image. It is possible to specify a ROI so that only the interesting part of the image is transformed.

This functionality can be useful in applications where the inspections must be made in the same position and rotation as in the reference image, for instance when using tools that only handle non-rotated rectangle ROI:s. The tool is also useful when presenting results to an operator.

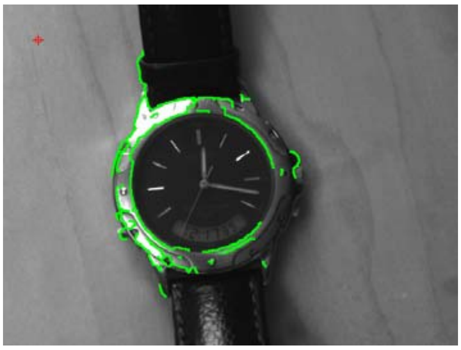
However, it must be stressed that the transformation of the live image will affect the information in the image, and that exact measurements cannot be performed on the transformed image.

The parameter Interpolation method controls how the pixel values are calculated in the destination image. It is possible to choose between bilinear interpolation (gives higher image quality) or nearest neighbor (gives faster execution time).

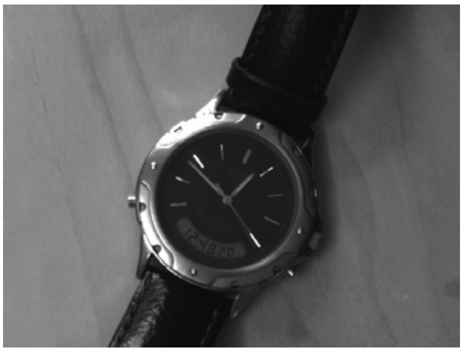
The images below show an example where the upper image is used as a reference to specify the shape of the clock. The lower images show the live image (to the left), and the transformed live image. The shape of the clock in the transformed image is placed in the same position as in the reference image.



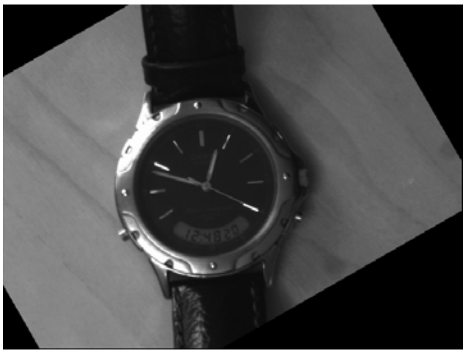
Reference image



Reference shape visualized.



Live image



Transformed Live image

The ROI specifies what part of the live image that shall be visible in the transformed image. Pixels outside the ROI will be black in the transformed image.

Input Parameters

01 = Source bank	The image bank where the live image is stored.

02 = ROI definition step	A ROI that limits the part of the live image to transform.
03 = Shape locator step	The Shape Locator step that was used to find shapes.
04 = Shape index	The zero-based index of the shape to retrieve information about.
05 = Interpolation method	The interpolation method to use when calculating the pixel values in the destination image.
06 = Destination bank	The image bank where the result shall be visualized. Set to -1 if no visualization is used.

Returned Values

01 = Search status	The status of the execution of the 'Shape Locator' step.

SEARCH STATUS

The result Search status can have one of the following values

0	All OK
8825	The reference point of the shape is located outside the image.

ERROR CODES

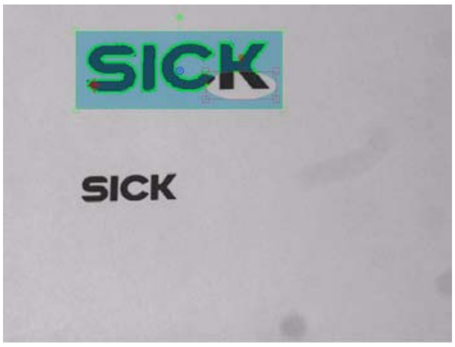
8810	The referenced step is not a Shape Locator step.
8812	The index of the shape is not valid, e.g. larger than the number of located shapes.
8813	No results found from the Shape Locator tool. This can happen if the execution of the Shape Locator tool failed for some reason.
8833	Timeout in the shape locating algorithm

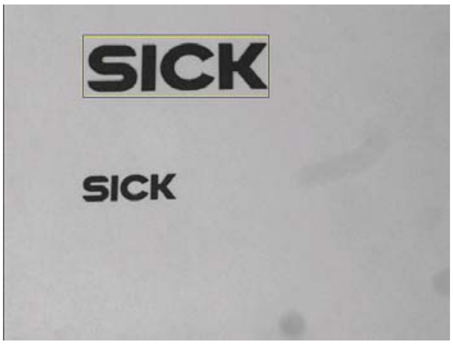
Transform ROI

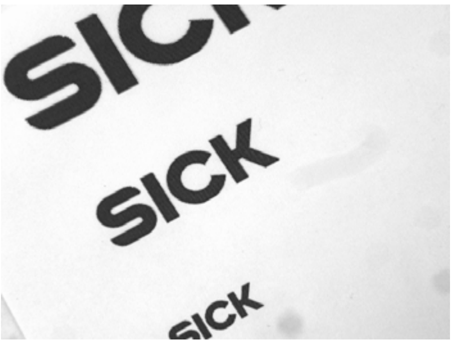
The Transform ROI tool is used together with the Shape Locator tool. This tool moves and rotates a ROI so that it is placed relative to the located shape as it was in the reference image.

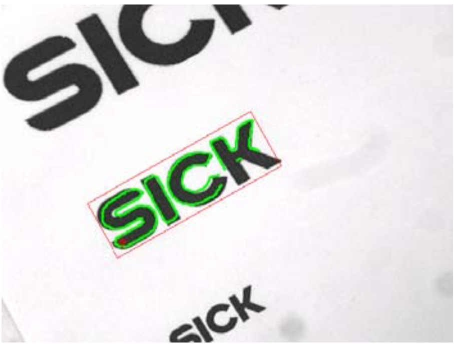
This functionality is useful when exact measurements must be performed relative to the located shape. The transformed ROI will be moved, rotated, and possibly scaled to the position of the located shape.

The tool refers to a previous Shape Locator step and the zero-based index of a located shape. The tool itself can be referred to as a ROI for all tools that can handle arbitrary shaped ROI:s.


Reference image


Position of ROI in reference image


Live image


ROI transformed to the position of a located shape.

Input Parameters

01 = ROI definition step The step where an arbitrary shaped ROI was created.

02 = Shape locator step The Shape Locator step that was used to find shapes.

03 = Shape index The zero-based index of the shape to retrieve information about.

Returned Values

01 = Search status	The status of the execution of the 'Shape Locator' step.

SEARCH STATUS

The result Search status can have one of the following values

0	All OK
8825	The reference point of the shape is located outside the image.

ERROR CODES

8810	The referenced step is not a Shape Locator step.
8812	The index of the shape is not valid, e.g. larger than the number of located shapes.
8813	No results found from the Shape Locator tool. This can happen if the execution of the Shape Locator tool failed for some reason.
8833	Timeout in the shape locating algorithm

Teach Rotation

This tool is used to learn the features of an object in order to calculate its rotation in relation to the learnt position. The calculation of rotation is based on a comparison between the patterns along concentric circles centered in the rotation point. Two different sized circles over the object to be learned are compared to the circles over the matching object. The first of the circles is used for the measurement itself unless there is a symmetry problem in which case the other one is used.

Input Parameters

01 = Source bank The image bank with the object you want to teach the device.

02 = X centre X coordinate of the concentric circles that hold the height information about the object. This should be also be the x coordinate of the center of rotation.

03 = Y centre Y coordinate of the concentric circles that hold the height information about the object. This should be also be the y coordinate of the center of rotation.

04 = Radius A The radius of the outer most circle.

05 = Radius B The radius of the inner most circle.

06 = Destination bank The image bank with your resulting teach object.

Returned Values

None

Match Rotation

Match shape is a tool designed to find the rotation of a previously learnt object in a region of interest. Simply set the parameters in the same fashion as in the 'Teach Rotation' tool and specify where in the step program that step is located with the **Rotation definition step** parameter.

Input Parameters

01 = Source bank The image bank with the object you want to match with your teach object.

02 =Rotation definition step The step in your program which you have defined your reference object.

03 = X center The x coordinate of the center of rotation.

04 = Y center The y coordinate of the center of rotation.

05 = Destination bank The image bank where the result of the matching will end up.

Returned Values

01 = Angle The resulting angle of the object in reference to the object of your teach object.

02 = Similarity (%) A measurement of the resemblance of the height information along the circles used.

Teach Pattern

The Pattern tools are used to locate and inspect patterns, for example labels, keypads and fiducial marks.

The functionality is divided into two parts:

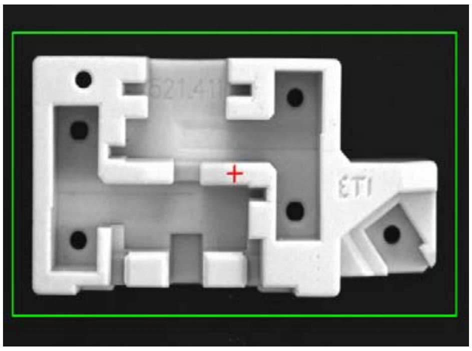
1. The Teach Pattern tool teaches the camera a pattern in a reference image.
2. The Inspect Pattern tool locates and inspects the pattern in a live image.

This page describes the specifics for the Teach Pattern tool. For a general introduction and detailed explanation of the Pattern functionality and its use, see the Inspect Pattern tool description on page 145.

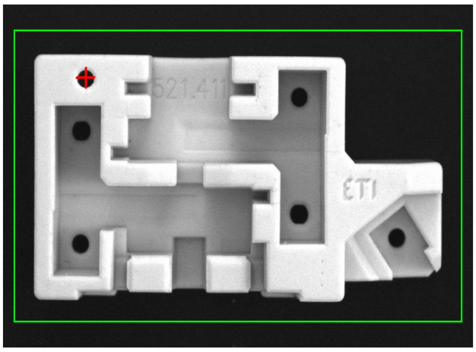
A ROI (Region of Interest) determines the area in which to teach the pattern. When the tool executes, the taught pattern is stored in a data block in the camera's working memory. This data block will be used by the Inspect Pattern tool.

The tools Save Data Block to Flash and Load Data Block from Flash, see pages 197 and 196, can be used to store and retrieve the taught pattern in a stand-alone application.

Each pattern has a reference point that defines the position of the pattern. The default position is the centroid of the ROI, but it can be set to any position in the reference image.



Default, centroid position of the reference point (red cross).



The reference point can be moved, for example to a key feature on the object.

When the Inspect Pattern step refers to a Shape Locator step, the expected position of the reference point will move with the located object's pose.

The reference point is not visualized, but it can be done with drawing tools right after the Teach step if needed. To find suitable coordinates manually, double-click the preview bank, and then hover with the mouse pointer to find the coordinate of the desired feature point.

Input Parameters

01 = Source Bank The image bank that contains the reference pattern to be taught.

02 = ROI Definition Step The reference to the region of interest that defines which part of the source bank shall be taught.

03 = Data Block The data block number in the working memory, where the reference pattern shall be stored.

04 = Ref. Point X Coordinate The X coordinate of the pattern's reference point.

05 = Ref. Point Y Coordinate The Y coordinate of the pattern's reference point.

Returned Values

None.

ERROR CODES

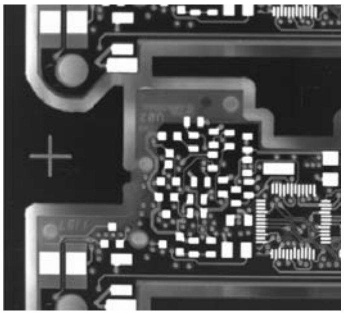
7300	Memory allocation problem
8835	Error in internal ROI handling
8838	ROI type error, please use ROI perimeter with filling “0 – Internal”
9010	General error for pattern inspection algorithm

Inspect Pattern

The Pattern tools are used to locate and inspect patterns, for example labels, keypads and fiducial marks:

Label inspection.

Keypad inspection.

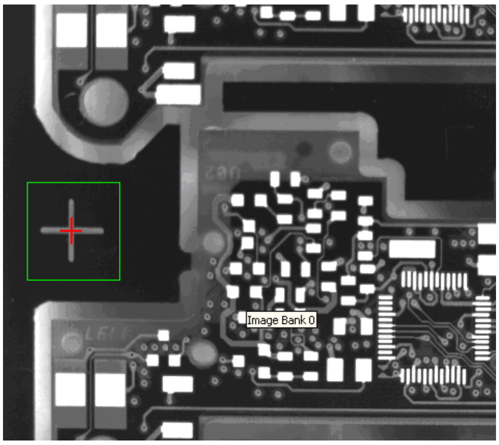


Fiducial mark positioning.

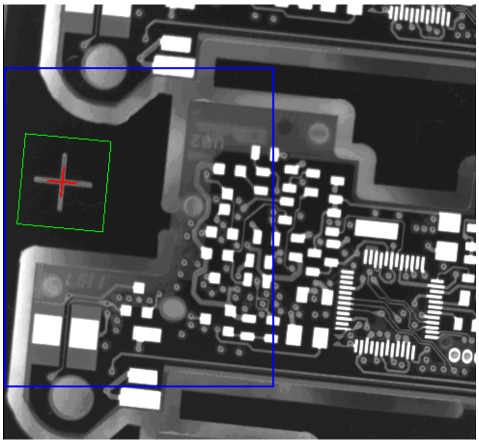
The functionality is divided into two parts:

1. The Teach Pattern tool teaches the camera a pattern in a reference image.
2. The Inspect Pattern tool locates and inspects the pattern in live images.

The pattern is searched for inside a search rectangle. The main results of the Inspect Pattern tool are the found pattern's position, angle and score. The reported coordinates are the position of the pattern's reference point. For an explanation of the reference point, see the Teach Pattern tool description on page 143.



The pattern is defined by its teach ROI in the reference image.



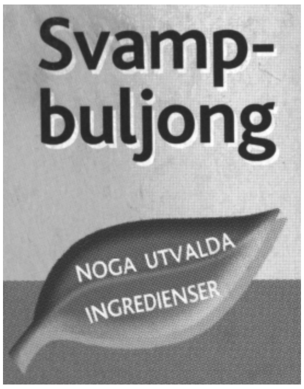
In run mode, the pattern (green) is found inside the search rectangle (blue).

Large pattern defects can either be found by setting the score threshold high, so that defective patterns won't be found, or by applying a pass/fail criterion to the score result.

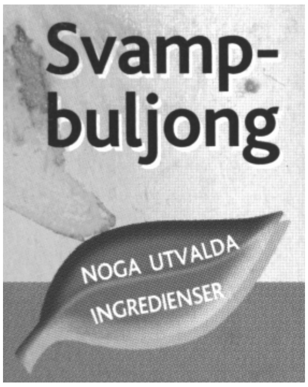
Small defects can only be identified robustly by the score parameter if the pattern ROI is small. For finding small defects in larger patterns, the difference image concept should be used.

Difference Image

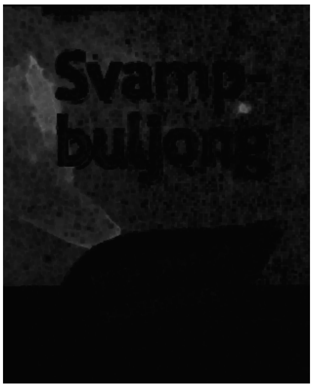
The tool has an optional visualization output called difference image, which is useful to find defects that are too small to affect the score. They are found by post-processing of the difference image, for example using Detail Extraction, Blob Finder or pixel counting.



Reference label.



Label with defect.



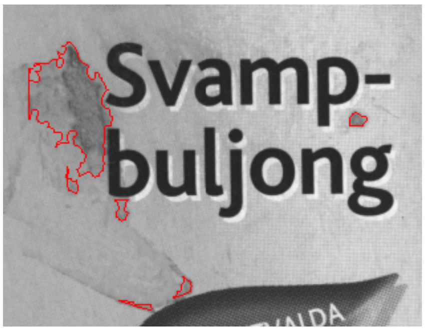
Difference image.

There are four options for the difference image:

1. **Diff**
   The absolute value of the intensity difference in each pixel. This option is preferable if the pattern's mean intensity is part of the inspection purpose.
2. **Normalized diff**
   Like the Diff mode, but compensated for changes in mean intensity and contrast. This option is preferable if uniform contrast variations shall be disregarded. (It is not effective to remove local illumination changes in the image.)
3. **Diff with edge suppression**
   Like the Diff mode, but less sensitive to edge artifacts from the pattern.
4. **Normalized diff with edge suppression**
   Like the Normalized diff mode, but less sensitive to edge artifacts from the pattern.

To high-light small defects on a pattern visually, for example in an HMI or demo, the following steps can be used:

1. Enable the parameter Create Pattern ROI
2. Generate the difference image with option Normalized diff with edge suppression
3. Locate the defects in the difference image by using Blob Finder. Optionally, preprocess further with Erode and/or Stretch Gray
4. FOR each blob/defect, use the Blob Analyzer to create a blob ROI
5. Inside the FOR loop, draw the blob ROI by using Draw ROI



High-lighted defects for HMI display or demo purposes.

An advanced use of the difference image is to enhance features by suppressing background print, for example increasing robustness of a barcode application.

Referencing to a Shape Locator Pose

When inspecting several small patterns on a large object, for example keys on a keypad, use the Shape Locator first and refer to it by the “Shape Locator step” parameter. This way, small defects can be found, according to the rule of thumb: “Search big, inspect small”.

In this mode:

- The Inspect Pattern search rectangle will automatically move with the Shape Locator pose and resize according to its scale.
- The position and angle of the found pattern relative to the Shape Locator pose will be reported as “Delta X”, “Delta Y” and “Delta angle”. These results are useful for example to determine that a pattern has the correct position on an object, rather than in the image.

Technical Comparison with Shape Locator

The Pattern tools are based on a normalized cross-correlation (NCC) method, which is very robust to variable contrast and ambient light conditions. The method is suitable for finding any type of pattern and it allows inspection of small defects. It performs best at small rotation tolerances, although full rotational search is supported at the cost of processing time.

The Shape Locator tools are based on a geometric pattern matching method, which is the best choice for locating large patterns (objects) in any rotation. This method is more tolerant to occlusion, noise and clutter than the normalized cross-correlation.

The following table provides a selection guide by describing several key aspects of the different algorithms:

	Pattern	**Shape Locator**
Information used in search	Intensity in all pixels	Edges
Soft edges tolerance	Very good	Limited
Poor contrast tolerance	Very good	Limited
Ambient light robustness	Very good	Good
Occlusion tolerance	Limited	Very good
Noise and clutter tolerance	Good	Very good
Distortion sensitivity	Locate pattern: Medium Difference image: High	Medium
Scale tolerance	• 20% with affect on the score • 20% without affecting the score when referring to a Shape Locator	• 20%
Processing time	Some variation	Constant
Accuracy* (mean error)	Sub-pixel (~0.05 pix) Sub-degree (~0.1 deg)	Sub-pixel (~0.1 pix) Sub-degree (~0.1 deg)
Multiple patterns/objects	No	Yes
Large search rectangle	Slow	Fast
Full rotation search	Slow	Fast
Difference image	Yes	No

* Accuracy testing procedure: Simple (Pac-Man) shape of radius 50 pixels as reference pattern. Search rectangle size 400x400 pixels. Pose measurement on 100 images, where the reference pattern has been synthetically moved and rotated to known poses. 3x3 smooth filter as pre-processing. Robustness parameter set to robust (Pattern). Accuracy parameter set to high (Shape Locator). No image distortion or noise added.

Optimizing Robustness and Speed

The parameter settings have a large impact on the tool's processing time.

The concept of image pyramids (down-sampling) is used to speed up the initial, coarse search for the pattern. The number of pyramid levels (max 8) is chosen automatically by the algorithm, based on a combination of the Robustness vs. Speed parameter and the pattern ROI size. The refined, final search is typically performed on the original image.

Rules-of-thumb:

- Small patterns (relative to search rectangle) make the tool very slow in the robust mode. Try to reduce the search rectangle size and use the normal mode
- Large patterns (relative to search rectangle) with solid features are well-suited for the fast search mode
- Patterns that consist of fine details or lines, i.e. lack solid features, require the robust mode, otherwise the characteristic details may get lost in the down-sampling
- To optimize speed, only use the rotation tolerance interval that the application requires. If the pattern is expected at different fixed angles, for example around 0 • 5 and 180 • 5 , it is faster and more robust to use the tool twice (once for each interval) than to search • 180

The Robustness vs. Speed parameter has some effect on the accuracy of the pattern pose, where the robust and normal modes are twice as accurate as the fast mode.

Input Parameters

01 = Source Bank	The image bank where to search for the pattern.
02 = Data Block	The data block number in the working memory, where the reference pattern is stored.
03 = Shape Locator Step	Reference to a Shape Locator step, to enable automatic pose adjustment of the search rectangle. The default value -2 means that no Shape Locator pose is used.
04 = Shape Index	A number that specifies which of the Shape Locator's found shapes to refer to. The default value 0 means the first shape found by the Shape Locator.
05 = ROI X Coordinate	The x coordinate of the search rectangle's left edge.
06 = ROI Y Coordinate	The y coordinate of the search rectangle's top edge.
07 = ROI Width	The width of the search rectangle.
08 = ROI Height	The height of the search rectangle.
09 = Rotation Tolerance (degrees)	The greatest angle the search for a match should be performed for. The value is symmetric, so that for example the value 180 means ±180 degrees, i.e. full rotation.
10 = Rotation Offset (degrees)	Expected angle offset of the pattern in the live image compared to the reference pattern. For example, if the offset is 45 and the tolerance is 5, the pattern will be searched for in the interval from 40 to 50 degrees.
11 = Min Score	The minimum score in % that will result in a match. If the best match is below the threshold, the pose and score will still be returned, but the status flag and visualization will indicate that no valid match was found.
12 = Robustness vs. Speed	The trade-off between robustness and speed: Robust, Normal and Fast.
13 = Create Pattern ROI	If enabled (true), the found pattern will generate a ROI in

the found position. Other steps can then refer to the Inspect Pattern step as a ROI definition step.

14 = Visualization
Defines how the result shall be visualized in the preview and destination banks:
0 = Off
1 = ROI perimeter
2 = Diff (absolute diff image)
3 = Normalized diff (normalized absolute diff image)
4 = Diff with edge suppression (removes thin edges of 1 pixel width)
5 = Normalized diff with edge suppression

15 = Destination Bank
Image bank in which the visualization is drawn.

Returned Values

01 = Search Status
The status of the execution of the tool, see explanation list below.

02 = Ref. Point X Coordinate
The X coordinate of the found pattern's reference point.

03 = Ref. Point Y Coordinate
The Y coordinate of the found pattern's reference point.

04 = Angle
The angle of the found pattern relative to the reference image, which is defined as 0 .

04 = Delta X
Not using Shape Locator:
The pattern's X movement relative to the reference image.
Using Shape Locator:
The pattern's X movement relative to the reference image, adjusted for the Shape Locator pose.

05 = Delta Y
Not using Shape Locator:
The pattern's Y movement relative to the reference image.
Using Shape Locator:
The pattern's Y movement relative to the reference image, adjusted for the Shape Locator pose.

06 = Delta Angle (degrees)
Not using Shape Locator:
The pattern's angle relative to the reference image.
Using Shape Locator:
The pattern's angle relative to the reference image, adjusted for the Shape Locator pose.

07 = Score
The similarity between the found pattern and the reference pattern in %.

SEARCH STATUS

0	Pattern found
8980	Pattern found, but partly outside the image bank borders
8981	No matching pattern is found
9015	A pattern is found, but the score is below threshold

ERROR CODES

7300	Memory allocation problem
8983	Packing datablock failed
8984	Unpacking datablock failed
8985	No usable result from the Shape Locator step, please re-run the Shape Locator step
8986	Shape index is too high, the Shape Locator step does not contain enough Number of Shapes
8994	Referenced step is of wrong type, please use a Shape Locator as reference or use -1 for no reference
8995	General visualization error, please change visualization type
8997	No ROI data in the referenced step, please re-run the step or change the reference
8998	Cannot use filled ROI as input, please use a ROI perimeter
8999	General error for pattern inspection datablock, please re-teach a pattern
9010	General error for pattern inspection algorithm
9012	There is no reference pattern stored in the datablock, please re-teach a pattern
9013	The reference pattern is not configured correctly, please re-teach a pattern
9014	Could not allocate memory when generating ROI

4.7 Circular

External Perimeter

This tool traces the external contour of an object and is similar to the tool 'Internal Perimeter'. Return values are the center of gravity coordinates of the area inside the contour. First this tool scans the height values along a user defined line to find a point on the external contour of the object. Beginning at the starting point of the line the first change in height values that is greater than a defined threshold is indicated as a point on contour. Note that the line must be drawn from left to right to achieve correct results. The tool then traces pixels with the required change of height value starting at the point on the contour. To make the algorithm more robust it is necessary to define a range of heights with an upper and lower threshold.

Recommend steps to set up the input parameters:

1. Double-click the input field for **Relative threshold** and double-click the appearing button. This opens an interactive window. Set the line in the image with the left mouse button. Remember that the line must be drawn from left to right. Modify the **Relative threshold** with the slider on the left side until a point on the contour is found. This point is marked with a cross. Close this window.
2. Double-click the input field for **Min height** or **Max height** threshold and double-click the appearing button. This opens an interactive window. Modify the lower and upper threshold with the slider on the left side until the external contour of the object is traced completely. Control the traced contour in the image and make sure that the traced contour is robust against small variations of the upper and lower thresholds.

The results of this tool can be used for the following tools:

- Circular perimeter ROI
- Circular analysis
- Check circular shape

Input Parameters

01 = Source bank	Image bank containing the image to be processed.
02 = Start point X	X coordinate for start point of line.
03 = Start point Y	Y coordinate for start point of line.
04 = End point X	X coordinate for end point of line.
05 = End point Y	Y coordinate for end point of line.
06 = Relative threshold (mm)	Required absolute change of height value to find contour points.
07 = Min height (mm)	Minimum height value of pixels along the contour.
08 = Max height (mm)	Maximum height value of pixels along the contour.
09 = Angular interval	Resolution for re-sampling the contour in degrees.
10 = Destination bank	Image bank in which to show the image with colored contour and calculated centroid of the external area.

Returned Values

01 = Error flag	Flag = 0 external perimeter found Flag = -1 no external perimeter found
02 = X center	X coordinate of calculated center of gravity. If no external perimeter was found X center = 0.
03 = Y center	Y coordinate of calculated center of gravity. If no external perimeter was found Y center = 0.

Example

The following example is for IVC-2D, but the principle is the same when using IVC-3D. The only difference is that the threshold is a height value in millimeters instead of gray level value.

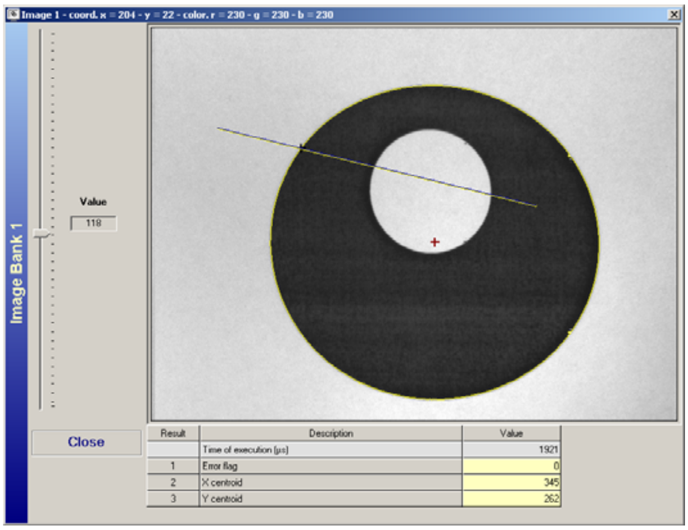


Image 1 - coord. x = 204 - y = 22 - color. r = 230 - g = 230 - b = 230
Image Bank 1
Close

Value 118

Result	Description	Value
	Time of execution [µs]	1921
1	Error flag	0
2	X centroid	345
3	Y centroid	262

Figure – Example of a successfully found external contour. Displayed is the line to find a contour point (yellow line), the found contour (yellow circle) and the center of mass (red cross).

Internal Perimeter

This tool traces the internal contour of an object and is similar to the tool 'External Perimeter'. Return values are the center of gravity coordinates of the area inside the contour. The operation can be described as follows: First, the tool scans the height values along a user defined line to find a point on the internal contour of the object. Beginning at the starting point of the line the first change in height values that is greater than a defined threshold is indicated as a point on the contour. Note that the line must be drawn from left to right to achieve correct results. Then the tool traces pixels with the required change of height value starting at the found point on the contour. To make the algorithm more robust it is necessary to define a range of heights with an upper and lower threshold.

Recommend steps to set up the input parameters:

1. Double-click the input field for **Relative threshold** and double-click the appearing button. This opens an interactive window. Set the line in the image with the left mouse button. Remember that the line must be drawn from left to right. Modify the **Relative threshold** with the slider on the left side until a point on the contour is found. This point is marked with a cross. Close the window.
2. Double-click the input field for **Min height** or **Max height** threshold and double-click the appearing button. This opens an interactive window. Modify the lower and upper threshold with the slider on the left side until the internal contour of the object is traced completely. Control the traced contour in the image and make sure that the traced contour is robust against small variations of the upper and lower thresholds.

The results of this tool can be used for the following tools:

- Circular perimeter ROI
- Circular analysis
- Check circular shape

Input Parameters

01 = Source bank	Image bank containing the image to be processed.
02 = Start point X	X coordinate for start point of line.
03 = Start point Y	Y coordinate for start point of line.
04 = End point X	X coordinate for end point of line.
05 = Endpoint Y	Y coordinate for end point of line.
06 = Relative threshold (mm)	Required absolute change of height value to find contour points.
07 = Min height (mm)	Minimum height value of pixels along the contour.
08 = Max height (mm)	Maximum height value of pixels along the contour.
09 = Angular interval	Resolution for re-sampling the contour in degrees.
10 = Destination bank	Image bank in which to show the image with colored contour and calculated centroid of the internal area.

Returned Values

01 = Error flag	Flag = 0 internal perimeter found Flag = -1no internal perimeter found
02 = X center	X coordinate of the calculated center of gravity. If no internal perimeter was found X center = 0.
03 = Y center	Y coordinate of the calculated center of gravity. If no internal perimeter was found Y center = 0.

Example

The following example is for IVC-2D, but the principle is the same when using IVC-3D. The only difference is that the threshold is a height value in millimeters instead of gray level value.

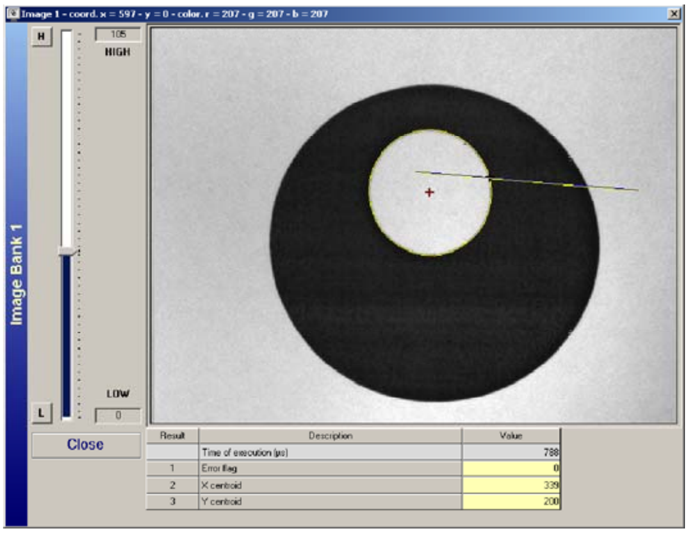


Image 1 - coord. x = 597 - y = 0 - color. r = 207 - g = 207 - b = 207

Result	Description	Value
	Time of execution (µs)	788
1	Error flag	0
2	X centroid	339
3	Y centroid	200

Figure – Example of a successfully found internal contour. Displayed is the line to find a contour point (yellow line), the found contour (yellow circle) and the center of gravity (red cross).

Circular Perimeter ROI

This tool generates a ROI with the shape of a processed external contour. Additionally it is possible to cut out up to three different internal contours. This tool must have the result of a previously performed ‘External perimeter’ tool to define the external shape of the ROI. To cut out an internal contour from the ROI it is necessary to execute the tool ‘Internal Perimeter’ in a previous program step.

Input Parameters

01 = External perimeter step	Refer to step number which executes the ‘External perimeter‘.tool
02 = Internal perimeter step A	Refer to step number which executes the ‘Internal perimeter‘tool to perform the first cut out.
03 = Internal perimeter step B	Refer to step number which executes the ‘Internal perimeter‘tool to perform the second cut out.
04 = Internal perimeter step C	Refer to step number which executes the ‘Internal perimeter‘tool to perform the third cut out.
05 = Destination bank	Image bank in which to display the resulting ROI.

Returned Values

01 = Error flag	flag = 0	tool terminated correctly.
	flag = -1	an error occurred.

Example

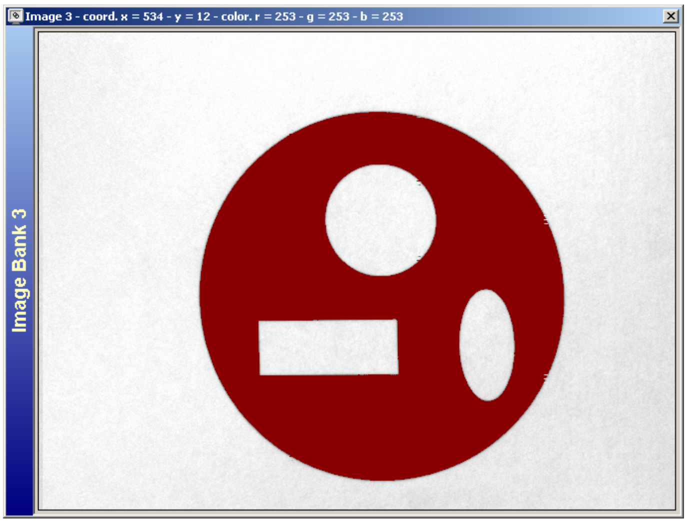


Image 3 - coord. x = 534 - y = 12 - color. r = 253 - g = 253 - b = 253
Image Bank 3

Figure – Example of a ROI generated by an external contour with cut outs of three different internal contours.

Circular Analysis

This tool provides several measurements of circularly shaped contours. It is possible to perform the measurement for one external and one internal contour at the same time or for one external contour only. This tool needs the results of an 'External perimeter' tool and /or an 'Internal perimeter'. tool

Input Parameters

01 = External perimeter step	Refer to program step number which executes the 'External perimeter'.tool
02 = Internal perimeter step	Refer to program step number which executes the 'Internal perimeter' tool. Type 0 to use 'Circular analysis' for measurements of an external perimeter only.
03 = Angular interval	Angular resolution of the measurements. Range: 1 – 90 in units of 0.5 . Note that a high resolution increases the processing time considerably.
04 = Destination bank	Image bank in which to show the results.

Returned Values

01 = Error flag	flag = 0 tool terminated correctly.
	flag = -1 an error occurred.

02 = Mean external diameter	Averaged external diameter.
03 = Max external diameter	Maximum found external diameter.
04 = Min external diameter	Minimum found external diameter.
05 = Mean internal perimeter	Averaged internal diameter.
06 = Max internal perimeter	Maximum found internal diameter.
07 = Min internal perimeter	Minimum found internal diameter.
08 = Ovalization	Performed for external perimeter only. Ratio between minimum external perimeter and maximum external perimeter. Perfect circle will yield 1.
09 = Concentricity	Distance between external and internal center of gravity in pixels.
10 = Mean difference radius	Distance between internal and external contour.

Check Circular Surface

This tool performs a homogeneity check of height values inside a circularly shaped ROI. The tool works similarly to 'Count Deviating Points' in the Measure category. It is possible to select the height values of pixels that should be considered for the homogeneity check. Only pixels with height values between an upper and a lower threshold are evaluated.

The ROI must be generated by the 'Circular Perimeter ROI' tool. Note that only ROIs generated by this tool can be used.

Double-click on the input field for **Sensitivity** and double-click again on the appearing button. This opens an interactive window. Set the minimum required difference in height values to detect a pixel as surface defect. Control the results in the image.

Double-click on the input fields for **Min height**/**Max height** and double-click again on the appearing button. This opens an interactive window. Set region of allowed height values. Control the results in the image.

Input Parameters

01 = Source bank	Image bank containing the image to be processed.
02 = Perimeter ROI definition step	Refer to step number which executes the 'Circular perimeter ROI' tool. This ROI defines the region where the surface check is performed. Note that only ROIs generated by this tool can be used.
03 = Min height (mm)	Minimum required height value for a pixel to be considered by the check.
04 = Max height (mm)	Maximum required height value for a pixel to be considered by the check.
05 = Sensitivity	Minimum required difference in height values to detect a pixel as surface defect.
06 = Grid distance	Dimension of the matrix in pixels. It is recommended to use uneven values only. If you enter an even value x the dimension is set to x+1.
07 = Destination bank	Image bank in which to display the image and any found defects as colored pixels.

Returned Values

01 = Error flag	Flag = 0 tool terminated correctly.
	Flag = -1 an error occurred.

02 = Found pixels	Total number of detected pixels inside ROI.

Check Circular Shape

This tool checks the shape of a circular contour for defects. The contour for the shape check must be generated by either the ‘External Perimeter’ or ‘Internal Perimeter’ tool. Due to the fact that the tool is designed for circular shaped contours the considered contour should have a circular shape as well.

Defects are classified in two different categories: spikes and dents (see the figure below). It is possible to detect either spikes or dents or both of them. Basically the algorithm calculates for a contour pixel the distance from the center of gravity and compares this result with the distance to the center of gravity of other contour pixels. Input parameter **Sensitivity** defines the accepted variation in distance. **Average pixels** are the number of pixels whose distances are averaged for the comparison.

The evaluation starts at the point on the contour which is defined in the tool External or Internal perimeter. Beginning at this point the algorithm follows the contour counterclockwise until the first defect is found. If a defect is detected the tool terminates and returns the coordinates of the first found defect.

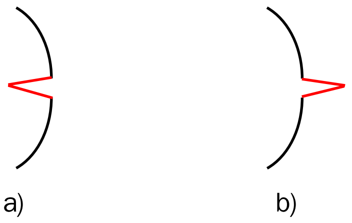


Figure – Example for the two categories of defects on an external circular shape: a) category dent, b) category spike.

Input Parameters

01 = Perimeter definition step Select the desired contour for the shape check. Refer to step program which executes either Internal perimeter or External perimeter.

02 = Type Set which shape defects that will be detected.

`-1` detect dents only
`1` detect spikes only
`0` detect both.

03 = Sensitivity Sensitivity to detect shape defects. Range: 0 .. 100. 0 is most sensitive to defects.

04 = Scan interval The interval between scanned pixels for comparison.

05 = Average pixels Number of pixels to calculate mean distance from center of gravity.

06 = Destination bank Image bank to display image and the point with the first defect.

Returned Values

01 = Transition flag
`0` at least one defect was found
`-1` no defect was found

02 = X transition X coordinate of the first found defect.

03 = Y transition Y coordinate of the first found defect.

4.8 Calculation

Mathematical Operation

This tool offers basic mathematical operations of two input parameters.
Note that division by 0 will return the value 2147483647.

Input Parameters

01 = Variable A	First value for operation.
02 = Variable B	Second value for operation.

03 = Mathematical operation	Operator
	Basic mathematical operations or Boolean operation.
	Double click on input box and select one of following operation:
	= : writes parameter A in the specified table row
	`+, - , ×, /` (basic mathematical operations)
	`OR`
	`Max`
	`Min`
	`Mean`
	`Absolute value of difference`
	`unsigned subtraction`
	`And`
	`Square root`: the square root of variable A. Variable B can be used for setting the number of decimals in the result:
	`-1` Do not round off the result
	`0 - 9` Number of decimals in the result

04 = Table index	Row in table where the result should be written.

Returned Values

01 = Operation result	Result

Mathematical Expression

This tool performs a calculation based on the mathematical expression given as input parameter. The evaluation is performed in the same way as when a mathematical expression is written directly in a tool's parameter field. It can be used to enhance readability of the step program by commenting the calculation in a meaningful way.

To maintain good readability when multiple mathematical expression steps are used after one another, it is suggested to group them together by using **Edit → Increase tabulation**.

Input Parameters

01=Expression Mathematical expression. Always starts with a "=", for example `=2*(S5R1-S4R1)`.

Returned Values

01=Result The result of the evaluated expression.

Example

Result values are sent from the camera to the PC by the tool 'Display'. Instead of writing an expression in each of the tool's parameter fields, it can be useful to refer to previous mathematical expression steps that are clearly commented.

In Range

This tool checks whether or not a value is within a defined range. Usually the value is the result from a previously performed program step. To set the range use **Min value allowed** for the lower bound and **Max value allowed** for the upper bound. If the value has to be exact the value, lower and upper bound values should be identical.

If you want to continue your step program on a certain step depending on the comparison result (conditional jump) you could use the ‘If in range goto’ tool from the Program category.

Input Parameters

01 = Value	Value to be compared if it’s within the range or not.
02 = Min value allowed	Lower bound of the range
02 = Max value allowed	Upper bound of the range

Returned Values

01 = Comparison result	Return value = 1 if the Reference value is within the range Return value = 0 if the Reference value is out of the range

Polar to Cartesian Coordinates

This tool calculates the Cartesian coordinates for any point on a circumference of a given circle. Typically the input parameters for the coordinates of the circle center will come as a result from a previously performed program step. To define a point on the circumference you need values for the radius and an angle. Note that the direction of rotation is for positive and negative input values always counterclockwise in respect to the x-axes.

The circle is displayed in the preview. The size and position of the circle can also be set in the preview using the left mouse button. Double-clicking the preview image opens a larger image in which the circle can be set with higher accuracy.

This function is useful if you want to define a specific point on the circumference of a circle. In particular if the center of the circle is calculated from a previously performed program step such as the 'Fit Circle' tool or a tool from the Measurement or Edge category.

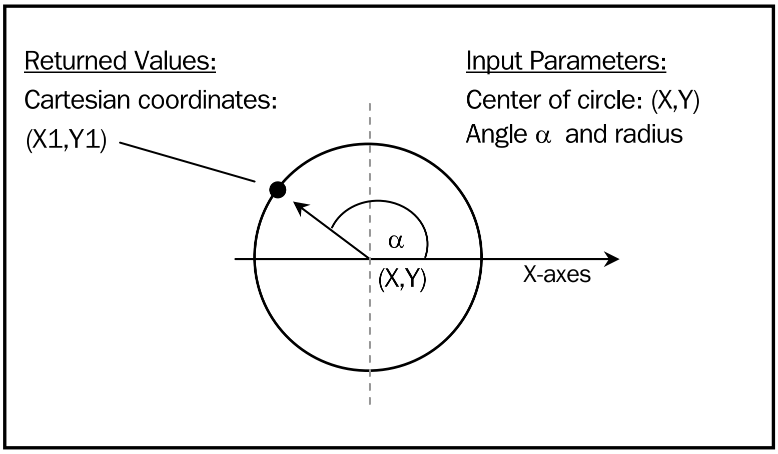
Input Parameters

01 = X center	X coordinate of the center of the circle.
02 = Y center	Like above but for Y direction.
03 = Radius	Radius
04 = Angle	Radius. Direction of rotation is counter clockwise independently if the input value is positive or negative.

Returned Values

01 = X coordinate	Cartesian coordinate in X-direction
02 = Y coordinate	Cartesian coordinate in Y-direction

Example



Fit Circle

This tool fits a circle to four input coordinates and outputs the coordinates of the center of the fitted circle and the radius in pixel units.

Note that you must enter all four coordinates; if you just type three coordinates the fourth coordinates is set to the default values (X4=0, Y4=0).

If the circumference is touching the border of the FOV or if parts of the circle are outside the FOV, the circle is not plotted in the destination bank. The calculation results for the center of the circle and the radius are calculated anyway.

The result of the error flag may be used to check if the tool was executed correctly during run mode.

Input Parameters

01 = Source bank	Number of the source bank. In this case just to copy
02 = X1	X coordinate of the first point
03 = Y1	Y coordinate of the first point
04 = X2	X coordinate of the second point
05 = Y2	Y coordinate of the second point
06 = X3	X coordinate of the third point
07 = Y3	Y coordinate of the third point
08 = X4	X coordinate of the fourth point
09 = Y4	Y coordinate of the fourth point
10 = Destination bank	Image bank in which to plot the fitted circle as an overlay on the copied image from the source bank. Only executed at debug mode.

Returned Values

01 = X center	X coordinate of the circle center
02 = Y center	Y coordinate of the circle center
03 = Radius	Circle radius in pixels.

Error Messages

Error 2	Input parameter values are "impossible" (e.g. negative or out of field of view)
Error 114	At least two points of the four input points are identical
Error 140	At least three points of the four input points are on the same line

Fit Ellipse

This tool fits an ellipse to six input coordinates and outputs the coordinates of the center of the fitted ellipse and the minor and major axes radiuses in pixel units.

Note that you must enter all six coordinates; if you just type five coordinates the sixth coordinates are set to the default values (X6=0, Y6=0).

The result of an error flag may be used to check if the tool was executed correctly during the run modus.

Input Parameters

01 = Source bank	Number of the source bank. In this case just to copy the source bank into the destination bank.
02 = X1	X coordinate of the first point
03 = Y1	Y coordinate of the first point
04 = X2	X coordinate of the second point
05 = Y2	Y coordinate of the second point
06 = X3	X coordinate of the third point
07 = Y3	Y coordinate of the third point
08 = X4	X coordinate of the fourth point
09 = Y4	Y coordinate of the fourth point
10 = X5	X coordinate of the fifth point
11 = Y5	Y coordinate of the fifth point
12 = X6	X coordinate of the sixth point
13 = Y6	Y coordinate of the sixth point
14 = Destination bank	Image bank in which to plot the fitted circle as an overlay on the copied image from the source bank.

Returned Values

01 = X center	X coordinate of the ellipse center.
02 = Y center	Y coordinate of the ellipse center.
03 = Minor diameter	Radius of the minor axes.
04 = Major diameter	Radius of the major axes.

Quick
A<Z
Z>A
Sort

Sort

This tool sorts a number of values or groups of values in the table in ascending or descending order. When groups of values are sorted, the sorting is based on a certain element in each group.

Note. Only table values are sorted, whereas table descriptions remain unsorted.

Input Parameters

01 = Table index	Start index in the table, i.e. the position of the first value of the first group
02 = Number of groups	Number of groups stored in the table
03 = Elements per group	Number of table values per group
04 = Element to order	The element in each group by which the groups should be sorted.
05 = Sort order	Select the sorting order: 0= ascending order 1= descending order

Returned Values

None.

Example

A blob analysis tool found three blobs and wrote the result to the table, starting at row 5. For each blob, the tool wrote three values; x coordinate of the centroid, y coordinate of the centroid and area.

Now we would like to sort the blobs according to their size (area) with the largest blob first, that is sort the groups in descending order by the third element in each group.

Tool settings:	Input parameter	Value
	01=Table index	5
	02=Number of groups	3
	03=Elements per group	3
	04=Element to order	3
	05=Sort order	1

	Table before sort		**Table after sort**	
	Index	Value	Index	Value
X of blob 1	5	410	5	120
Y of blob 1	6	230	6	145
Area of blob 1	7	*80*	7	*210*
X of blob 2	8	120	8	304
Y of blob 2	9	145	9	190
Area of blob 2	10	*210*	10	*135*
X of blob 3	11	304	11	410
Y of blob 3	12	190	12	230
Area of blob 3	13	*135*	13	*80*

Update Statistics

This tool enables statistical operations on up to ten selected values. Typically these values are results of previously performed program steps.

The statistical results are calculated for each value separately and in the following order:

1. Minimum out of all monitored values
2. Maximum out of all monitored values
3. Average value
4. Standard deviation
5. Number of collected values for the statistical operations on that specific value

The results are placed in the table and are ordered in blocks. The first block in the table contains all 5 results for the first values followed by the second block for the 5 results for the second value and so on. You need to select the start index on the table for the first value of the first block. Please note that you need 5 rows for each monitored value in the table for the results. Thus, the number of rows you need from the starting index is equal to: Number of monitored values* 5.

The result parameter **Counter** starts at zero at program start or after a 'Reset Statistics' tool is executed, and is increased by 1 each time this step is performed (=number of repetitions). By the help of this parameter it is easy to update the statistic if the desired number of repetitions have been performed, simply by using this result in an 'If then GoTo' tool from the Program category.

If you would like to restart the statistical evaluation and delete the old data it is essential to execute the 'Reset Statistics' tool before the new evaluation.

This tool is useful for teaching results from program steps that slightly change or to control the process and stability of the results.

Input Parameters

01 = Number of variables	Number of different values for the statistical evaluation.
02 = Table index	Starting index of table for the statistical result values. The first value (=Minimum) from the first block starts at that row.
03 = Variable A	Value for statistical evaluation.
…	
12 = Variable J	

Returned Values

01 = Counter	Number of executions since program start or last 'Reset statistics' tool.

Reset Statistics

This tool resets a previously performed statistical evaluation executed by the 'Update statistics' tool.

It sets the values in the rows of the table that the 'Update statistics' tool refers to, to default values, which are not zero except for the average values. Furthermore it sets the result value **Counter** of the 'Update statistics' tool to zero.

Make sure that this tool is not performed during your statistical evaluation loop since this constantly resets your statistics.

Input Parameters

01 = Step with statistics to reset	Select the update statistics tool in your step program which you would like to reset.

Returned Values

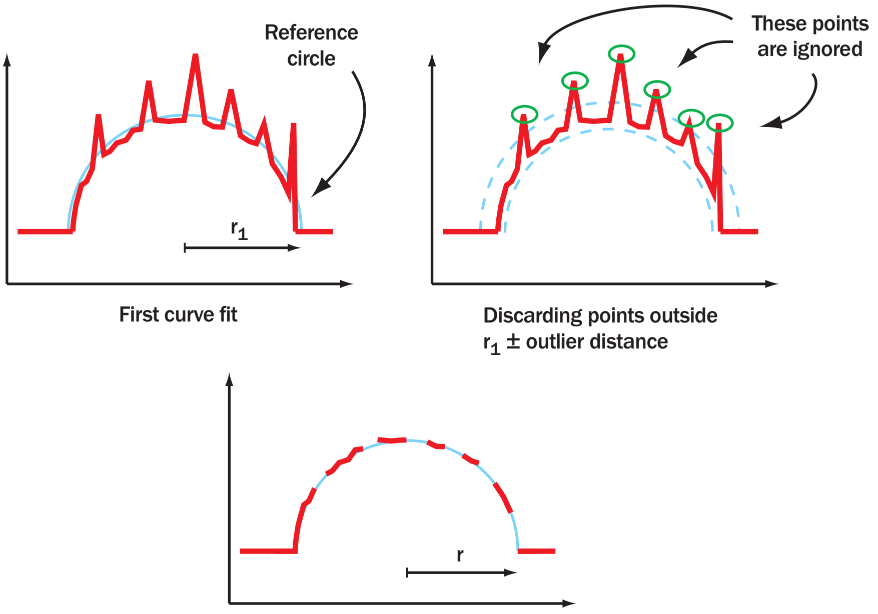
None

Fit Circle to Profile

This tool finds the circle that fits best to a selected part of a profile. The part of the profile to which to fit the circle is specified by a region of interest. If the region of interest does not contain at least 8 pixels with valid height data, an error message will be returned.

The **Min radius** and **Max radius** parameters are used to force the resulting circle to have a radius that is within a certain interval. If these values are set to zero, the radius will not be bound to any interval.

If necessary, an **Outlier distance** can be used for removing noise in the profile. In this case a normal circle fit is carried out first, resulting in a reference circle. The points that deviate more than **Outlier distance** from the reference circle are then discarded, and a new circle fit is made with the remaining points.



First curve fit

Discarding points outside r_1 ± outlier distance

Second curve fit

When specifying an Outlier Distance, points that deviate too much from the fitted curve are ignored and a new curve is then fitted.

If **Outlier distance** is set to zero, every point on the profile will be included when fitting the circle. Note that this tool usually runs faster when **Outlier distance** is set to 0.

Optionally, the curve can be visualized by choosing a **Destination Bank.**

Input Parameters

01 = Source bank	Image bank that contains the profile to which a circle is fitted.
02 = ROI definition step	The program step where the ROI was defined.
03 = Min radius (mm)	Minimum radius to be found.
04 = Max radius (mm)	Maximum radius to be found.
05 = Outlier distance (mm)	The maximum distance between the profile and the fitted circle.
06 = Destination Bank	Image bank in which to draw the resulting circle. -1 suppresses visualization.

Returned Values

01 = X center (mm)	Calibrated x coordinate of the circle center.
02 = Z center (mm)	Calibrated y coordinate of the circle center.
03 = Radius (mm)	Circle radius.

Error Messages

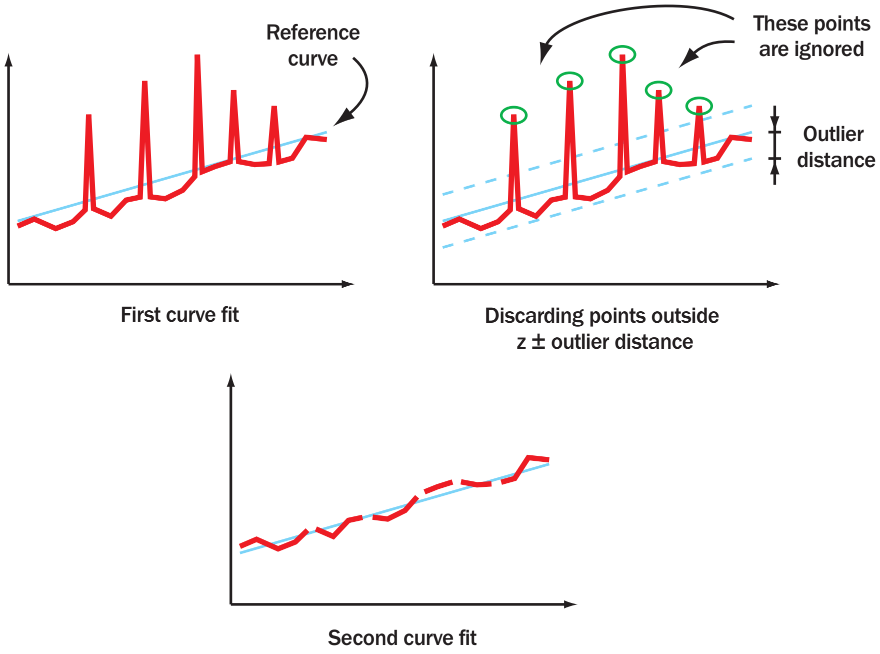
Err. = 7704	The region of interest has parts that are outside the source bank.
Err. = 7801	The region of interest does not contain enough valid data to perform a fitting.
Err. = 7808	A fitting cannot be carried out since the height data within the ROI is singular.

Fit Curve

This tool finds the straight line or a second-degree curve that fits best to a selected part of a profile. The part of the profile to which the curve is fitted is specified by a region of interest.

The region of interest must contain a sufficient number of points with valid height data, since using too few points may produce unreliable results. The lowest acceptable number of valid height data points is specified by the **Min valid points** parameter.

If necessary, an **Outlier distance** can be used for removing noise in the profile. In this case, a normal curve fit is carried out first, resulting in a reference curve. The points that deviate more than **Outlier distance** from the reference curve are then discarded, and a new curve fit is made with the remaining points.



First curve fit

Discarding points outside z ± outlier distance

Second curve fit

When specifying an Outlier Distance, points that deviate too much from the fitted curve are ignored and a new curve is then fitted.

If **Outlier distance** is set to zero, every point on the profile will be included when fitting the curve. Note that this tool usually runs faster when **Outlier distance** is set to 0.

The resulting curve can be used in subsequent steps by using the step number of this step as input parameter (Curve definition step).

Additionally, the coefficients of the curve can be stored in the table starting at row **Table index**. The curve's equation is given in the following form (in millimeters):

$$z = a_0 + a_1 \cdot x + a_2 \cdot x^2$$

and each coefficient is stored sequentially in the table:

a_0	Table index
a_1	Table index + 1
a_2	Table index + 2 (only if a second-degree curve was fit)

The equation for the curve is based on calibrated coordinates, that is both x and z in the equation has the unit millimeters.

Input Parameters

01 = Source bank	Image bank that contains the profile to which the curve is fitted.
02 = ROI definition step	The program step where the ROI was defined.

03 = Curve type	`Constant height line`
	Straight line parallel with the x-axis.
	`Line`
	Straight line.
	`Parabola`
	Second-degree polynomial curve.

04 = Min valid points	The lowest acceptable number of valid height data points within the ROI
05 = Outlier distance (mm)	The maximum distance between the profile and the curve.
06 = Table index	Position in the table where the curve's coefficients are written. If set to `-1` the coordinates will not be stored in table.
07 = Destination bank	Image bank in which to draw the resulting curve. `-1` suppresses visualization.

Error Messages

Err. = 7704	The region of interest has parts that are outside the source bank.
Err. = 7801	The region of interest does not contain enough valid data to perform a fitting.
Err. = 7808	A fitting cannot be carried out since the height data within the ROI is singular.

Fit Surface

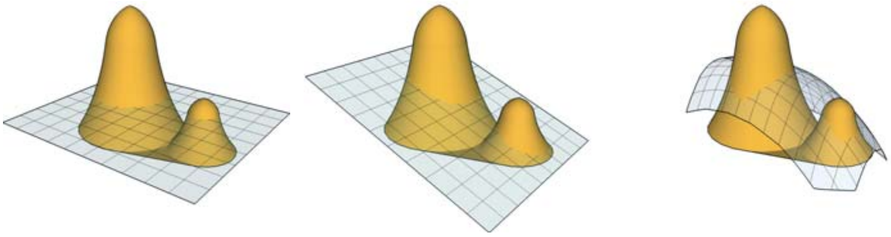
This tool finds the surface that best fits a selected part of a 3D image. Typically, this tool is used for defining the zero-level surface for volume calculations or deviation measurements.

The part of the 3D image to which the surface is fitted is specified by the region of interest in **ROI definition step**. If the region of interest does not contain enough pixels with valid height data, an error message will be returned.

There are four types of surfaces that can be fitted to the 3D image:

- `Constant height surface` fits a plane that is parallel with the xy-plane
- `Plane surface` fits an ordinary plane surface
- `Second degree surface` can be fitted to slightly more complicated shapes
- `Background plane –` this automatically fits a planar surface to the 'Background ration' lower pixels

The tool runs significantly faster when fitting a plane compared with a second-degree surface.



Constant height surface *Plane surface* *Second degree surface*

If necessary, an **Outlier distance** can be used for removing noise in the 3D image. In this case, a standard surface fit is carried out first, resulting in a reference surface. The points in the 3D image that deviate more than **Outlier distance** from the reference surface are then discarded, and a new surface fit is made with the remaining points.

If **Outlier distance** is set to zero, every point in the 3D image will be included when fitting the surface. Note that this tool usually runs faster when **Outlier distance** is set to 0.

The resulting surface can be used in subsequent steps by using the step number of this step as input parameter (Surface definition step).

The Output parameter makes it possible to draw the fitted surface in the ROI or in the full image. It also makes it possible to draw a compensated image in either one. A surface compensated image is an image where the fitted surface has been subtracted from the original data to generate a 'flattened' image. This is very useful as a pre-processing to e.g. the Blob Finder. Note that when output is set to one of the compensating options (Compensated in ROI or Compensated in full image) the surface is always a constant height surface. This surface refers to the compensated image rather than the original one.

Advanced: The fitted surface model is internally stored and the user does not need to consider how it is represented. However, in some applications it may be interesting to use the fitted coefficients to e.g. compute a normal vector to a fitted plane. For that purpose the tool returns the surface coefficients as results. To obtain the height value Z of a surface at a point (X, Y) the following formula is used:

Z = Ao + X * Ax + Y * Ay +X^2 * Axx + X * Y * Axy + Y^2 * Ayy

Input Parameters

01 = Source bank	Image bank containing the 3D image to which the surface is fitted.
02 = ROI definition step	The program step where the ROI was defined.

03 = Surface type	`Constant height surface`
	Plane surface parallel to the xy-plane
	`Plane surface`
	First order ploynomial surface
	`Second degree surface`
	Second degree surface

04 = Outlier distance (mm)	The maximum distance between a point in the 3D image and the surface.
05 = Destination bank	Image bank in which to draw the resulting surface. `-1` suppresses visualization.
06 = Background ration (0-100%)	A rough estimate of how much of the image consist of background.
07 = Output	Determines what to put in the destination bank. See description above.
08 = Fill missing data	When enabled, missing data will be replaced with the value of the fitted surface at that point.

Returned Values

01 = Ao (mm)	Surface coefficients
02 = Ax (mm/pixel)	Surface coefficients
03 = Ay (mm/pixel)	Surface coefficients
04 = Axx (mm2/pixel2)	Surface coefficients
05 = Axy (mm2/pixel2)	Surface coefficients
06 = Ayy (mm2/pixel2)	Surface coefficients

Error Messages

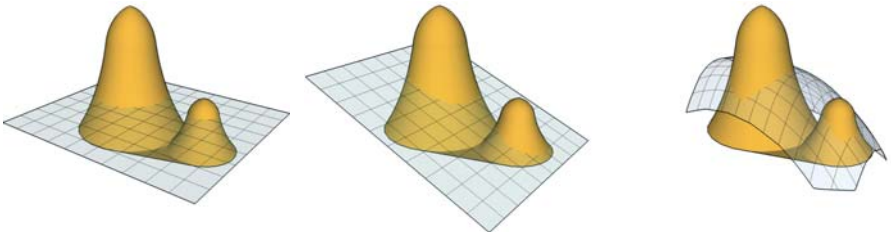
Err. = 7801	The region of interest does not contain enough valid data to perform a fitting.
Err. = 7808	A fitting cannot be carried out since the height data within the ROI is singular.
Err. = 7811	The ROI is too small. It must be at least 2 x 2 pixels.

Fit Surface to Points

This tool finds the surface that best fits a list of 3D points.

The list of points is read from the table, and up to 1024 points can be used to specify the surface. The tool reads the X and Y coordinate for each point from the table, and the Z value is read from the selected image bank. If the list of points does not contain enough pixels with valid height data, an error message will be returned.

Currently, it is only possible to fit a plane surface to the given points.



Constant height surface *Plane surface* *Second degree surface*

If necessary, an **Outlier distance** can be used for removing noise in the 3D image. In this case, all given points will in a first step be used to find a reference surface. In a second step, the points whose Z value deviate more than **Outlier distance** from this reference surface are discarded, and a new surface fit is made with the remaining points.

If **Outlier distance** is set to zero, the reference surface will be the final result, i.e. every point in the list will be included when fitting the surface. Note that this tool usually runs faster when **Outlier distance** is set to 0.

The resulting surface can be used in subsequent steps by using the step number of this step as input parameter (Surface definition step).

To visualize the resulting surface, please use the Draw Surface tool.

Advanced: The fitted surface model is internally stored and the user does not need to consider how it is represented. However, in some applications it may be interesting to use the fitted surface's coefficients to e.g. compute a normal vector. For that purpose the tool returns the surface coefficients as results. To obtain the height value Z of a surface at a point (X, Y) the following formula is used:

Z = Ao + X * Ax + Y * Ay +X^2 * Axx + X * Y * Axy + Y^2 * Ayy

Input Parameters

01 = Source bank Image bank containing the 3D image to which the surface is fitted.

02 = Number of Points The number of points to read from the table. Each point needs two table cells; one for the X coordinate, and one for the Y coordinate.

03 = Table Index The starting index in the table to read the points from.

04 = Surface type This parameter is reserved for future use. It shall always be set to 'Plane Surface'.

05 = Outlier distance (mm) The maximum distance between a point used for the final surface and the reference surface.

Returned Values

01 = Ao (mm) Surface coefficients

02 = Ax (mm/pixel) Surface coefficients

03 = Ay (mm/pixel)	Surface coefficients
04 = Axx (mm2/pixel2)	Surface coefficients
05 = Axy (mm2/pixel2)	Surface coefficients
06 = Ayy (mm2/pixel2)	Surface coefficients

Error Messages

Err. = 7403	Grab setup must be executed before this step is executed.
Err. = 7801	The list of points does not contain enough valid data to perform a fitting. The algorithm requires at least three valid points.
Err. = 7808	The calculation resulted in an attempt to divide by zero. This can happen if the points are too close to each other.

Coordinate Alignment

The Coordinate alignment tool is used for aligning the IVC-3D’s coordinate system to an external coordinate system (world coordinates).

The result from the tool is a transform, which is stored in a data block in the IVC-3D, and can be used later by the 'Get calibrated point' tool to get aligned measurement values.

This tool is used through an interactive setup. Therefore, the program step can be removed from or disabled in the program after creating the transform.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

Input Parameters

None.

This tool is used through the interactive setup, which is opened by double-clicking the Setup button. See “Coordinate Alignment” on page 262 for more information on the interactive setup.

Returned Values

None.

Get Calibrated Point

This tool calculates the calibrated coordinates X, Y, Z (in mm) for a pixel in either a profile or a 3D image. The height value is acquired from the image in the specified **Source bank**.

The tool has a built-in filter that can be used when calculating the height value (Z coordinate) in noisy images. The parameter **Filter type** is used for setting the filter to use either the mean or the median value of a matrix of 3x3 pixels (1x3 for profiles) or 5x5 pixels (1x5 for profiles) surrounding the specified pixel.

If the coordinates should be aligned with an external coordinate system (world coordinates), the **Transform data block** parameter specifies which transform that should be used for the alignment. This transform is created using the interactive setup for the 'Coordinate Alignment' tool. Setting the parameter to `-1` means that the coordinates should not be aligned.

When a profile is used as source image, the parameter **Y pixel** is ignored. The returned calibrated y coordinate will always be 0 for a profile.

When a 3D image is used as source image, the tool requires that the y coordinate sampling distance is set, by using the 'Grab setup' tool. This sampling distance can be set either manually or indirectly by an external encoder device. See the documentation for the 'Grab setup' tool for more information.

If this tool is applied on a profile that was extracted from a 3D image with the 'Extract Profile' tool, the returned coordinates are relative to the profile and not the original 3D image.

Input Parameters

01 = Source bank	The image bank containing a 3D image or profile that contains the value of the point.	
02 = X pixel	The x coordinate of the pixel.	
03 = Y pixel	The y coordinate of the pixel.	
04 = Filter Type	Specifies how to calculate the height value (z coordinate)	
	`No filter`	The height value for the pixel
	`Mean 3`	The mean value of 3x3 pixels (3x1 for profiles)
	`Median 3`	The median value of 3x3 pixels (3x1 for profiles)
	`Mean 5`	The mean value of 5x5 pixels (5x1 for profiles)
	`Median 5`	The median value of 5x5 pixels (5x1 for profiles)
05 = Transform data block	The number of the data block in which the transform to use is stored. `-1` means that the coordinates should not be aligned to world coordinates.	

Returned Values

01 = Calibrated X (mm)	Calibrated X coordinate in millimeters
02 = Calibrated Y (mm)	Calibrated Y coordinate in millimeters
03 = Calibrated Z (mm)	Calibrated Z coordinate in millimeters

4.9 Program

Goto

This tool jumps to the selected step in the step program. The program continues execution from that point.

Input Parameters

01 = Goto step

Step number where the program continues.
If selected step was deleted during the setup of the program this row is marked red and the previously set value changes to –1.

Returned Values

None

If Then Goto

This tool jumps to a defined program step if the condition in **Control expression** is true (Conditional jump).

Input Parameters

01 = Control expression
Condition.
Definition: 0 = false.
For example = (v2 > v5).

02 = Goto step
Step number where the program continues if condition is true.

Returned Values

None

If Error Goto

This tool handles upcoming errors in program steps. It is recommended to handle potentially occurring errors in critical program blocks with this tool. This avoids that the program stops due to an error.

If a program step returns an error the program either skips this step and continues with the following step or jumps to a defined program step.

Please select the **Goto step** carefully to avoid accidentally creating an infinite loop.

Return parameters are the step number where the last error occurred and the error code.

Input Parameters

01 = Goto step	Step number where to continue in case of an error.	
02 = Continue to next step?	`False`	The program continues at step number given by **Goto step.**
	`True`	The step with error is skipped and the program continues with the next step. In this case parameter **Goto step** is ignored.

Returned Values

01 = Last step with error	Step number which evoked the last error.
02 = Last error code	Error code of last error.

If in Range Goto

This tool checks if a value is inside a certain range. Depending on the setting of the **Goto if** parameter the tool jumps to a defined step number if the value is within or outside the range.

Input Parameters

01 = Value to be compared	Value to be checked.
02 = Min value allowed	Lower range.
03 = Max value allowed	Upper range.
04 = Goto if	Condition for jump. `In range` perform jump if value in range. `Out of range` perform jump if value out of range.
05 = Goto step	Step number to which the program will jump and continue if value in range.

Returned Values

01 = Comparison result	1 if condition in **Goto if** is true. 0 if condition in **Goto if** is false.

If All in Range Goto

This tool is similar to the ‘If in range goto’ tool. It checks if up to four values are inside their individual range or not. If all values are inside their ranges the tool jumps to a defined step number.

Input Parameters

01 = Value A	First value to be checked.
02 = A min value	Lower range first value.
03 = A max value	Upper range first value.
04 = Value B	Second value to be checked.
05 = B min value	Lower range second value.
06 = B max value	Upper range second value.
07 = Value C	Third value to be checked.
08 = C min value	Lower range third value.
09 = C max value	Upper range third value.
10 = Value D	Fourth value to be checked.
11 = D min value	Lower range fourth value.
12 = D max value	Upper range fourth value.
13 = If all in range goto step	Step number to which the program jumps and continues at if all values are in range.

Returned Values

01 = Comparison result	`1`
	`0`
		all values are in range.
		at least one value is out of range.

If

The 'If' tool is used together with an 'End' tool and optionally an 'Else' tool for enclosing programs steps that should only be executed if a certain condition is fulfilled:

- If the condition in the **Control expression** is true all program steps are executed between this tool and the tool referred to by the **ELSE or END step** parameter.

  If the tool referred to is an 'Else' tool, the steps following that tool are skipped and the program continues with the program steps following the 'End' tool referred to by the 'Else' step.
- If the condition in the **Control expression** is false the following program steps are skipped and the program continues with the program steps following the tool referred to by the **ELSE or END step** parameter.

A construction with an 'If' tool must always end with an 'End' tool.

Input Parameters

01 = Control expression	Definition: 0 = false. Boolean operations and mathematical expressions are allowed, for example `= (v2 > v5)`
02 = ELSE or END step	Step number that refers to the corresponding 'Else' or 'End' tool. .

Returned Values

None

Example

Step 1	tool : If
	01 = **Control expression:** (condition)
	02 = **END step:** 4

Step 2	Program step

Step 3	Program step

Step 4	tool : End
	01 = Start step : 1

Step 1	tool : If
	01 = **Control expression** : (condition)
	02 = **END step:** 4

Step 2	Program step

Step 3	Program step

Step 4	tool : Else
	01 = IF step : 1
	02 = **END step:** 6

Step 5	Program step

Step 6	tool : End
	01 = Start step : 1

Else

This tool could be used after the ‘If’ tool and must be terminated with the ‘End’ tool. It depends on the condition in the ‘If’ tool. If the condition is true all program steps between ‘Else‘ and ‘End’ are skipped. If the condition is false only the program steps between ‘Else‘ and ‘End' are executed. See figure below.

Input Parameters

01 = IF step
This parameter refers to the step number with corresponding ‘If‘ tool.

02 = END step
This is the step number with the corresponding ‘End‘ tool.
Note that no other step numbers are allowed.

Returned Values

None

Example

Step 1	tool: If
	01 = Control expression : (condition)
	02 = END step: 4

Step 2	Program step

Step 3	Program step

Step 4	tool: Else
	01 = IF step : 1
	02 = END step: 6

Step 5	Program step

Step 6	tool: End
	01 = Start step : 1

For

This tool performs a for loop. It repeats the execution of program steps between ‘For‘ and ‘End’. It initializes the loop index with the start value and repeats program steps until **Loop index** is equal to or greater than **Stop value.** After each repetition the **Increment value** is added to **Loop index.**

The repetition of program steps terminates if the **Loop index** is equal to or greater than the **Stop value.**

Input Parameters

01 = Start value	Initialize start value for **Loop index.**
02 = Stop value	Set stop value for **Loop index.**
03 = Increment	Increment for **Loop index.**
04 = END step	Step number with corresponding **End.**

Returned Values

01 = Loop index	Current loop index.

Example

Input Parameters	**Returned Values**
Start value = 1	Loop index = 1, 5, 9
Stop value = 10	
Increment = 4	
Start value = 10	Loop index = 10, 7, 4, 1, -2, -5, -8
Stop value = -10	
Increment = -3	

While

This tool performs a while loop. It repeats all program steps between 'While' and 'End' until the condition in **Control Expression** is false. Due to that this tool must be terminated with an 'End' tool.

Input Parameters

01 = Control Expression
Condition.

Boolean operations and mathematical expressions are allowed. For example:
`= (v2 > v5).`

02 = END step
Step number that refer to the corresponding function 'End'.
Note that no other step numbers are allowed.

Returned Values

None

Subroutine Start

This tool defines the beginning of a subroutine and must be followed by the 'End' tool. When the subroutine is called it executes all program steps between Subroutine and End.

A subroutine can be called by the following tools:

- Goto
- If then go to
- If in range goto
- If all in range goto

After the subroutine is executed the program continues at the step following the step calling the subroutine.

Input Parameters

01 = END step	Step number of the 'End' that belongs to the subroutine.

Returned Values

01 = Calling step	Step number which called the subroutine

Example

Step number	Step tool
1	Goto step 15
2	
3	
4	
5	
.	
.	
.	
.	
15	Subroutine Start
16	Intermediate steps
17	Intermediate steps
18	End step

Execution order
1
15
16
17
18
2
3
4
5
.
.
.
.

End

The End tool must follow the following tools*:*

- If
- While
- For
- Subroutine

Input Parameters

01 = Start step Step number that refer to the corresponding ‘If‘, ‘While‘, ‘For‘, or ‘Subroutine‘ tool.

Returned Values

None

Run Flash Program

This tool is used for loading and running a step program that is stored in a program bank in the flash memory of the device.

Execution of the loaded program starts at the program step specified by the **Start step** parameter.

By setting the parameters **Start load table** index and **Number of elements**, you can specify which rows of the table stored with the step program that should be loaded with the program.

The loaded step program will entirely replace the program currently in the working memory. If you want to continue running the previous program after loading a program from flash, that program must also be stored in the flash memory, and the loaded program must contain a 'Run flash program' step that loads the previous program from flash.

Input Parameters

01=Program number Number of the program bank in which the program and table to load is saved.

02=Start step Step number in the loaded program where to start the execution.

03=Start load table index Index of the first table row to be loaded from the table stored with the step program and into the active table.

04=Number of elements The number of table rows to be loaded from the table saved with the step program and into the active table.

Returned Values

None

Program Protection

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

The Program protection tool can be used for preventing a program from being imported from the device and opened in IVC Studio, and for preventing a program to be copied to and run in another device.

A program containing this tool cannot be imported from the Flash memory into IVC Studio.

If the **Lock to device** parameter is set, the program will only run on the device to which it was loaded from IVC Studio. If the program is copied from one device to another, it will refuse to run on the other device.

If the **Lock to device** parameter is not set, the program can be copied to other devices through FTP and run on those devices, but never imported back into IVC Studio.

Note: If you use this program step in a program, make sure that you keep the original project file, since there is no way to recover the program from a device if the project file is lost.

Input Parameters

02=Lock to device If this parameter is set, the program will only run on the device that it was written to flash from IVC Studio.

If you try to copy this program from one device to another, it will refuse to run on the other device.

Returned Values

None.

4.10 System

Get Timer

This tool allows monitoring of the system time. The total processing time or the processing time of certain step sequences can be calculated by subtracting the results of two different Get timer tools or of one tool in two cycles of the step program. Since it is not possible to reset the timer the return value should be stored in the table to calculate cycle times of step program sequences. The maximum value for system time is 1,157,627,903 (which correspond to 44FFFFFF hexadecimal). When maximum value is reached the value will be wrapped.

Input Parameters

None

Returned Values

01 = System time	System time in microseconds (µs).

Wait

This tool sets a time delay in the step program. The program stops at this step and continues after the specified waiting time.

Note that the displayed Time of execution has no meaning in this step. Please ignore this value.

Input Parameters

01 = Wait time (ms)	Desired time delay in milliseconds. Maximum time delay = 9999 ms.

Returned Values

None

Read from Table

This tool reads a value from the table. The return value of this tool is the selected value from the table.

Input Parameters

01 = Table index Index number of the table in which to select a value.

Returned Values

01 = Value Returns the read value from the table.

Write to Table

This tool writes a value into the table.

Input Parameters

01 = Value	Value to be written in the table.
02 = Table index	Index in table where the value should be written.

Returned Values

None

Fill Table

This tool fills a value into a selected array in the table. The array is defined by a **Start table index** at which this tool starts to fill the table and an **End table index** at which this tool stops to fill the table. Either each cell in this array is filled with the value or only every nth row.

Input Parameters

01 = Value	Value to be filled in the table.
02 = Start table index	Index number of the table to define first row of the array.
03 =End table index	Index number of the table with the last row of the array.
04 = Fill interval	Number of skipped rows between each value. 1 means all cells in the array are filled with the value.

Returned Values

None

Load Data Block from Flash

This tool loads data that is stored in the flash memory into a data block in the working memory.

The data is stored in a file on the flash memory, which is referred to by the **File name** parameter.

Input Parameters

01 = File name	Name of the file to be loaded.
02 = Data block	The number of the data block in working memory into which to load the data.

Returned Values

None

Error Messages

Err=2	A timeout occurred.
Err=159	Failed to read file from flash.

Save Data Block to Flash

This tool writes a data block in the working memory to the flash memory. The flash memory holds that data even if the power to the device is shut off.

When saved to the flash memory, the data is contained in a file whose name is specified in the **File Name** parameter.

This tool is useful for example in combination with the ‘Shape Locator’, and ‘Add Shape Runtime’ tools in the Matching category. These tools store data about an object in a data block in the working memory. ‘Save Data Block‘ to flash allows this memory block to be in the flash memory and be used by the ‘Shape Locator’ tool later – or in other programs – without having to teach the object again.

Note: If a data block already exists on the flash with the same name as the one being written, the existing one will be replaced by the new data block, and the amount of dead space on the flash disk will increase with the size of the previous data block. For details see section on page 282 in the Troubleshooting guide.

Note: This tool may perform an automatic defragmentation of the flash disk if the amount of dead space exceeds the specified threshold. Please refer to section **Setting Device Parameters** in the appendix for information on how to set this threshold. This will significantly increase the execution time of the tool. Note also that this is only the case when the camera is running, not when executing the tool with F5/F8. In the latter situation, an error code will be returned indicating that it is time to defragment the flash.

Input Parameters

01 = Data block The number of the data block in working memory in which the data to be saved is stored.

02 = File name Name of the file in which to save the data.

Returned Values

None

Error Messages

ITF Error = 2 Timeout. The execution time to save the data block on flash is too long. Increase the timeout limit (Options → Configuration on the IVC Studio menu bar).

Err. = 8960 The amount of dead space on the flash exceeds the specified threshold. Please defragment the disk by using the Clear Unused Memory option on the Flash menu in the Device list.

Err. = 8961 The automatic defragmentation failed. The camera may need to be restarted to restore the flash.

Load Image from Flash

This tool loads an image that has previously been stored in the flash memory into a specified image bank.

Note that when loading an image in an IVC-3D camera, the camera must have the same settings for field-of-view (FOV) and length as when the image was saved.

Input Parameters

01 = Flash bank Number of the flash bank in which the image to be loaded is stored.
Available numbers of flash banks: 0 – 9999.

02 = Destination bank Number of the image bank into which to load the image.

Returned Values

None

Error Messages

Err. = 361 Type of image to restore is different from image type of bank.

Err. = 7304 The file could not be found.

Err. = 7306 The size of the image bank to be loaded from file does not match current FOV settings.

Save Image to Flash

This tool saves an image in an image bank into the flash memory. There are up to 9999 flash banks available for storage. The actual number of available banks is determined by the size of the saved images.

Note: If the selected flash bank already contains a stored image, this image will be replaced by the new image without any warning.

The images can be saved in three different image formats:

`Raw` Saves the raw data of the image without compression.

`Compressed raw` Saves the raw data of the image with lossless compression.

`Jpeg` Saves the image in a compressed jpeg format, which is a lossy compression. The amount of compression is set with the **Quality factor**, where `100` means no compression.
The execution time of this tool depends on how much the image is compressed, as described in the following table.

For IVC-3D, profiles cannot be saved in Jpeg format.

Note that the execution times can vary about several milliseconds, which can result in a non-constant cycle time.

An example of the variation of execution time is listed in the following table:

Format	**Time of execution (min and max execution times in ms)**	
	IVC-2DM1111	**IVC-2DM1121 (HiRes)**
`Raw`	9.000 – 11.000	15.000 – 17.000
`Compressed raw`	9.000 – 10.000	15.000 – 17.000
`Jpeg` (**Quality factor** `100`)	780 – 1.900	8.000 – 10.000
`Jpeg` (**Quality factor** `50`)	185 – 500	1.000 – 1.500
`Jpeg` (**Quality factor** `1`)	145 – 160	200 – 400

Note: This tool may perform an automatic defragmentation of the flash disk if the amount of dead space exceeds the specified threshold. Please refer to section **Setting Device Parameters** in the appendix for information on how to set this threshold. This will significantly increase the execution time of the tool. Note also that this is only the case when the camera is running, not when executing the tool with F5/F8. In the latter situation, an error code will be returned indicating that it is time to defragment the flash.

Input Parameters

01 = Source bank Image bank containing the image to be saved to flash.

02 = Flash bank Number of the flash bank in which the image will be stored. Valid numbers for flash banks are 0 – 9999.

03 = Format Image format for the saved image:
`Raw`
`Jpeg`
`Compressed raw`

04 = Quality factor When **Format** is set to `Jpeg`, the amount of compression of the image. Valid values: 1–100.
`100` Highest quality of the image (no jpeg compression)
`1` Low image quality and short execution time (maximum jpeg compression).

Returned Values

None

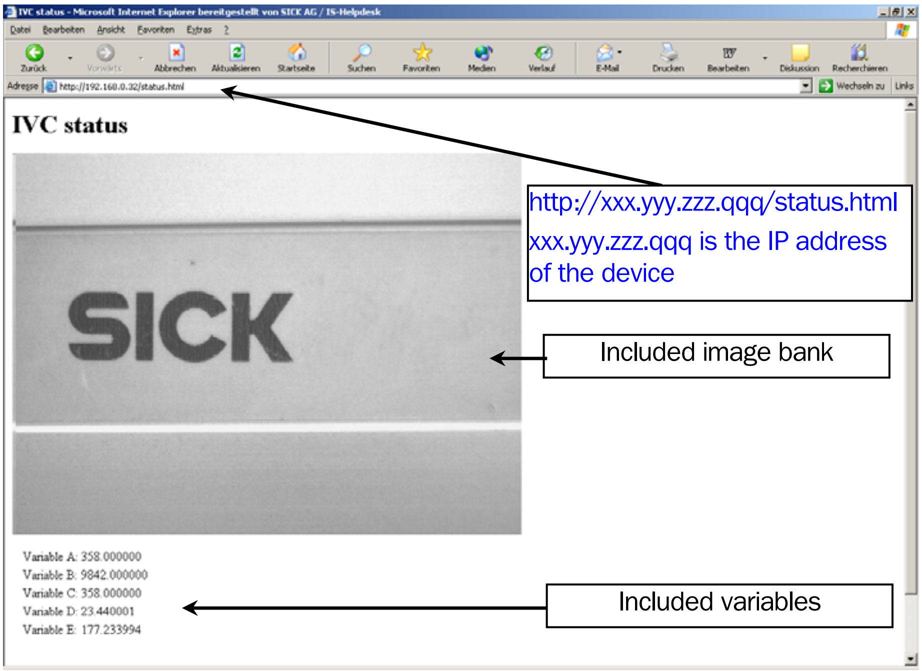
Error Messages

ITF Error = 2	Timeout. The execution time to save image bank on flash is too long. Increase the timeout limit (Options → Configuration on the IVC Studio menu bar).
Err. = 8960	The amount of dead space on the flash exceeds the specified threshold. Please defragment the disk by using the Clear Unused Memory option on the Flash menu in the Device list.
Err. = 8961	The automatic defragmentation failed. The camera may need to be restarted to restore the flash.

Web Status Page

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

The parameters of this tool are written to a status page that is accessible via a web browser. This enables to monitor the selected parameters during the runtime of the device. The page is accessed as http://xxx.yyy.zzz.qqq/status.html where the xxx.yyy.zzz.qqq is the IP-number of the selected device.


IVC status - Microsoft Internet Explorer bereitgestellt von SICK AG / IS-Helpdesk
http://192.168.0.32/status.html
SICK

IVC status

Variable A: 358.000000
Variable B: 9842.000000
Variable C: 358.000000
Variable D: 23.440001
Variable E: 177.233994

http://xxx.yyy.zzz.qqq/status.html xxx.yyy.zzz.qqq is the IP address of the device

Included image bank

Included variables

Figure – Screen shot of a status page.

The web page will contain one image bank and it is possible to monitor up to five variables. The selected image bank can be copied to a buffer to ensure that the included image on the web page is synchronized with the execution of the Web Status Page in the step program. If the image bank is not copied to a buffer the included image could be depending on the current stage of the step program when you update the status web page.

Note that copying an image bank to a buffer takes some time and so the execution time will increase. Colors in the image bank will be displayed in white on the web page.

Also note that the description that can be added in the parameters **Description A-E** allows only strings (no numerical values). If no description or numerical values is used the variable will not be included in the web page.

To update the status page just click on the refresh button of your web browser.

Input Parameters

01 = Source bank Selected image bank that will be included on the web page.

02 = Copy bank Option if the image bank should be copied or not.

`True` The image bank is copied to a buffer and synchronic with the execution of the Web Status Page tool in the step program.

`False` The image bank will not be copied to a buffer and is dependent on when the status page is accessed by the browser.

03 = Description A Description for variable A that will be included on the web page (only strings).

04 = Variable A Parameter specifies variable that will be included on the web page with **Description A**.

05 = Description B Description for variable B that will be included on the web page (only strings).

06 = Variable B Parameter specifies variable that will be included on the web page with **Description B**.

07 = Description C Description for variable C that will be included on the web page (only strings).

08 = Variable C Parameter specifies variable that will be included on the web page with **Description C**.

09 = Description D Description for variable D that will be included on the web page (only strings).

10 = Variable D Parameter specifies variable that will be included on the web page with **Description D**.

11 = Description E Description for variable E that will be included on the web page (only strings).

12 = Variable E Parameter specifies variable that will be included on the web page with **Description E**.

Returned Values

None

Errors

If you are unable to connect to the device with a web browser, try the following:

- *Check that the HTTP server is enabled*

  Go to: Options → Configuration→ Ethernet Devices.
  Click on button: Ethernet Device Configuration and check Device Parameters on the right table. HTTP Server Enabled must set to 1.

- *Make a Proxy Server exception in the web browser*

  If your computer is on a network using a proxy server (typical at large networks), a proxy exception needs to be made to allow for direct communication between the computer and camera. To know if your network uses a proxy server, look at the LAN Settings for your web browser. Tools → Internet Options → Connections → LAN Settings.

  To make the exception in for example Internet Explorer, choose Tools → Internet Options → Connections → LAN Settings → Proxy Server, Advanced. In the Exceptions list, add your domain number, `;xxx.yyy.zzz.*` Other browsers usually work similarly. If you still have problems, contact your network technician.

  For example, if your camera has IP address 10.162.8.100, the following should be added in the exceptions list: `;10.162.8.*`

Write Table To Flash

This tool writes a section of the current table to the flash memory on the camera and the data will be stored on a readable text file.

Warning: Frequent writing to flash devices will wear down the device. Never include a write table to flash step which will run in every program cycle. This tool should only be used in a special section of the step program which is only executed when e.g. an operator changes some operation parameters. Failure to comply with this warning will eventually result in a broken flash device.

Note: This tool may perform an automatic defragmentation of the flash disk if the amount of dead space exceeds the specified threshold. Please refer to section **Setting Device Parameters** in the appendix for information on how to set this threshold. This will significantly increase the execution time of the tool. Note also that this is only the case when the camera is running, not when executing the tool with F5/F8. In the latter situation, an error code will be returned indicating that it is time to defragment the flash.

Input Parameters

01 = Table index	Index of the first table element to be stored on flash.
02 = Number of elements	The number of table elements to be stored on flash.
03 = File name	Name of the file on flash where the data will be stored.
04 = Warning! Wears down flash	The tool will only work if this parameter is set to 'Accept'. The default value is 'Do not accept'. This is a safety precaution to reduce the risk of accidental inclusion of the step in your main loop.

Returned Values

01 = Result	0 – Everything is ok. -1 – Warning! Wears down flash was not set to Accept. 1 – The file could not be written, most likely because the flash disk is full

Error Messages

ITF Error = 2	Timeout. The execution time to save image bank on flash is too long. Increase the timeout limit (Options → Configuration on the IVC Studio menu bar).
Err. = 8960	The amount of dead space on the flash exceeds the specified threshold. Please defragment the disk by using the Clear Unused Memory option on the Flash menu in the Device list.
Err. = 8961	The automatic defragmentation failed. The camera may need to be restarted to restore the flash.

Read Table From Flash

This tool reads a section of the table from flash. To be able to do this the file should previously be written by the Write Table To Flash tool.

Input Parameters

01 = Table Index	The elements read from the flash will be stored in the current table starting from this index.
02 = File Name	Name of the file on flash

Returned Values

01 = Result	0 – Everything is ok. 1 – The file does not exist. 2 – The file could not be read and interpreted.

4.11 Communication

Setup RS485

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

This tool initializes the RS485 port. It must be executed in the step program before using following tools:

- 'Write RS485 Values'
- 'Read RS485 Values'
- 'Write RS 485 String'
- 'Read RS 485 String'

Input Parameters

01 = Baud rate	Select desired **Baud rate** (`1200 – 115200`).

02 = Parity	Select parity:
	`None`
	`Even`
	`Odd`

03 = Data bit	Select how many data bits:
	`7`
	`8`

04 = Stop bit	Select number of stop bits:
	`1`
	`2`

Returned Values

None

Read RS485 Values

This tool receives data through port RS485 and writes the values in the table. The received values are successive filled in the table beginning at a selected start row.

Only transmit values up to 8 bit. Do not transmit any other values.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

Input Parameters

01 = Timeout (ms)	Maximum time to receive one byte before an error message occurs due to time out.
02 = Expected values	Total number of expected values. Since the number of rows in the table are limited to 2000 the **Table index + Expected values** < 2001.
03 = Table index	Start row in table to write received values in a successive manner.

Returned Values

01 = Received bytes	Total number received values.

Error Messages

Err. = 407	`Serial protocol` Check if a 'Setup RS485' tool was executed before using this tool. Check **Timeout in ms.** Check if the number of **Expected values** is equal to **Received bytes.**

Write RS485 Values

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

This tool will send values form the table via the port RS485. The values will be sent in a successive manner from the table beginning at the row defined by the parameter **Table index**. The parameter **Number of values** defines how many values that will be sent.

Note that only 8-bit values (0 .. 255) can be sent.

Input Parameters

01 = Table index Select row in table with the first value that will be sent.

02 = Number of values Total number of values that will be sent in a successive manner.

Since the number of rows in the table are limited to 2000 the **Table index + Number of values** < 2001.

Returned Values

None

Error Messages

Err. = 407 `Serial protocol`

Check if a 'Setup RS485' tool was executed before using this tool.

Example

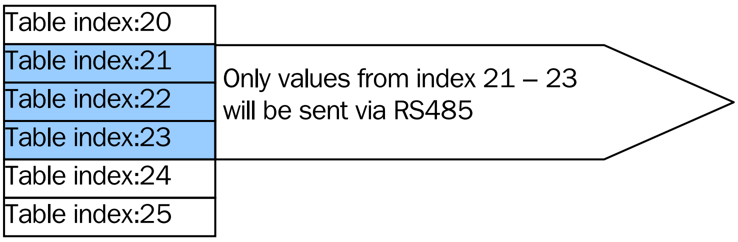


Table index:20
Table index:21
Table index:22
Table index:23
Table index:24
Table index:25

Only values from index 21 – 23 will be sent via RS485

Figure – Example for sending values from table via RS485.
*Input Parameters: **Table index**: 21 and **Number of values**: 3.That means beginning at table index 21 three successive values will be send.*

Read RS485 String

This tool will read a string with up to 4095 characters via port RS485. If there is no string to read the tool waits up to the user defined time limit **Timeout** and then the program will continue to the next step.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

Note that the tool reads only up to 4095 characters at a time. If there are remaining characters in the queue the next 4095 characters will be read the next time the tool is executed. To ensure that the tool reads the first 4095 characters each time it is executed the tool 'Setup RS485' should be inserted before 'Read RS485 string' to clear the queue before a new string is transmitted.

The read string is found in the result value **Received string.**

Input Parameters4

01 = Timeout	Time limit about how long the tool waits to read string via the RS485 port.

Returned Values

01 = Received bytes	Number of received bytes.
02 = Received string	Received string.

Error Messages

Err. 407	`Serial protocol` Check if a 'Setup RS485' tool was executed before using this tool.

Write RS485 String

This tool will write a string with up to 4095 characters via port RS485.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

Input Parameters

01 = String

String to write.
Note that only up to 4095 characters can be sent.

Returned Values

None

Error Messages

Err. 407

`Serial protocol`
Check if a 'Setup RS485' tool was executed in the step program before using this tool.

Err. 8006

The string to send is too long (more than 4095 characters)

Enable Ethernet

This tool handles transmission of result values and images from the device to PC via the Ethernet port. Input parameter **Status** controls if the transmission will be enabled or disabled. Transmission via Ethernet port = enabled is the default setting.

If **Status = false** transmission will be disabled. In this case the 'Display' tool will not be updated with current result values and no image will be shown.

If **Status = true** transmission will be enabled again. After enable the transmission again it is recommended to include a 'Wait' tool with a delay of at least 1 ms in the step program before using tools that need result values or images. This ensures that the values will be available for the following tool.

Input Parameters

01 = Status	`False`	Disable transmission of result values and images from the device to PC via Ethernet port.
	`True`	Enable transmission of result values and images from the device to PC via Ethernet port.

Returned Values

None

Open Ethernet Raw

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

This tool is used for setting up a connection to a device over Ethernet. This connection can be used later in the program for either sending or receiving data from that device.

It is possible to have several connections open at the same time. When sending or receiving data over the connection, the program step where the connection is opened is used as one of the parameters.

The **Transport Protocol** parameter specifies which type of connection to open:

- `Outgoing TCP` Connects to another device using the TCP protocol.
- `Incoming TCP` Waits for other devices to connect using the TCP protocol.
- `UDP` Sends and receives data using the UDP protocol.

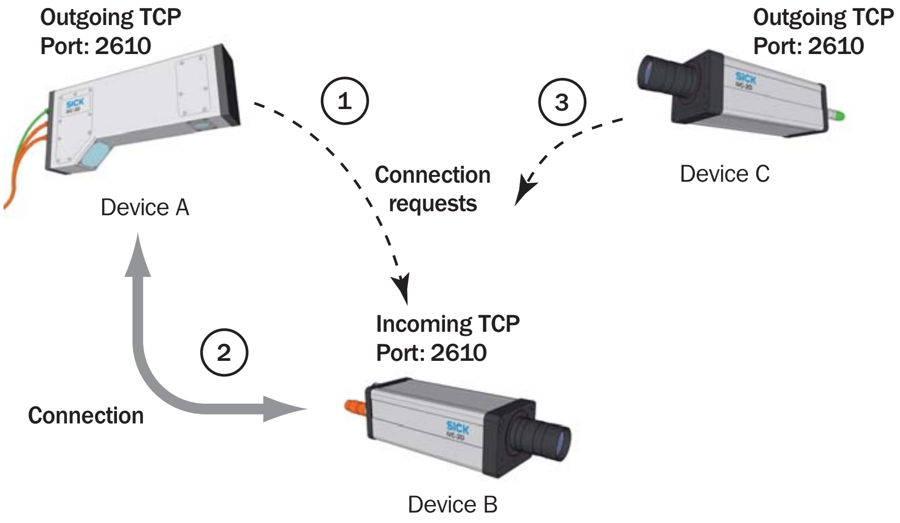
The connection can be set up for communication using either the TCP or UDP protocol. A TCP connection can always be used for both sending and receiving data. An UCP connection can be limited to either sending or receiving by setting the other parameters for the tool.

Please note that the UDP protocol is not safe in that sense that there is no indication whether or not the data was actually received by the other device.

When establishing a connection using TCP between two devices, one of the devices initiates the connection by sending a connection request to the other device. If the other device replies to the request, the connection can be established.

- If the device should initiate the connection, the connection type should be set to Outgoing TCP in the 'Open Ethernet Raw' step.
- If the device should wait for other devices to connect, the connection type should be set to Incoming TCP in the 'Open Ethernet Raw' step. A connection will be established with any device that requests a connection.

For an outgoing connection to be established successfully, the device to which to connect must be waiting for an incoming connection. If the device is an IVC-2D or IVC-3D camera, this means that the camera must have executed an 'Open Ethernet Raw' tool with the **Transport Protocol** parameter set to `Incoming TCP`.



1. *Device A requests a connection to device B on the specified port.*
2. *If the device is waiting for incoming connections, the connection is established and the devices can send and receive data over the connection.*
3. *If another device tries to connect to the same device and on the same port, it will fail since the connection is already busy. The connection must be closed by device B before device C can establish a connection.*

For `Outgoing TCP` connections, the **Associated IP** specifies which device to communicate with and the **Associated Port** specifies which port the other device will listen on. The **IVC Device Port** can be set to 0, in which case the camera's port number will be set automatically.

For `Incoming TCP` connections, the **IVC Device Port** must be set, while the parameters **Associated IP** and **Associated Port** are ignored. This means that the camera will accept a connection from any other device that connects to the **IVC Device Port**.

For `UDP` connections, setting the **IVC Device Port** to 0 will prevent the camera from receiving data over this connection. Likewise, leaving **Associated IP** empty and setting **Associated Port** to 0 will prevent the camera from sending data over the connection. If the **Associated IP** is set, the camera will only receive data from that device.

If an `Outgoing TCP` or `Incoming TCP` connection could not be established before the timeout, the camera will try to re-establish the connection on every subsequent read or write operation. Furthermore, if a connection is closed for any reason, it cannot be used again until it is closed (by using the 'Close Ethernet raw' tool) and reopened again.

Input Parameters

01=Timeout
The time in milliseconds during which the camera will try to establish the connection.

02=Transport Protocol
Type of connection to be established and protocol (TCP or UDP) for the connection.

```
Outgoing TCP
Incoming TCP
UDP
```

03=IVC Device Port
The port number on which the camera will send or receive data. Valid port numbers are `1500–65535`.

For `Outgoing TCP`, this parameter can be set to 0. In this case the port number will be set automatically.

For `UDP`, if this parameter is set to 0 the camera will not be able to receive data on this connection.

04=Associated IP
The IP address of the device to which to establish the connection. If this parameter is set, the **Associated Port** must also be set.

For `Incoming TCP`, this parameter is ignored and can be left empty.

For `UDP`, if this parameter is empty the camera will not be able to send data on this connection.

05=Associated Port
The port number used on the device to which to connect. If this parameter is set, the **Associated IP** must also be set.

Valid port numbers are `1–65535`, however port numbers `1–1023` are usually reserved for the system

For `Incoming TCP`, this parameter is ignored and can be left empty.

For `UDP`, if this parameter is 0 the camera will not be able to send data on this connection.

Returned Values

None.

Error Messages

Err. = 8002	No connection possible to the associated address.

Close Ethernet Raw

This tool closes the Ethernet connection that has been established with a device.

For `Incoming TCP` and `Outgoing TCP`, any data that is queued will be received or sent before the connection is actually closed, which may take an unspecified amount of time.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

Input Parameters

01=Open step	The program step in which the connection was opened.

Returned Values

None.

Error Messages

Err. = 1	The program step referred to by the parameter **Open step** does not contain an 'Open Ethernet raw' tool.

Read Ethernet Bytes

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

This tool is used for receiving a number of bytes – that is, integer values between 0–255 – from another device over an Ethernet connection.

The received values are stored in the table as numerical values. The first received value is stored in table row **Table index**, the next value in row **Table index** +1 etc, until a total number of **Expected bytes** have been received.

If the other device sends more data than expected, the remaining bytes are queued and will be read the next time a 'Read Ethernet' tool is used with the connection.

In order to receive data from a device, a connection to that device must have been opened with the 'Open Ethernet Raw' tool. The program step in which the connection was opened is used as the parameter **Open step**.

Input Parameters

01=Open step The program step in which the connection was opened.

02=Timeout The time in milliseconds during which the camera will try to receive data. This includes the time it takes to establish the connection, if necessary.

03=Expected bytes The number of values that are expected to be received.

04=Table index Table row in which to store the first received value.

The tool will store values in the table rows from **Table index** to (**Table index** + **Expected bytes** -1)

Returned Values

01=Received bytes The number of bytes that have been received and stored in the table.

Error Messages

Err. = 1 The program step referred to by **Open step** is not an 'Open Ethernet Raw' step.

Err. = 8000 Connection timed out.

Err. = 8001 Connection is broken.

Err. = 8002 Not possible to connect to the specified device.

Err. = 8004 The specified connection is for sending data only.

Read Ethernet Bytes Formatted

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

This tool is used for receiving a number of bytes from another device over an Ethernet connection.

The received values are stored in the table as numerical values. The first received value is stored in table row **Table index**, the next value in row **Table index** +1 etc, until all values specified in the **Format string** have been received.

If the other device sends more data than expected, the remaining bytes are queued and will be read the next time a 'Read Ethernet' tool is used with the connection.

In order to receive data from another device, a connection to that device must have been opened with the 'Open Ethernet Raw' tool. The program step in which the connection was opened is used as the parameter **Open step.**

Formatting string

The format of the information to receive is specified in a string where the type and precision is specified for each value. The binary data is formatted according to the IEEE-754 standard. The following formats are available:

Format	Description
Ix	Integer with x bytes (1, 2 or 4 bytes)
Fy	Float with y bytes (4 or 8 bytes)
Uz	Unsigned integer with z bytes (1, 2 or 4 bytes)
Pn	Pad with n bytes (0-999 bytes). The padded bytes will be set to 0.

For padding bytes, no table cell is accessed.

Example:

If the telegram holds two integers with 2 bytes, one integer with 4 bytes and three floats with 4 bytes, the string shall have the following format:

```
I2I2I4F4F4F4
```

Input Parameters

01=Open step The program step in which the connection was opened.

02=Timeout The time in milliseconds during which the camera will try to receive data. This includes the time it takes to establish the connection, if necessary.

03=Table index Table row in which to store the first received value.

04= Format string A string specifying how the values shall be formatted. See table above.

05= Endian Controls Little or Big Endian for the byte order of the received data.

Returned Values

01=Received bytes The total number of bytes that have been received.

Error Messages

Err. = 1 The program step referred to by **Open step** is not an 'Open Ethernet Raw' step.

Err. = 8000 Connection timed out.

Err. = 8001 Connection is broken.

Err. = 8002 Not possible to connect to the specified device.

Err. = 8004 The specified connection is for sending data only.

Err. = 8970 Parsing error. The format string may be empty.

Err. = 8971 Syntax error. The format string does not have the correct format, e.g. the string contains an invalid character.

Err. = 8972 Precision error. The number of bytes is not valid for the specified data type.

Err. = 8974 Buffer too long. The total number of bytes exceeds the size of the Ethernet buffer (currently 4096 bytes).

Read Ethernet String

This tool is used for receiving a string that may contain up to 4095 characters from another device over an Ethernet connection. The received string is available in the returned value **Received string**.

The received string consists of every character that was received until a timeout occurred. If the string that was sent contained more than 4095 characters, the remaining characters will be queued and can be received by using this tool once more with the connection.

In order to receive data from another device, a connection to that device must have been opened with the 'Open Ethernet Raw' tool. The program step in which the connection was opened is used as the parameter **Open Step**.

As the length of the string is not known in advance, this tool will always wait the time specified in the parameter **Timeout** before returning the received string.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

Input Parameters

01=Open step	The program step in which the connection was opened.
02=Timeout	The time in milliseconds during which the camera will try to receive the string. This includes the time it takes to establish the connection, if necessary.

Returned Values

01=Received bytes	The length of the received string., that is the number of bytes that was received.
02=Received string	The received string.

Error Messages

Err. = 1	The program step referred to by **01=Open step** is not an 'Open Ethernet Raw' step.
Err. = 8000	Connection timed out.
Err. = 8001	Connection is broken.
Err. = 8002	Not possible to connect to the specified device.
Err. = 8004	The specified connection is for sending data only.

Write Ethernet Bytes

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

This tool is used for sending bytes – integer values between 0–255 – to another device over an Ethernet connection.

The tool sends the values in the table starting at row number **Table index** and the following rows, until **Number of bytes** values has been sent. If a value is outside the valid range (0–255), the least significant byte of that value will be sent.

In order to send data to a device, a connection to that device must have been opened with the 'Open Ethernet Raw' tool. The program step in which the connection was opened is used as the parameter **Open Step.**

Input Parameters

01=Open step	The program step in which the connection was opened.
02=Timeout	The time in milliseconds during which the camera will try to send data. This includes the time it takes to establish the connection, if necessary.
03= Table index	Table row in which the first value to send is stored.
04= Number of bytes	The number of values to send.

Returned Values

01=Sent bytes	The number of bytes that was sent.

Error Messages

Err. = 1	The program step referred to by **01=Open step** is not an 'Open Ethernet Raw' step.
Err. = 8000	Connection timed out.
Err. = 8001	Connection is broken.
Err. = 8002	Not possible to connect to the specified device
Err. = 8003	The specified connection is for receiving data only.
Err. = 7601	Some of the table entries that should be sent had an incompatible type (only numeric values are allowed).

Write Ethernet Bytes Formatted

This tool is used for sending multiple bytes with a specified format to another device over an Ethernet connection.

The tool sends the values from the table starting at row number **Table index** and continues with the following rows until **Number of value** values has been sent.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

In order to send data to a device, a connection to that device must have been opened with the 'Open Ethernet Raw' tool. The program step in which the connection was opened is used as the parameter **Open Step**.

Formatting string

The format of the information to send is specified in a string where the type and precision is specified for each value. The binary data is formatted according to the IEEE-754 standard. The following formats are available:

Format	Description
Ix	Integer with x bytes (1, 2 or 4 bytes)
Fy	Float with y bytes (4 or 8 bytes)
Uz	Unsigned integer with z bytes (1, 2 or 4 bytes)
Pn	Pad with n bytes (0-999 bytes). The padded bytes will be set to 0.

The format specified in the sting will have precedence over the format in the table cell. E.g. if the table cell holds a float, and the string specifies an integer, the value will be truncated to an integer.

For padding bytes, no table cell is accessed.

Example:

If the telegram holds two integers with 2 bytes, one integer with 4 bytes and three floats with 4 bytes, the string shall have the following format:

```
I2I2I4F4F4F4
```

Input Parameters

01=Open step The program step in which the connection was opened.

02=Timeout The time in milliseconds during which the camera will try to send data. This includes the time it takes to establish the connection, if necessary.

03= Table index Table row in which the first value to send is stored.

04= Number of values The number of values to send.

05= Format string A string specifying how the values shall be formatted. See table above.

06= Endian Controls Little or Big Endian for the byte order of the transmitted data.

Returned Values

01=Sent bytes The total number of bytes that was sent.

Error Messages

Err. = 1 The program step referred to by **01=Open step** is not an 'Open Ethernet Raw' step.

Err. = 8000 Connection timed out.

Err. = 8001 Connection is broken.

Err. = 8002 Not possible to connect to the specified device

Err. = 8003 The specified connection is for receiving data only.

Err. = 8970 Parsing error. The format string may be empty.

Err. = 8971 Syntax error. The format string does not have the correct format, e.g. the string contains an invalid character.

Err. = 8972 Precision error. The number of bytes is not valid for the specified data type.

Err. = 8974 Buffer too long. The total number of bytes to send exceeds the size of the Ethernet buffer (currently 4096 bytes).

Write Ethernet String

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

This tool is used for sending a string to another device over an Ethernet connection.

The maximum length of the string to send is 4095 charactes when using the TCP protocol. When using the UDP protocol, the maximum number of characters to send is 1472.

Only the characters that are contained in the string are sent. No delimiting character – such as a NUL or end-of-line character – is appended to the string.

In order to send strings to a device, a connection to that device must have been opened with the 'Open Ethernet Raw' tool. The program step in which the connection was opened is used as the parameter **Open Step**.

Input Parameters

01=Open step The program step in which the connection was opened.

02=Timeout The time in milliseconds during which the camera will try to send data. This includes the time it takes to establish the connection, if necessary.

03= String The string to send.

Returned Values

01=Sent bytes The number of characters (bytes) that were sent.

Error Messages

Err. = 1 The program step referred to by **01=Open step** is not an 'Open Ethernet Raw' step.

Err. = 8000 Connection timed out.

Err. = 8001 Connection is broken.

Err. = 8002 Not possible to connect to the specified device

Err. = 8003 The specified connection is for receiving data only.

Err. =8006 The string to send is too long (more than 4095 characters when using TCP, more than 1472 characters when using UDP)

Communication Setup

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

The Communication setup tool is used for specifying which parameters the device should publish and subscribe to, using either the Ethernet/IP or the OPC protocol.

This tool only specifies the parameters that should be read from or written to the network. The actual reading and writing of values occurs when a 'Communication Read/Write' tool is executed.

The Communication setup tool can be used several times in a program, and it is possible to change the definition of an already specified parameter. For example, if one Communication setup tool defines that the value from table row 1 should be published as a certain parameter, and another Communication setup tool defines that table row 2 should be published as the same parameter, the actual content of the parameter depends on which Communication setup tool that was executed last.

Input Parameters

None.

This tool is set up by using the interactive setup, which is opened by double-clicking the Setup button. See “Communication Setup” on page 266 for more information on the interactive setup.

Returned Values

None.

Error Messages

Err. = 8101	There is a syntax error in the definition of the assembly.

Communication Read/Write

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

The Communication read/write tool is used for updating values for parameters that are read from the network, and to publish updated parameter values on the network, using either the Ethernet/IP or the OPC protocol.

This tool is used for updating all values read from and published on the network. The **Read/write** parameter specifies whether the tool should update the values of subscribed parameters, publish updated values for other devices to read, or both.

To specify which parameters to subscribe to and publish, use the 'Communication setup' tool.

Input Parameters

01 = Read/Write Specifies whether values should be read from the network, written to the network, or both.

`Read`	Read updated values for the subscribed parameters.
`Write`	Write updated values for the parameters published on the network.
`Read/Write`	Read and write updated values.

Returned Values

None.

Error Messages

Err. = 8103 The value to write was too large for the type of the published parameter, or would need to be rounded (was real when expected integer).

Allowed value ranges are:

SINT:	-128 … 127
INT:	-32 768 … 32 767
DINT:	-2 147 483 648 … 2 147 483 647

Err. = 8104 The value to write was a string when expecting a value, or a value when expecting a string.

Send to FTP

Note: This tool replaces the previous version of the Send to FTP tool. The previous version is made obsolete in IVC 3.1 SR1, and we recommend that the new tool is used instead.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

This tool is used for saving files on an FTP server, files that contain an image, a data block or values from the table. The saved files can either be used for debugging purposes or when developing programs using the Emulator as device.

The device will log on to the FTP server using the supplied user name and password. If there is a firewall between the device and the FTP server and there are problems connecting to the FTP server, setting **Passive mode** to `True` may help.

The files are saved in the location and with the name specified by the **Directory** and **Filename** parameters. You can use expressions to create filenames based on values from the table and results from other steps. For example, by setting **Directory** to `‘images’`, and **Filename** to:

```
='image_no_' + str(V2) + '.jpg'
```

the image will be saved in the `images` directory on the FTP server with the file name `image_no_19.jpg`, if the table row 2 contains the value 19.

Images can be saved in either raw, grayscale JPEG, or color JPEG format. Images saved in raw format can be imported and used in IVC Studio. Use the raw format if the images are to be used by the Emulator; make sure that the file names have the extension .raw (2D and 3D images) or .img (3D images). Note that the raw format is no longer compatible with bmp for 2D images. Use instead the bmp option for this. When saved in grayscale JPEG the image is saved without any added graphics (such as ROIs and results added by other tools), whereas they would be included if saved in color JPEG format.

The **Quality factor** parameter sets the compression ratio for the images when saving in JPEG format.

When saving data, the tool saves the values from the table to the file, from row number **Table index** and up to (but not including) row number **Table index** + **Number of elements**.

The tool can transmit images and table data in the same call. In this case, the filename and folder will specify the location for the image file, and the table information will be stored in a file called “TableData.txt”. This file will be stored in a folder called Data which is located in the image folder. For example, if the image file is specified as ‘`images\110114\image_xx.jpg`’, the table data will be stored in the file `‘images\110114\data\TableData.txt’`.

If a data block is transmitted, no other data type is allowed, and the parameters **Table index** and **Image bank** must be set to -1.

Note: the parameter **Timeout** refers to interruptions during the transfer of FTP data. E.g. if the parameter is set to 1000 ms (1 second), the transfer will still be successful even if the total time of the transfer exceeds 1 second. The transfer will in this case report timeout only if the time between two consecutive data packets containing the image exceeds 1 second.

The parameter **Quote command** can be used to send a generic command to the FTP server. If this parameter is used, the command text entered in the parameter will be sent to the FTP server immediately after a successful connection. If the parameter is empty (default), no command will be sent. If the FTP server fails to interpret or handle the command, the connection will be terminated and no data will be sent.

The tool can store table data in two formats:

Configuration

This format is compatible with the Get from FTP tool and the table data file can only hold one set of data. The first row in the file specifies the number of data rows, and each of the following rows contain datatype and actual data.

Example:

```
3
0 429
2 1.717000e+01
3 6 ‘Hello
```

The file contains three rows of data from the table. The first row contains an integer, the second row a double float and the last row contains a string. The length of the string is also specified.

The available data types are:

0: Long integer
1: Single float
2: Double float
3: String

CSV Append / CSV Overwrite

This format is compatible with Excel and each value is separated by a comma. When the Append format is specified, each call to the tool will result in a new row in the file.

Example:

```
429,17.17,Hello
429,18.18,World
```

The file contains two rows. Decimal separator is always ‘.’ for floating values.

Input Parameters

01=IP address	The IP address of the FTP server to connect to.
02=Port	The port number used on the FTP server to connect to.
03=Username	A user name used for connecting to the FTP server.
04=Password	The password for the user on the FTP server.
05=Timeout	Timeout in milliseconds for connection and transmission of the data.
06=Passive mode	Specifies whether or not to use passive mode when connecting to the FTP server.
07=Directory	Directory on the FTP server where the file shall be stored. The directory will be created if it does not exist. The folder name cannot contain backslash ‘\’. Use the slash ‘/’ character to separate folders.
08=Filename	The name of the file where the information shall be stored. The filename cannot contain slash nor backslash characters.
09=Data block	The ID of the data block to transmit. Set to -1 if not used.
10=Source bank	The index of the image bank to transmit. Set to -1 if not used.

11=Image format The image format in which the image should be saved:

`raw`
`jpeg color`
`jpeg greyscale`
`bmp color`
`bmp greyscale`

Choose raw or bmp greyscale if the images are to be used by the Emulator.

12=Quality factor When Image format is set to `Jpeg gray` or `Jpeg color`, this sets the compression ratio of the saved image. Possible input values: 1–100.

`100` Highest quality of the image (no jpeg compression)

`1` Low image quality and short execution time (maximum jpeg compression).

13=Table index Table index of the first row of data to send. Set to -1 if not used.

14=Number of elements Number of table rows to send.

16=Quote command A generic command that can be sent to the FTP server.

17=Table format Specifies the format of the information stored in the table data file. The parameter can have the following values:
`Configuration` – The contents of the file can be reloaded using the Get from FTP tool. The file will always be overwritten if it exists.
`CSV Overwrite` – The data is stored with each value separated with a comma. The file is always overwritten.
`CSV Append` – The data is stored with each value separated with a comma. The data is appended if the file exists.

Returned Values

None

Error Messages

Err=158 The specified data block is invalid or does not contain any data.

Err=8900 Could not connect to the FTP server.
Check IP address and port number.
Check user name and password.
Check firewall settings and try using Passive mode.

Err=8901 The account for the specified user name is invalid

Err=8902 Access denied.

Err=8903 Timeout

Err=8904 No connection to the FTP server

Err=8906 The specified directory was not found

Err=8907 The FTP server did not understand or could not handle the Quote command.

Err=8909 At least one of the data types (datablock, image or table) must be specified.

Get from FTP

This tool retrieves a data block, an image, or a number of table rows from a file that is stored on an external FTP of the camera.

Note that the information is only stored in the working memory of the camera (i.e. the table, an image bank or a data block). The tools for saving information to flash (‘Save Data Block to Flash’, ‘Save Image to Flash’, and ‘Write Table to Flash’) shall be used if the data retrieved by this tool shall be persistently stored on the camera flash.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

The camera will log on to the FTP server using the supplied user name and password. If there is a firewall between the camera and the FTP server and there are problems connecting to the FTP server, setting **Passive mode** to `True` may help.

Note: the parameter **Timeout** refers to interruptions during the transfer of FTP data. E.g. if the parameter is set to 1000 ms (1 second), the transfer will still be successful even if the total time of the transfer exceeds 1 second. The transfer will in this case report timeout only if the time between two consecutive data packets containing the image exceeds 1 second.

The tool can only retrieve one type of data from the specified file, e.g. if an image shall be retrieved, the parameters **Data block**, and **Table index** shall be set to -1. If more than one of these parameters have values that are not -1, an error will be reported.

The tool can also be used to transfer a file from an FTP server directly to the flash disk of the camera. In this case, the parameters **Image bank**, **Table index** and **Data block** shall be set to -1. The file will be copied to the flash with the same name as on the FTP server. The length of the file name is limited to 15 characters (including extension) for the flash. Note that the file will overwritten if it already exists in the flash. This behavior is controlled by the parameter **Save Mode**.

Note: For IVC-2D grayscale bitmaps (*.bmp) and raw images (*.raw or *.img) are supported by the tool, and for IVC-3D only raw (*.raw or *.img) images are supported.

Input Parameters

01=IP address	The IP address of the FTP server to connect to.
02=Port	The port number used on the FTP server to connect to.
03=User name	A user name used for connecting to the FTP server.
04=Password	The password for the user on the FTP server.
05=Timeout	Timeout in milliseconds for connection and transmission of the data.
06=Passive mode	Specifies whether or not to use passive mode when connecting to the FTP server.
07=Directory	The directory on the FTP server where the file is stored.
08=Filename	The name of the file in which the information is stored.
09=Data block	The number of the data block in working memory in which the information shall be stored. Set to -1 if not used.
10=Image bank	The index of the image bank where to store the image file. Set to -1 if not used.
11=Table index	The index of the table where the elements from the file shall be stored. Set to -1 if not used.

12=Save Mode	Controls how the retrieved file shall be stored in the camera: **RAM Only** – The file will be stored in RAM only in an image bank, data block or in the table. **FFS Only** – The file will be stored only on the flash. The parameters 9-11 must in this case be set to -1 **RAM and FFS** – The file will be stored both in RAM and on the flash.

Returned Values

None

Error Messages

Err=8900	Could not connect to the FTP server. Check IP address and port number. Check user name and password. Check firewall settings and try using Passive mode.
Err=8901	The account for the specified user name is invalid
Err=8902	Access denied.
Err=8903	Timeout
Err=8904	No connection to the FTP server
Err=8905	The specified file was not found
Err=8906	The specified directory was not found
Err=8909	At least one datatype (image, datablock or table) must be specified.
Err=8910	When storing a file to the flash, the parameters **Data block**, **Image bank** and **Table index** must be set to -1.
Err=8911	Only one datatype (image, datablock or table) can be specified in the same call.
Err. = 8960	The amount of dead space on the flash exceeds the specified threshold. Please defragment the disk by using the Clear Unused Memory option on the Flash menu in the Device list.
Err. = 8961	The automatic defragmentation failed. The camera may need to be restarted to restore the flash.

Get SNTP Time

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

The IVC camera can be configured to synchronize with an external SNTP time server. The IP address of the time server is configured in the Ethernet Device Settings dialog. Please refer to Setting Device Parameters for details. The synchronization is then performed when the camera is rebooted.

This tool is used to force synchronization with an SNTP server during execution of the step program.

The parameter **IP address** shall hold the IP address of the SNTP server. If no address is entered, the default value from the Ethernet Device Settings will be used.

The parameters **Time format** and **Time zone** control how the results from the tool are calculated. **Time zone** specifies the offset from UTC time in hours, and the **Time format** specifies how the date shall be returned. The following table shows the available combinations.

Format	Value	Example
YYYY-MM-DD hh:mi:ss	0	2010-09-02 20:51:33
DD.MM.YYYY hh:mi:ss	1	02.09.2010 20:51:33
MM/DD/YYYY hh:mi:ss AM/PM	2	09/02/2010 08:51:33 PM

The tool returns the synchronized time, both as seconds, and as a date/time string as specified in the table above.

Input Parameters

01=IP address The IP address of the SNTP server to connect to.

02=Timeout Timeout in milliseconds to wait for the SNTP server to respond.

03=Time format The format that the date/time string shall use.

04=Time zone The offset in hours from UTC.

Returned Values

01=Seconds The number of seconds since 1 January 1970.

02=Time A string holding date and time in the format specified in the **Time format** parameter.

Error Messages

Err=8002 Could not connect to the SNTP server.
Check IP address.
Check firewall settings, SNTP uses UDP on port 123.

Err=8000 The SNTP server did not respond within the specified timeout.

4.12 Input/Output

INPUT

Read Input

This tool reads the state of an input signal and returns the current status (High or Low). This enables synchronization of the step program with an external input.

In addition, it is possible to set the tool to wait until the input signal has a specified state, by setting the **Wait** parameter to `True` and **Wait for** to the state to wait for. Please note that when running a program that contains such a step, the execution will be halted indefinitely until the signal changes to the selected state. When executing the program step using Execute Step or Step by Step, the tool will time out after 100 ms.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

Input Parameters

01 = Input number The input signal to read the status of:

Value	*Signal*	*Pin*	*Color*
`0`	Trigger In/In 0	Power connector, pin 1	White *
`1`	In 1	Power connector, pin 5	Gray *
`2`	In 2	Power connector, pin 6	Pink *
`3`	In 3 (IVC-2D)	RS485 connector, pin 8	Red **

* Color is valid for cable type DOL-1208-

** Color is valid for cable type STL-1208-

02 = Wait

`True` Wait until the input signal is high or low, as specified by **Wait for.**

`False` Read the status immediately. The input parameter **Wait for** is ignored.

03 = Wait for The input signal to wait for.

```
High
Low
```

Returned Values

01 = Signal value Actual status on selected pin.

```
0 = Low
1 = High
```

OUTPUT

Set Output

This tool sets an output status on a selected pin.

Input Parameters

01 = Output number Selects pin where to set output status.

Value	*Signal*	*Pin*	*Color*
`0`	Out 0	Power connector, pin 3	Green *
`1`	Out 1	Power connector, pin 4	Yellow *
`2`	Out 2	RS485 connector, pin 3	Green **

* Color is valid for cable type DOL-1208-

** Color is valid for cable type STL-1208-

02 = Signal value Status :
`High`
`Low`

Returned Values

None

OUTPUT

Set All Outputs

This tool sets all outputs to individual user defined values at the same time.

Input Parameters

01 = Set all outputs

Value	*Outputs*		
	Out 0	Out 1	Out 2
0	Low	Low	Low
1	High	Low	Low
2	Low	High	Low
3	High	High	Low
4	Low	Low	High
5	High	Low	High
6	Low	High	High
7	High	High	High

Output	*Pin*	*Color*
Out 0	Power connector, pin 3	Green[*]
Out 1	Power connector, pin 4	Yellow[*]
Out 2	RS485 connector, pin 3	Green[**]

[*] Color is valid for cable type DOL-1208-

[**] Color is valid for cable type STL-1208-

Returned Values

None

Set Timed Output

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

This tool sets an output status independent from the step program. It is useful to customize the status, duration and delay of outputs.

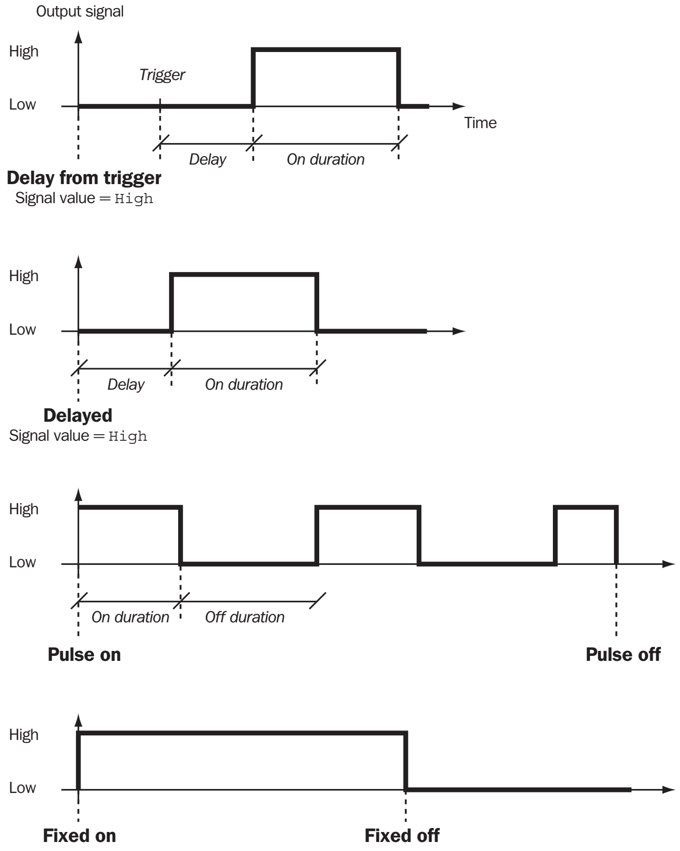
The output can be set in the following ways:

Delay from trigger After being triggered by the 'Trigger in' signal, it waits for a specified time and then sets the output signal.

Delayed The output signal is set after a specified delay time.

Pulse on/Pulse off **Pulse on** starts a pulsed signal on the output, which alters between high and low after specified duration times. This signal is stopped by using another 'Set timed output' tool with **Pulse off**.

Fixed on/Fixed off Immediately sets the signal to high or low respectively.



Since this tool runs as independent task it does not affect the execution time of the program steps.

Input Parameters

01 = Output number
Specifies which output signal to set.
`0` = Out 0
`1` = Out 1
`2` = Out 2

02 = Type

`Delay from trigger`
When triggered by the Trigger In signal, it waits for the **Delay time** before setting the output to **Signal Value.** After the time in **On duration**, the signal is reversed.

How and when to trigger is set in the 'Grab setup' tool.

`Delayed` Waits for the **Delay time** before setting the output to **Signal Value.** After the time in **On duration**, the signal is reversed.

`Pulse on` Starts a pulsing output. Immediately sets the output to high for the time in **On duration**, then sets it to low for the time in **Off duration.** This is repeated until a 'Set timed output' tool is executed with **Type** set to `Pulse off`, the output is set by another tool, or the camera is powered down.

`Pulse off` Stops a pulsing output that has been started by a 'Set timed output' tool with **Type** set to `Pulse on`,

`Fixed on` Immediately sets the output to high.

`Fixed off` Immediately sets the output to low.

03 = Delay time (ms)
The delay time when **Type** is set to `Delay from trigger` or `Delayed`. 0 – 10.000 ms.

04 = On duration (ms)
The time during which the signal is set to **Signal value** (**Type** is `Delay from trigger` or `Delayed`) or high (**Type** is `Pulse on`). 0 – 10.000 ms.

05 = Off duration (ms)
The time during which the signal is set to low when **Type** is set to `Pulse on`. 0 – 10.000 ms.

06 = Signal value
Specifies how to set the output signal when **Type** is set to `Delay from trigger` or `Delayed`.

Can be set to `High` or `Low`.

Returned Values

None

Set Output by Distance

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

This tool is used when an output shall be activated at a specified conveyor belt position based on encoder pulse counting.

The method to use encoder pulses makes it possible to create applications that are insensitive to different conveyor belt speeds or speed variations. It is possible to control the length of the output signal either depending on encoder pulse counting or depending on time.

The tool calculates the number of pulses between the start position and the requested output position by using internal information about number of profiles per mm from the Grab Setup tool and the delay distance input parameter. The encoder value for the start position can be retrieved as an output from the Grab tool.

Each output number has a separate queue where up to a hundred encoder based output requests can be waiting for activation to allow for several inspections between the camera and the output position. The output requests of each queue are then activated when the encoder pulse counter reaches the correct position. Each element in the queue holds information about the Delay and Duration distances as well as the timeout.

The tool can operate in two modes; allowing only discrete outputs or allowing outputs to overlap. This is controlled by the parameter **Allow overlap**. If the parameter is set to **True**, two overlapping outputs will be merged into one. This mode can be useful in situations where the output duration is set high outside the object (before and/or after) in combination with objects lying close together.

The tool returns the encoder positions where the output shall be activated and deactivated. Note that if the parameter **Allow overlap** is set to **True**, the values may be for a merged output.

Note: The Encoder control must be selected in the Grab Setup in order to use this tool.

Input Parameters

01 = Delay distance (mm)	The distance from the start position to the position where the output should be activated.
02 = Start tick	Encoder value at the start position.
03 = Signal value	Indicates if the active period is a high or low value on the output signal.
04 = Pulse on duration (mm)	The distance during which the output should be active. If the value is 0, only timeout will be used.
05 = Timeout (ms)	The maximum time that the output shall be active. If the value is 0, no timeout will be used.
06 = Output number	The output that should be activated. There are three available outputs 0, 1, 2.
07=Allow overlap	If set to **True**, outputs may be merged if they overlap. The default setting is **False**.

Returned Values

01 =ON tick	Encoder value when the output will be activated.
02 = OFF tick	Encoder value output will be de-activated.

Error Messages

Err. = 7950	Delay Distance is too long. The number of encoder pulses may not be larger than the encoder wrap value (set in Grab Setup)

Err. = 7951 Invalid distance. Outputs may not be added too close to the current position.

Err. = 7952 Invalid position. New output may not overlap current output.

Err. = 7953 The queue is full.

Err. = 7954 Synchronization error.

Err. = 7955 Invalid parameter in Grab Setup. Encoder control must be selected.

Err .= 7956 The output queue already contains one or more elements with a different setting of the Allow overlap parameter.

Clear Output Queues

This tool will remove output requests added to the output request queues by the Set Output by Distance tool.

If the step program using the Set Output by Distance tool is stopped and restarted, the queued elements will remain in the queues. This can lead to undefined behaviour if the conveyor belt is moved, or items on the belt are moved during the time when the step program was not executed.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

Input Parameters

01 = Output queue 0	`Ignore`	The contents of the queue and the output will not be affected.
	`Signal High`	The queue will be cleared and the output is set to high.
	`Signal Low`	The queue will be cleared and the output is set to low.
02 = Output queue 1	`The parameter can have the same values as` **Output queue 0**	
03 = Output queue 2	`The parameter can have the same values as` **Output queue 0**	

Returned Values

None

Get Encoder Tick

This tool returns the current encoder value and is used for synchronization with external equipment.

Note: This tool requires FPGA 1.5.0.12 that is available in IVC-Studio 2.6 SR1 or later versions.

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

Input Parameters

None

Returned Values

01 = Encoder Tick	Current encoder value.

Encoder Difference

This tool is used to calculate the difference between two encoder positions. It returns three values:

- The difference in number of encoder ticks
- The distance in mm between the two positions
- The number of profiles captured between the two positions

The Emulator does not emulate this tool. See section Handling the Emulator for more information.

The tool handles the case when the encoder has wrapped i.e. when value B is lower than value A.

To use this tool in a program, Encoder controlled must have been selected in the Grab setup tool and Pulses per mm must be set.

Notes: Encoder values can be taken from the returned values of the ‘Get Encoder Tick’ step, or ‘Grab’ step.

This tool requires FPGA 1.5.0.12 that is available in IVC-Studio 2.6 SR1 or later versions.

Input Parameters

01 = Encoder value A	The first encoder value
02 = Encoder value B	The second encoder value

Returned Values

01 = Difference in ticks

02 = Difference in mm

03 = Number of profiles

Set LED

This tool sets the color of the LED with the label “function” on the device, or turns it off.

Input Parameters

01 = Set LED	Select one of the four options:
	`Off`
	`Green on`
	`Red on`
	`Yellow on`

Returned Values

None

4.13 Reader

Read Barcode

The Read barcode tool is used for reading linear barcodes in images. The tool can read the following barcode formats:

Pharmacode
EAN-8
EAN-13
UPC-A
UPC-E
PDF417
Code 32
Code 39
Code 128
Interleaved 2of5
Code 2/5 industrial

This tool has an interactive setup in which you can set the input parameters and immediately see how the result is affected by the changes. The interactive setup is opened by double-clicking the Setup button.

This tool has a number of options for improving the reliability of the reading, but which also may affect the execution speed:

- With the **Interpolation method** parameter you can choose which interpolation method to use for analyzing the thickness of the bars.
- Setting the **Variable bar length** parameter can compensate for differences in thickness of the bars, for example if the barcodes are viewed from an angle, or if they are wrapped around a bottle.
- By setting the **Normalization** parameter, the images will be normalized before reading the barcode to reduce variations in exposure, which may make the reading more accurate.
- If the barcode type supports checksums, the tool will verify the read barcode if the **Use checksum** parameter is set.

The tool returns the code that was read as a string in **Read string**. In addition **Edge has defects** indicates whether there was any dark areas found in the edge of the barcode.

When reading Pharmacode barcodes, the tool returns a quality factor for the reading in **Reading reliability.** This quality factor is the percentage of the readings that were successful, based on the number of reading set by the **Max number of readings** parameter.

The reading of PDF417 barcodes requires stable lighting conditions and at least 3.5 pixels per “cell” in the barcode to perform reliably.

Input Parameters

01=Source bank Image bank containing the image with the barcode to be read.

02=ROI definition step The program step where the ROI was defined.

03=Code type The type of barcode to read.

04=Max number of readings The maximum number of times the tool should try to read the barcode before reporting an error.

05=Reading direction The direction in which to read the barcode.

`Horizontal` reads the barcode from both from left to right and from right to left.

`Vertical` reads the barcode in both directions: up and down.

`Left->right` reads the barcode left to right.

`Right->Left` reads the barcode right to left.

`Down->up` reads the barcode down and up.

`Up->Down` reads the barcode up and down.

06=Relative threshold Required change of height value between bars and spaces.

07=Interpolation method Method to use when analyzing the thickness of the bars:

`Linear`
`Third-degree`

08=Variable bar lengths Specifies whether or not the bars in the image of the barcode can have different thickness.

09=Normalization Specifies whether or not the height value in the image should be normalized before reading the barcode.

10=Display code Specifies whether or not the read code should be added to the image in the destination bank.

11=Use checksum Specifies whether or not the read code should be verified using the checksum in the barcode.

Checksums are only used in certain barcode types.

12=Min number of characters The minimum number of characters to be read for the barcode to be considered valid.

13=Destination bank Image bank in which the resulting image will be stored.

Returned Values

01=Error flag Flag = 0 if the barcode was read without problems.

02=Read string A string containing the code that was read.

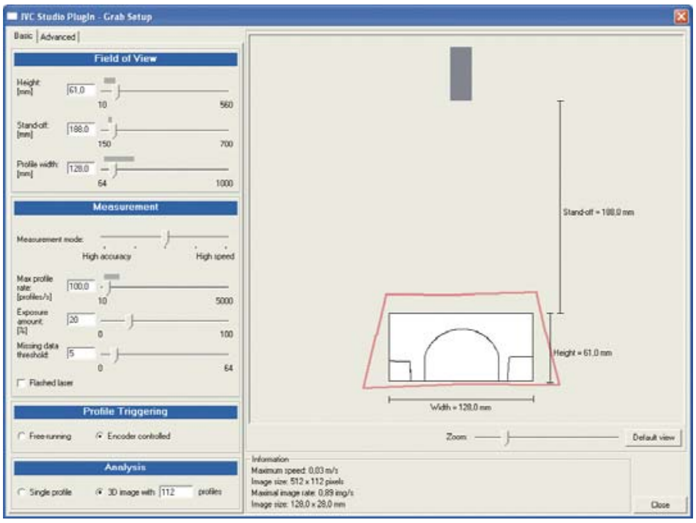
03=Reading reliability For Pharmacode barcodes, the percentage of the readings that were sucessful.

04=Edge has defects Flag = 1 if there was any dark areas found in the edge around the barcode

5 Interactive Setups

Grab Setup

The Grab setup tool is used for setting up the IVC-3D camera before capturing profiles or 3D images with it. The effects of the settings are previewed as the profile inside the white box in the right pane in the window.



IVC Studio Plugin - Grab Setup

Basic | Advanced

Field of View

Height [mm]: 61,0 (10 – 560)

Stand-off [mm]: 188,0 (150 – 700)

Profile width [mm]: 128,0 (64 – 1000)

Measurement

Measurement mode: High accuracy – High speed

Max profile rate [profiles/s]: 100,0 (10 – 5000)

Exposure amount [%]: 20 (0 – 100)

Missing data threshold: 5 (0 – 64)

□ Flashed laser

Profile Triggering

○ Free-running ● Encoder controlled

Analysis

○ Single profile ● 3D image with 112 profiles

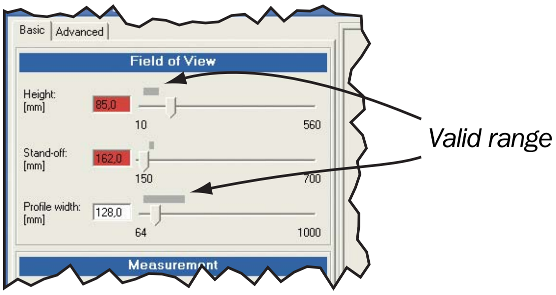
Information
Maximum speed: 0,03 m/s
Image size: 512 x 112 pixels
Maximal image rate: 0,89 img/s
Image size: 128,0 x 28,0 mm

Figure – The Grab Setup interactive setup window

The IVC-3D can be set up to capture either single profiles, or 3D images where each image is made from a number of profiles. In addition it may be necessary to adjust the measurement settings in order to improve the quality or rate of the images.

Even though the IVC-3D camera is capable of capturing a large number of profiles per second, there is a limit for how much data the camera can handle. In a time critical application it may be necessary to balance size, resolution and speed in order to get a satisfactory result from the analysis. A large image takes longer time to capture, which will reduce the maximum number of the images that the camera can produce per second.

The interactive setup helps keeping track of the limits of the camera. If a value is set outside the currently valid range, it is marked with red. The same will happen if one setting affects the valid range of another setting, so that the latter value comes outside the new valid range.



Basic | Advanced

Field of View

Height: [mm] 85,0 (10 – 560)

Stand-off: [mm] 162,0 (150 – 700)

Profile width: [mm] 128,0 (64 – 1000)

Measurement

Figure – Parameter values outside the valid range are marked with red

Capturing Profiles

Field of View

The field-of-view (FOV) is the area within the laser plane in which the device will look for a profile to capture. The parts of a profile that are outside the FOV are either ignored (if to the right or the left of the FOV) or treated as missing data (if above or below the FOV).

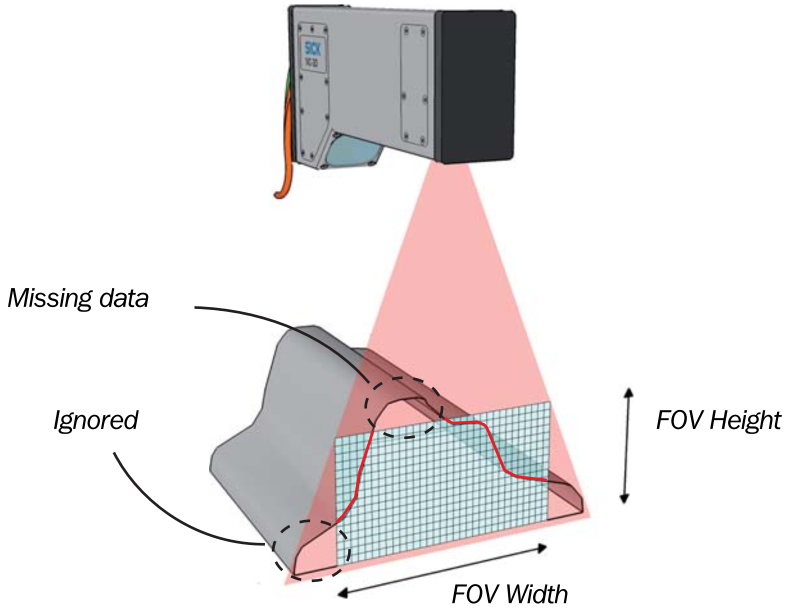


Figure – The field of view (FOV) and captured profile

Both the size and the location of the FOV affect the maximum profile rate.

The resolution of the resulting profile (width resolution) can be set in three ways:

- Manually
- Automatically – the resolution will be set to 75% of the maximum resolution.
- Square pixels – used when capturing 3D images to get the same resolution along the X axis as along the Y axis in the resulting images.

The maximum width resolution depends on which measurement method is use; Robust or High resolution.

Note that the width of the FOV will be adjusted so that the width of a profile will always be a multiple of 32 pixels.

Reference Level

The reference level is a line across the profile where the height is considered to be the same. This level can be rotated, for example to compensate for the device not being mounted parallel with the axis along which the height should be measured.

Note that when the reference level is rotated, the IVC-3D will still be measuring in a FOV that is aligned with the device, but that the captured profile will be adjusted before being made available for the step program.

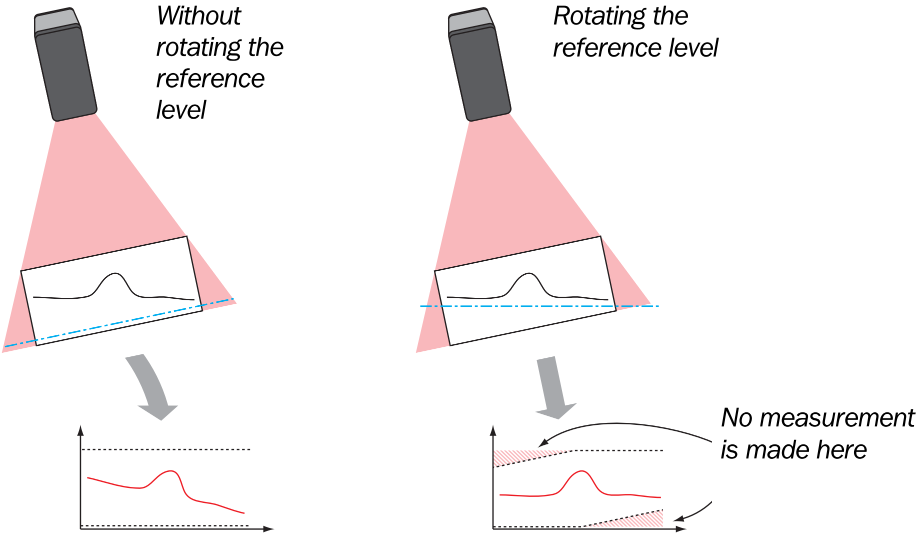

Without rotating the reference level
Rotating the reference level
No measurement is made here

Figure –Measuring with a rotated IVC-3D

Triggering Profiles

The IVC-3D captures profiles in either *free-running* mode or *triggered* by an encoder:

- In free-running mode, the device will capture a new profile after a constant time interval, determined by the Profile rate setting. The actual distance between two profiles depends on the speed of the object.
- When triggered by an encoder, the device will capture a new profile when the object has moved a constant distance, which is set by the Profile distance setting. The time between capturing two profiles depends on the speed of the object.

  The shortest time between two profiles is determined by the Max profile rate setting. If the encoder runs faster than this – that is, triggers profiles faster than the device can produce them – profiles may be lost.

The highest possible profile rate is shown in the interactive setup window as the upper limit of the Profile rate/Max profile rate setting. This rate is affected by the size and location of the FOV, and the measurement settings.

Capturing 3D Images

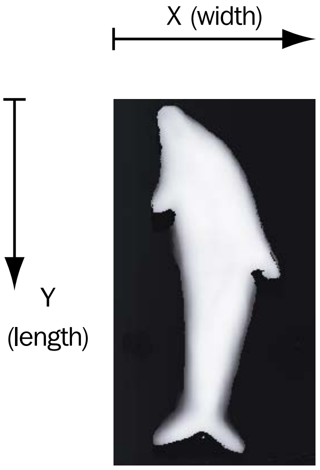
3D images are generated from a sequence of captured profiles. The resolution of the 3D image depends on settings for capturing profiles:

- The resolution along the X-axis is the same as the width resolution for the profiles.
- The resolution along the Y-axis is defined by the distance between two profiles, which is set by Profile distance.

  When Profile triggering is set to Encoder controlled, this will be the true distance between the profiles.

  When set to Free-running, it is the assumed distance between two profiles. The actual distance depends on the speed of the object – that is, how far the object has moved during the time between the profiles. This time is specified by the Profile rate setting.

To capture 3D images where the objects have the right proportions, set the width (X) resolution to Square pixels.



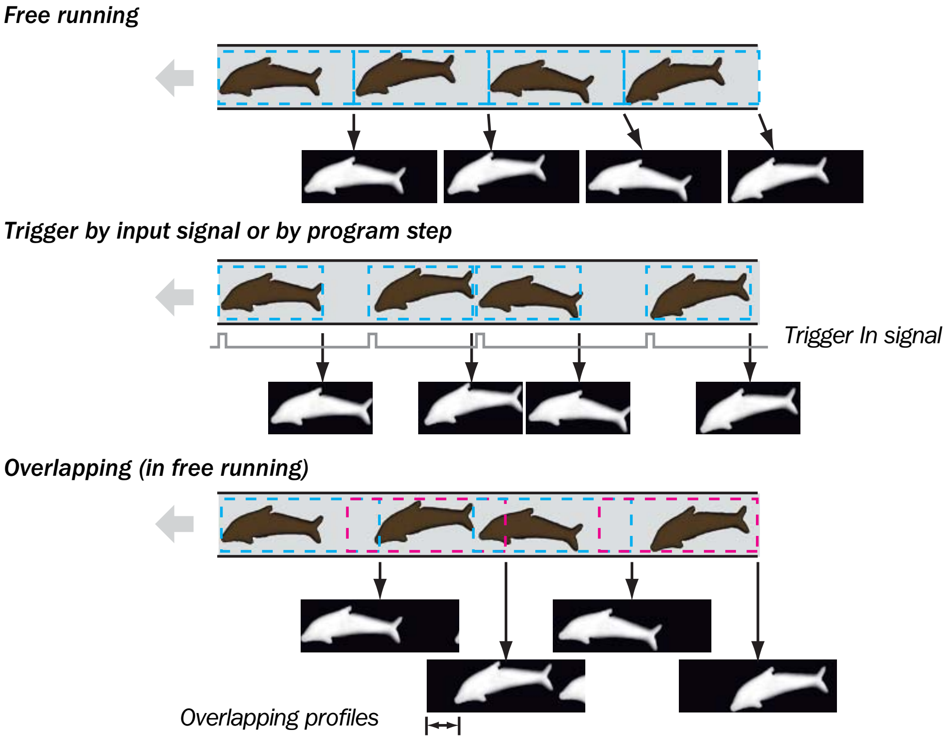
Triggering 3D Images

There are three different ways to trigger an image – that is, when to capture the first profile in the image:

Free running — A new image will be started as soon as the previous image is ready.

Trigger by input signal — A new image is started when the Trigger In signal becomes high.

Trigger by program step — A new image is started when a 'Grab on command' tool is executed in a step program.


Free running

Trigger by input signal or by program step

Overlapping (in free running)

Figure – Methods for triggering 3D images

When capturing 3D images in free-running mode, it is possible to capture overlapping images, which means that a number of profiles will be included in both the current and the next image.

If the device is triggered to capture a new image before it is finished capturing an image, that trigger is ignored and the device will continue capturing the image until finished.

Adjusting Exposure

The Exposure amount specifies the exposure when capturing a profile. The exposure is specified as a percentage of the maximum possible exposure, which is usually limited by the Profile rate/Max profile rate setting.

This setting works different depending on whether or not Flashed laser is selected:

- When not selected, the exposure is controlled by adjusting the sensitivity of the sensor inside the device.
- When selected, the sensitivity of the sensor is set to maximum and the exposure is controlled by adjusting the duration of the flashes.

Too much laser light may cause overexposure in some parts of the object, which leads to lower measurement accuracy in those parts. It is therefore recommended to adjust the exposure so that no important parts of the object are overexposed. In the preview, overexposed parts of the profile are colored red.

If an encoder is used and the speed of the objects varies, it is recommended to use flashed laser. Since the time between two profiles may vary, the exposure of the object would also vary if the laser would be on all the time. This may lead to lower profile quality, but is avoided if using flashed laser.

For setups with continuous laser, the first profile of the image will be discarded and set to missing data. The reason for this is that the sensor has been exposed to light for an “infinite” time, and the pixels of the sensor are saturated. This is not the case when using overlapping images, as the exposure of images is performed continuously preventing the sensor from being over exposed.

Reflection handling

In some situations reflections from the objects could by mistake be interpreted as the profile. The best way to avoid this is to adjust the FOV so the reflections are outside the FOV. If this is not sufficient there three different methods for how to treat any reflections:

Normal	Choose the height value with the highest intensity.
Top-most	Choose the highest height value with intensity higher than the specified threshold.
Bottom-most	Choose the lowest height value with intensity higher than the specified threshold.

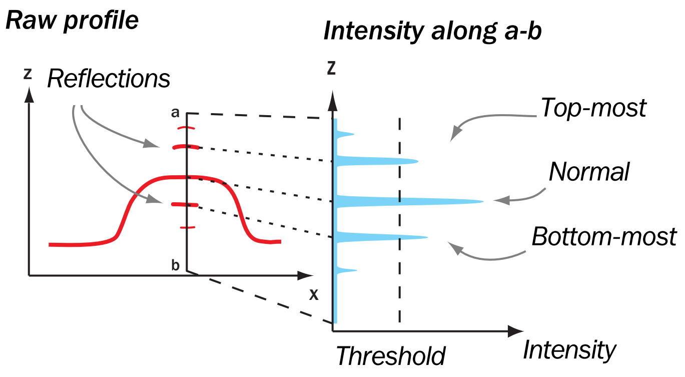


Figure – Methods for handling reflections

Settings

Field of View

The Field of view settings are used for setting the area within the laser plane in which the device will look for a profile to capture. The current field of view is shown in the right pane, together with the profile that the IVC-3D currently reads inside the FOV.

Height (mm)
Stand-off (mm)
Profile width (mm)

Sets the size and location of the field of view (FOV).

Measurement

The Measurement settings can be used for adjusting the quality of the profiles, and the rate at which profiles can be captured. Note that the size and location of the FOV also affects the valid profile rates.

Measurement mode

Specifies which measurement method to use for detecting the profile. The method with the highest accuracy also takes longest time and vice versa

Changing measurement method will affect the maximum profile rate.

Profile rate /
Max profile rate

When profile triggering is free running, Profile rate sets the time to wait before capturing a new profile.

When using an encoder, Max profile rate sets the highest rate at which profiles should be captured.

Exposure amount

When Flashed laser is not selected, sets the sensitivity of the sensor inside the IVC-3D.

When Flashed laser is selected, sets the duration of the flash as a percentage of:

- The time between two profiles, as set by Profile rate when profile triggering is Free-running.
- The shortest time between two profiles, as set by Max profile rate when using an encoder.

Missing data threshold

Sets the minimum brightness of a point on the profile to be considered a valid height. If the brightness is lower than this threshold, that point will be set to missing data.

Flashed laser

Specifies whether or not to use flashing laser.

Profile Triggering

The Profile triggering settings are used for selecting between capturing profiles in free-running mode or triggered by an encoder.

When using an encoder, the IVC-3D counts the number of pulses – or ticks – since the camera was rebooted. This encoder tick value is returned with the profile or image by the 'Grab' tool, and can be used for example to synchronize other devices.

Free-running

Profiles are captured after a specified time interval. The time is set by Profile rate.

Encoder controlled

Profiles are captured after a specified number of pulses on the Encoder input. The number of pulses is set by Pulses per mm and Profile distance (mm).

Encoder tick counter wraps around at

When using an encoder, sets the highest value of the encoder tick counter. When this value is reached, the tick count is reset to 0.

Analysis

The Analysis settings are used for selecting between capturing profiles or 3D images.

Single profile	Specifies that the IVC-3D should capture profiles.
3D image with ... profiles	When capturing 3D images, the number of profiles to use for each image is set. This will also be the size of the 3D images in pixels along the Y axis. The resolution along the Y axis is determined by Profile distance (mm).

Width Resolution

The Width resolution settings are used for setting the resolution along the X axis in the captured profiles or 3D images. The maximum possible width resolution depends on which measurement method is used.

When setting width resolution, the width of the FOV may be adjusted so that the width of a profile is always a multiple of 32 pixels.

Square pixels	Sets the resolution along the X axis to be the same as the profile distance in mm.
Automatic	Sets the resolution along the X axis to 75% of maximum.
Manual (mm/pixels)	Sets the resolution along the X axis, in mm/pixels.

Measurement method	Robust	Less sensitive to reflections and noise than the High resolution method.
	High resolution	Has higher maximum width resolution than the Robust method.

Reflection Handling

The Reflection handling setting is used for specifying how to handle reflections within the FOV when detecting the profiles.

Normal	Always use the height value with the highest intensity.
Top-most	Use the highest height value with intensity above the Intensity threshold.
Bottom-most	Use the lowest height value with intensity above the Intensity threshold.
Intensity threshold	When reflection handling is set to Top-most or Bottom-most, sets the lowest intensity for a height value to be considered a point on the profile.

Profile Triggering

The Profile triggering settings affect the triggering of profiles when using an encoder. When not using an encoder, **Profile distance** is still relevant for specifying millimetre- resolution along the Y-axis.

Pulses per mm	This parameter should be set to the number of pulses that the connected encoder gives per millimetre. This setting is ignored when no encoder is used (when Profile triggering is set to Free running).
Profile distance (mm)	This setting always decides the profile distance in millimetres (Y-resolution), but has different effect for Free Running and Encoder Controlled profile triggering. When using an Encoder, the parameter defines the actual distance between every profile the IVC-3D acquires, provided **Pulses per mm** is correctly defined.

When not using an encoder, this parameter sets the millimetre distance the IVC-3D assigns to every profile. Profiles will be acquired according to the **Profile rate**, therefore this parameter must be configured to correspond to the Profile rate and object speed in order to get correct size measurements.

Image Triggering

The Image triggering settings are used for specifying when to start capturing a new 3D image.

Free-running	A new 3D image is started as soon as the previous image is ready.
Trigger by input signal	A new image is started when the Trigger In signal becomes high.
Trigger by program step	A new image is started when a 'Grab on command' tool is executed
Image overlap	When Image triggering is Free-running, sets the number of profiles that should be included in both the current and the next image. **Note:** The number of overlapping profiles must be less than 50% of the image size. The value is automatically adjusted to the nearest multiple of 16.

It is possible for IVC-3D to send a trig signal to an external device when it starts to capture an image. To enable this functionality, select the **Trigger pulse** checkbox. It is possible to configure the length of the pulse (in ms) and which of the digital outputs to use for the pulse. This functionality can for instance be used to trig a robot or a PLC when the image is captured by IVC.

Reference Level

The reference level – the line along which measurements have the same height – can be rotated by selecting User defined and adjusting the settings. The current reference level is displayed as a blue line in the right pane.

Rotation	The angle between the reference level and the plane in which the IVC-3D is measuring. This setting can be used for compensating that the IVC-3D is not mounted exactly along the z axis of the measurements.
Preview	When selected, the profile displayed in the right pane is adjusted so that it shows the profiles as when used in the step programs. When not selected, the profile displayed is the non-adjusted profile, captured in the FOV.

Using the Emulator as Device

When the Emulator is the selected device in IVC Studio, and the new image format is used, the Grab step can read the FOV settings from the image file. If the FOV settings of the image differ from the Grab Setup settings in the device, the user will be prompted to open the interactive Grab Setup to adjust the FOV settings to comply with the image. This adjustment is then made automatically when the interactive setup is opened.

To be able to support all variations in the physical devices, the available FOV in the emulator is larger in all directions than both the typical and the guaranteed FOV.

Shape Locator Interactive Setup

The interactive setup for the Shape Locator is used to fine tune the parameters for the locator algorithm. The possibility to interactively teach the camera a reference shape is available via the Add Shape and Edit Shape buttons.

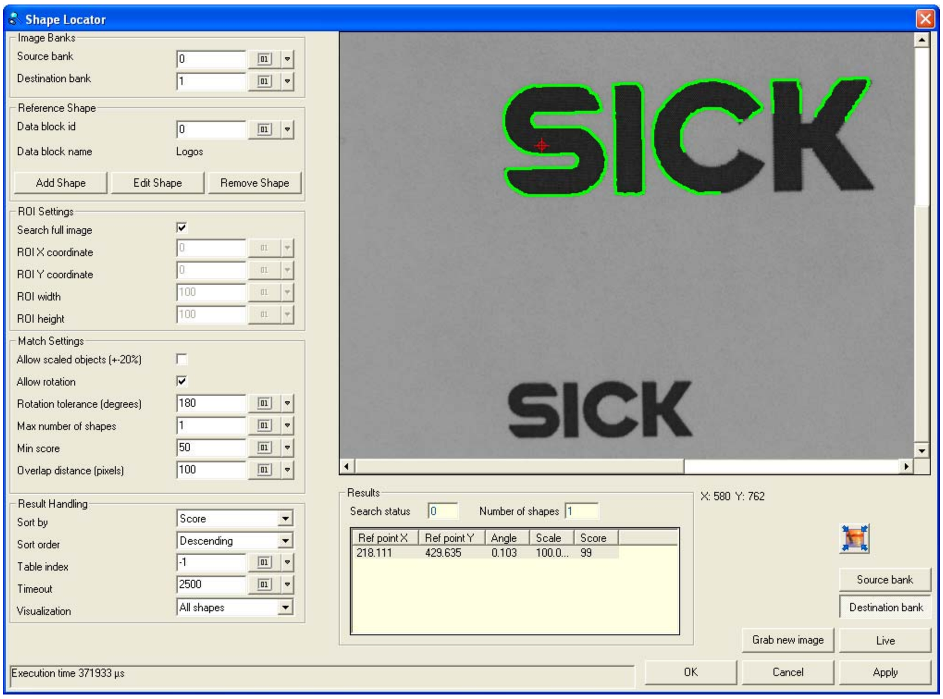


Image Banks
Source bank: 0
Destination bank: 1

Reference Shape
Data block id: 0
Data block name: Logos

ROI Settings
Search full image: ☑
ROI X coordinate: 0
ROI Y coordinate: 0
ROI width: 100
ROI height: 100

Match Settings
Allow scaled objects (+-20%): □
Allow rotation: ☑
Rotation tolerance (degrees): 180
Max number of shapes: 1
Min score: 50
Overlap distance (pixels): 100

Result Handling
Sort by: Score
Sort order: Descending
Table index: -1
Timeout: 2500
Visualization: All shapes

Results
Search status: 0
Number of shapes: 1

Ref point X	Ref point Y	Angle	Scale	Score
218.111	429.635	0.103	100.0...	99

X: 580 Y: 762

Execution time 371933 µs

Figure – The Shape Locator interactive setup

Image banks

The source bank holds the live image in which the matching is performed. The destination bank will hold a visualization of the resulting shape (-s).

Reference shape

The reference shape used in the matching process is stored in a data block in the memory of the camera. From the interactive setup it is possible to add a new data block containing a reference shape, edit the contents of an existing data block, or permanently delete a data block from the working memory.

The Add Shape and Edit shape buttons open the Add/Edit Shape Interactive Setup, see page 254.

Note: A data block created by the Add Shape Runtime tool cannot be edited. The reason for this is that the Teach ROI used in runtime can be of arbitrary shape and no definition of this is stored in the data block.

ROI settings

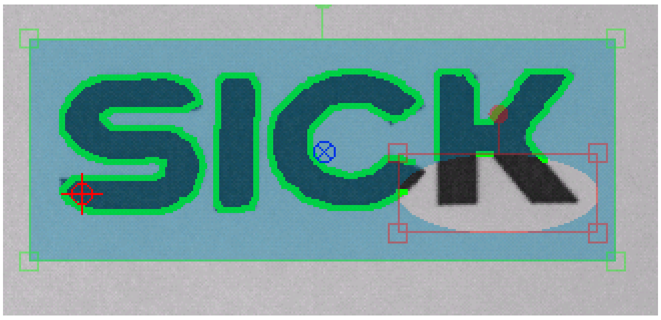
It is possible to search the full image, or to specify a rectangle area in order to limit the search. The tool behavior is depending on these settings; if the full image is searched, shapes that are partly outside of the image are also found. If a search ROI rectangle is specified, only shapes with all edges inside the ROI are returned.

Match Settings

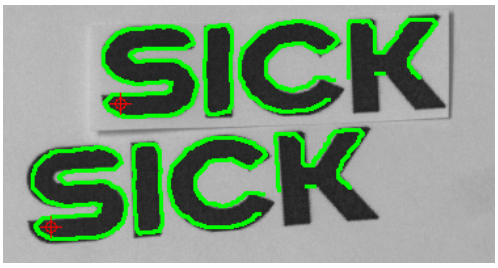
In addition to the settings in the data block, there are some runtime parameters that affect the performance of the tool. The scale of the shape can be allowed to vary up to ±20%. It is also possible to allow the shapes to be rotated. The **Rotation tolerance** parameter is specifying this tolerance in degrees. I.e. ±180 means that full rotation is allowed. By not allowing scale or rotation tolerances it is possible to optimize the execution time of the tool. Limiting the number of shapes that the tool shall look for is also affecting the performance, as poor matches are discarded early in the process. The same can be said for the **Min score** parameter.

The **Overlap distance** parameter is recommended only for advanced users. It controls the performance of the tool in difficult situations, such as cluttered images. By reducing the allowed overlap distance, matches that are too close (closer than the overlap distance) are regarded as duplicates and only the one with the highest score will continue through the process. The overlap distance is based on the center of gravity of the reference shape (i.e. the center point of the Teach ROI). This point is visualized in the interactive setup for Add Shape as a blue circle with a cross.

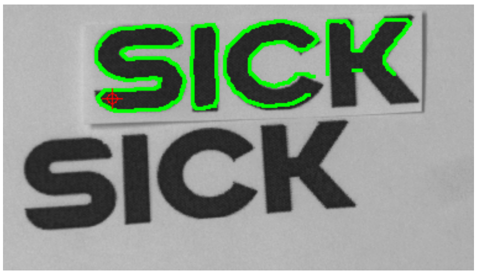
The example below shows how the **Overlap Distance** parameter affects the result of the matching algorithm. The top image shows the reference shape with the center of gravity marked with a blue cross. The two lower images show the results with different **Overlap Distance** settings.



Reference shape with center of gravity



Result with Overlap Distance set to 100 pixels



Result with Overlap Distance set to 200 pixels

Result Handling

If more than one shape is located, it is possible to specify the order in which the shapes are returned by the tool. It is possible to sort the shapes by any of the attributes (x, y, scale, angle, score), and if the shapes shall be returned in ascending or descending order. It is also possible to sort the shapes by the distance to a user specified sorting point. In this case, the shapes are sorted by the distance (measured in pixels) between the reference point of the shape and the specified sorting point.

If a table index is specified, information about all shapes will be stored in the table starting at the specified index.

It is also possible to limit the execution time of the algorithm. This can be useful in situations where the total cycle time is limited. If the algorithm returns prematurely, the Search Status result will indicate if the returned shapes are valid or not.

Finally, it is possible to determine how the results shall be visualized in the destination bank. It is possible to show the first shape (by the specified sorting order), all shapes, or no shapes at all.

Results

The tool will return information about the overall search status, and the number of shapes that was found. In addition to this information about the first shape is returned. The interactive setup can show information about all shapes, but this is only available in the GUI and not in the step program.

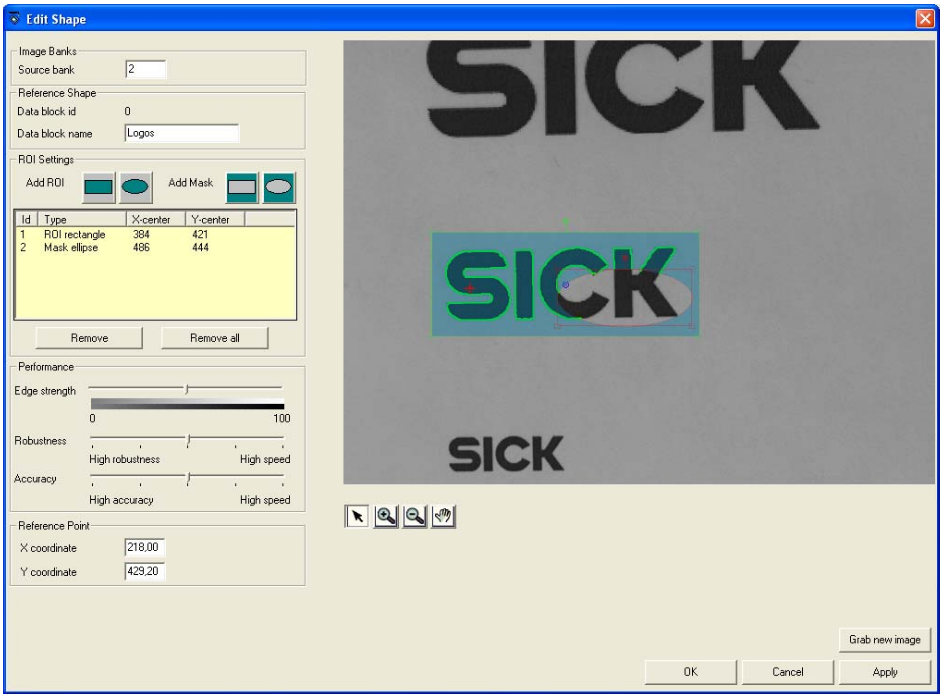
Replacing the Source image

It is possible to replace the image currently stored in the Source bank. This is done by clicking the **Grab new image** button. If the emulator is used, the next image from the specified image folder will be retrieved. This functionality is not available if a camera is used.

The **Live** button executes the Shape Locator tool and grabs new images continuously. The result is displayed in the Interactive setup window. The continuous execution is stopped by clicking the button once again. The **Live** button is only available for the emulator.

Add/Edit Shape Interactive Setup

The interactive setup for Add/Edit Shape is used to create a reference shape. The image below shows an example where the Teach ROI consists of one rectangular ROI and one elliptical Mask. The edges included in the reference shape are marked with green, and the reference point is marked as a red cross. The blue circle with a cross indicates the centre of gravity for the Teach ROI and it is used for the **Overlap Distance** parameter in the Shape Locator tool.



Edit Shape

Image Banks
Source bank: 2

Reference Shape
Data block id: 0
Data block name: Logos

ROI Settings

Id	Type	X-center	Y-center
1	ROI rectangle	384	421
2	Mask ellipse	486	444

Reference Point
X coordinate: 218,00
Y coordinate: 429,20

Figure – The Add/Edit shape interactive setup

Image Banks

The **Source bank** specifies where the reference image is stored. It is recommended to not use the same source bank as for the Shape Locator tool as this may lead to the image data being overwritten during the execution of the step program.

Reference Shape

The ID of the data block that holds the reference shape is specified in the Shape Locator GUI and cannot be modified in this interactive setup. IT is however possible to edit the name of the data block.

Teach ROI Settings

The Add ROI and Add Mask buttons are used to create a Teach ROI that specifies the part of the shape or image that shall be included in the reference shape. The Teach ROI is created by adding one or more ROI:s and Masks to the reference image. A Teach ROI can consist of up to 16 ROI:s and Masks, and must contain at least one rectangular or elliptic ROI. Preferably, the Teach ROI shall cover only the interesting shape, and as little as possible of the surrounding parts of the image.

Each ROI and Mask can be moved, resized and rotated using the mouse.

The edges defining the reference shape are marked with green in the reference image. Note that only edges within the Teach ROI are included in the reference shape. The reference shape must not be too small. In order to get a stable matching result, it is recommended to arrange the setup so that the edges of the shape cover at least 5% of the image size.

Performance

Some settings affecting the performance of the tool are necessary to perform already when creating the reference shape. The **Edge strength** slider controls the number of edges included within the Teach ROI. A reference shape containing too many edges may slow down performance.

The sliders for **Robustness** and **Accuracy** are used for trade-off between execution performance and the integrity of the results. For instance, in an application that is only used to verify the presence of a shape within an image the **Accuracy** slider can safely be set to **High Speed**. On the other hand, in an application where the exact position of the shape is crucial, e.g. when picking objects, the slider will probably need to be pulled closer to **High Accuracy**. In situations where the image is cluttered with similar shapes or other forms of distortion, the **Robustness** slider should be set to **High Robustness**.

Image handling

It is possible to zoom in and out of the image by using the Zoom buttons. E.g. if the **Zoom in** button is pressed, each mouse click in the image will zoom in around the clicked position, and vice versa for the **Zoom out** button. The **Pan** button can be used to move the visible part of the image when it is zoomed in. When the **Pointer** button is pressed, it is possible to work with the ROI:s and Masks composing the Teach ROI using the mouse.

Reference point

This is an arbitrary point that can be specified anywhere in the reference image. The reference point is marked with an encircled red cross. The position of the located shape will refer to the position of this point. This point shall not be confused with the blue centre of gravity of the Teach ROI which is used when discarding duplicate matches using the **Overlap Distance** parameter in the Shape Locator tool.

The position of the reference point can either be specified by entering the exact coordinates in the text boxes or by moving the point using the mouse. It is also possible to refer to a table cell by entering “=Vn” where n is the index of the table cell.

Replacing reference image

It is possible to grab a new image to the reference bank by using the button **Grab new image**. In the emulator, the next image in the specified image folder will be fetched to the source bank. This functionality is not available if a camera is used.

Locating Shapes (tips and tricks)

The purpose of the Shape Locator tool is to find the best possible match or matches of a reference shape. This section holds important information on how to set up the tools, and also some examples on how to use the combine the tools to achieve the best performance.

Basic description of the algorithm

The 'Shape Locator' tool identifies the major edges (contours) of any shape. These edges are used to locate the position of the reference shape in a new image. The edge extraction is based on local gray scale gradients and the tool is therefore relatively insensitive to absolute gray scale level and shading effects.

The localization is performed in two steps

- Coarse pose (position, rotation, and scale) of the shape is found. This search only considers the major edges of the shape, drawn green in the reference image. This puts a lower limit on the size of the reference shapes and the details that can be detected. The algorithm cannot locate shapes that cover less than 2% of the image area.
- Fine tuning the coarse pose using the fine detail of the reference shape. So even if the green major edges look somewhat rough, the fine-tuning will ensure sub-pixel and sub-degree precision.

Different applications have different needs in trade-off between execution time on one hand, and positioning robustness and accuracy on the other. The tool therefore has a number of parameters to control this balance. The two most important settings are the **Robustness vs. Speed** and **Accuracy vs. Speed** parameters. The **Robustness** trade-off controls the first step, the coarse localization. For a clean high contrast image with a large reference shape, the robustness trade-off can be set to high-speed. For cluttered or low contrast images with a small reference shape, the robustness trade-off should be towards high robustness.

The **Accuracy** trade-off controls the fine-tuning of the second step in a similar manner. For applications where the sub-pixel accuracy requirements are high, the trade-off should be set to high accuracy. For high speed applications, however, where precise positioning is not needed, it can be set to high speed.

The tool may be sensitive to shape variations compared to the reference shape. Typical causes of shape variations can be object variations or occlusion caused by lighting related effects and/or partly covered objects. Moderate variations are handled, but affect the score. Major variations may cause the tool to fail locating the shape.

The 'Shape Locator' tool can find several instances of the reference shape in one image depending on the setting of the parameter **Max number of shapes.** The tool identifies the shapes with the highest score and presents them in the search result.

Teach tips

The selection of edges defining the reference shape is an important key to a fast and robust location of shapes. The reference shape edges are controlled by a combination of the Region Of Interest (ROI) selecting a part of the reference image and the **Edge strength** parameter setting the threshold for which gray scale gradients (i.e. variations in gray scale) that should be regarded as an edge.

More edges will increase the execution time. Adjust the **Edge strength** parameter so that the characteristic major edges of the shape are extracted but minor details are ignored. Also select an **Edge strength** value where the extracted edges stay more or less constant when the **Edge strength** value is varied around the selected value. This ensures that the same edges will be extracted even if the illumination changes.

Excluding parts of the reference shape that may vary during runtime will improve the robustness. Such variations may stem from the inspected objects themselves (e.g. varying date codes on packages), from illumination effects (e.g. shadows or direct reflexes) or from occlusion effects. Masks can be used to exclude the parts of the reference shapes that are affected by variations.

If the ROI perimeter is used with the 'Add Shape Runtime' tool to define the ROI for the reference shape, please use the filling **0 = internal** to get all edges within the ROI.

Locate tips

The region of interest defines the area to be searched. If using a search ROI, only shapes with all edges completely inside the ROI will be found.

If using the **Search full image** setting, also shapes with edges partly outside the image may be returned in the search result. The criterion for being regarded inside using the "Search full image" mode is that the center of gravity point of the ROI used when creating the reference shape must be inside the image. Note that there therefore is a difference between the "Search full image" mode and to search within a ROI covering the whole image.

The value of the **Edge strength** parameter of the reference shape is also used when searching for shapes. Having a similar contrast level in the reference image and in the search image will therefore increase the robustness of the tool.

It is good practice to set the parameter **Max number of shapes** = 1 if only searching for one shape. Using a higher value will lead to a longer execution time even if only one shape is present in the image.

Advanced algorithm details

Lens distortion and perspective distortion of 2D images have a negative impact on both the score and position results of the tools. Try to minimize these types of image distortion if high robustness and accuracy is required.

The rotation handling of the tools is based on the assumption that the pixels are square. Use the square pixels option in 3D grab setup. Encoder support is highly recommended for 3D applications if the **Allow rotation** option is used.

The polarity of an edge (going from dark to bright or vice versa) is significant for the locate tool. The tool will give lower score if the polarity is switched for example by changing from a bright to a dark background. The recommendation is to avoid edges that may change polarity. One trick to improve robustness is to avoid outer edges and only include internal edges if the background has variations.

The first steps of the algorithm only use the major edges to locate the position and orientation of the shapes. This may lead to problems for objects with rotational symmetry (more than one possible match for the major edges) where the best rough match may turn out to be in the wrong direction when later using all edges. This may result in the shape getting a score below the score threshold.

Summary for improving speed and algorithm performance

To improve robustness and accuracy

Adjust the edge strength so that only the major edges of the shape are extracted.

Teach the whole shape to be found, not only a small detail.

Mask away edges that may vary between images.

Enable scale search.

Adjust the two trade-off parameters towards robustness and accuracy.

Increase the max number of shapes.

Reduce any clutter in the image.

To improve speed

Reduce the rotation search interval.
Disable the scale search.
Adjust the two trade-off parameters towards speed.
Decrease the max number of shapes.
Mask away extracted edges that are not part of the characteristic shape.
Reduce any background clutter in the image.

Environmental considerations

2D	Select optics with low lens distortion.
	Mount the camera straight to avoid perspective distortion.
	Select an illumination that reduces direct reflections and shadows.
3D	Use the square pixels option together with an encoder in the IVC-3D grab setup.
	Mask away edges due to missing data areas that may vary between images.
	Do not include edges that are result of occlusion.
	Mount the camera straight to avoid skewed height data.

Examples on workflows

The suite of tools for locating shapes can be used in a number of various workflows. These examples show some of the most common ways to use the tools. In all examples (excluding the last), the reference shape is created using the interactive setup Add/Edit Shape available in the interactive setup for Shape Locator.

During the configuration phase of the development, the interactive setup for the Shape Locator tool is used to create one or more reference shapes and to adjust the parameters to the correct settings. Once the configuration is done, the Shape Locator tool is executed directly from the step program, using the reference shape (-s) created during the configuration.

Workflow	*Tools to use*
Locate one object	**Shape Locator** Information about the shape is available as direct results from the Shape Locator tool.
Locate multiple objects	**Shape Locator** **Get Shape** Information about each shape is found either by calling Get Shape for each shape or by reading the table.
Locate and inspect relative to the reference image	**Shape Locator** **Transform Image** The image is moved and rotated so that the located shape is placed in the same position as it was in the reference image.

Locate and inspect relative to the located shape

Shape Locator

Transform ROI

A ROI defined in the reference image is moved and rotated to the position of the located shape.

Teach using external operator interface

ROI step

An arbitrary shaped ROI defined in the step program.

Add Shape Runtime

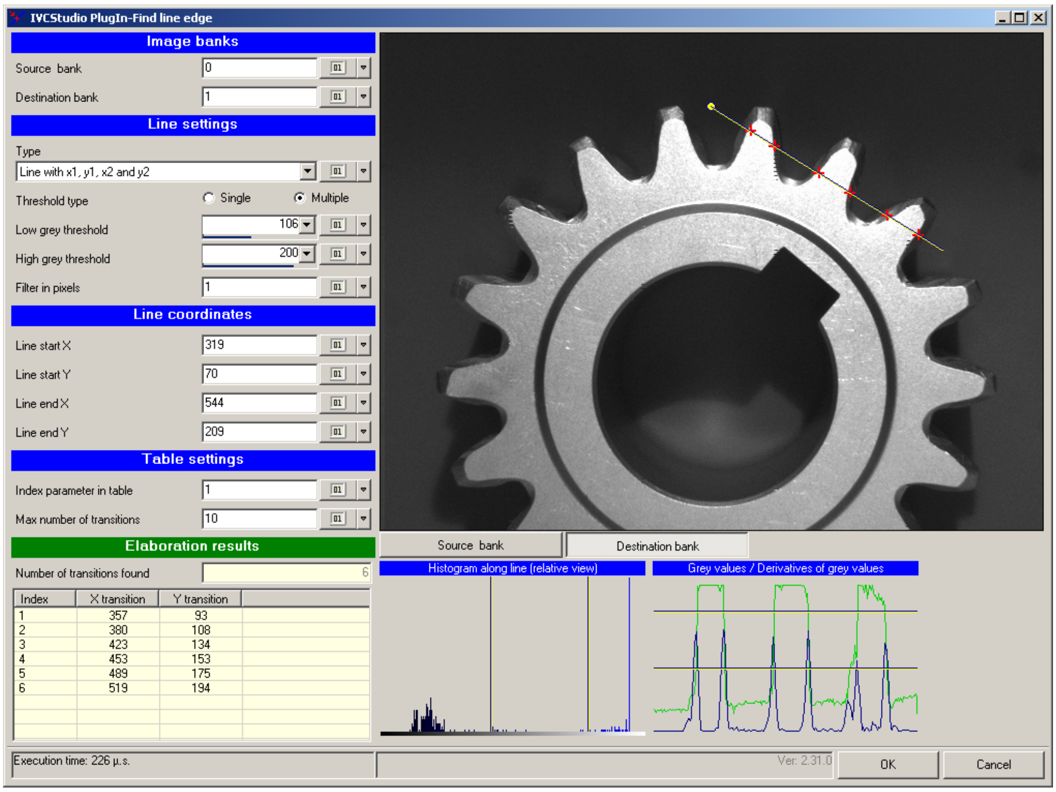
The reference shape is created during runtime by specifying a source image and the ROI specified previously.

Shape Locator

Get Shape, Transform Image or Transform ROI

Find Line Edge

This tool evaluates the changing of height values along a user defined straight line. This enables to detect transitions/changes of height values along the line. The tool offers two evaluation methods to detect transitions/changes of height values. You find the introduction of this tool in “Find line edge”.



IVCStudio PlugIn-Find line edge

Image banks

Source bank: 0
Destination bank: 1

Line settings

Type: Line with x1, y1, x2 and y2
Threshold type: ○ Single ● Multiple
Low grey threshold: 106
High grey threshold: 200
Filter in pixels: 1

Line coordinates

Line start X: 319
Line start Y: 70
Line end X: 544
Line end Y: 209

Table settings

Index parameter in table: 1
Max number of transitions: 10

Elaboration results

Number of transitions found: 6

Index	X transition	Y transition
1	357	93
2	380	108
3	423	134
4	453	153
5	489	175
6	519	194

Execution time: 226 µ.s.

Source bank
Destination bank
Histogram along line (relative view)
Grey values / Derivatives of grey values
Ver: 2.31.0
OK
Cancel

Figure – Screenshot of interactive setup Find line edge. Upper left: input boxes for Input Parameters; upper right: displayed image with line and found transition points (red crosses) as overlay; lower left: result table with the coordinates of the found points; lower right: plots of a relative histogram, pixel values and derivation of pixel values along the line.

(This screenshot is for IVC-2D, but the principle is the same when using IVC-3D. The only difference is that the threshold values are in millimeters instead of gray level values.)

How to set Input Parameters:

Type the number of the source bank holding the desired image for evaluation and the destination bank where the image, the line, and the found points are to be plotted. Make sure that the evaluation bank is different from the destination bank.

Select the geometrical interpretation for the start and end points of the line by clicking the input box with the caption Type. Select one of the three available options. The values are shown in the four input boxes with the caption Line coordinates. Note that depending on the selected geometrical interpretation the Line end X and Line end Y values have different interpretations like delta X /delta Y or length and angle. You can setup the lines length and position by directly editing the values in the input boxes, or more conveniently by using a drag-and-drop operation. To use a drag-and-drop operation click the start or end point of the line in the image and drag this point to the desired position. The starting point of the line is indicated with a yellow dot.

To select the Evaluation Method select one of the options for threshold types.
Single meaning: Evaluation Method 1: Detect relative change of height values,
Multiple meaning: Evaluation Method 2: Detect absolute change of height values.

Depending on the chosen Evaluation Method set just one of or both the maximum and minimum height threshold values by typing or selecting the values. A third option to set the threshold is to move a horizontal line with the left mouse button in the plot of the height values (lower right in the figure above). If you can't see a horizontal line, pull it from the top (upper threshold) or bottom (lower threshold) of the plot area.

Input Parameter Filter in pixels allows on average over up to 10 pixels in line direction. This option is available with Evaluation Method 2: Detect absolute change of height values only.

To select an upper limit of how many found points should be stored in the table and the table index for the first entry edit the input boxes with the caption Table settings.

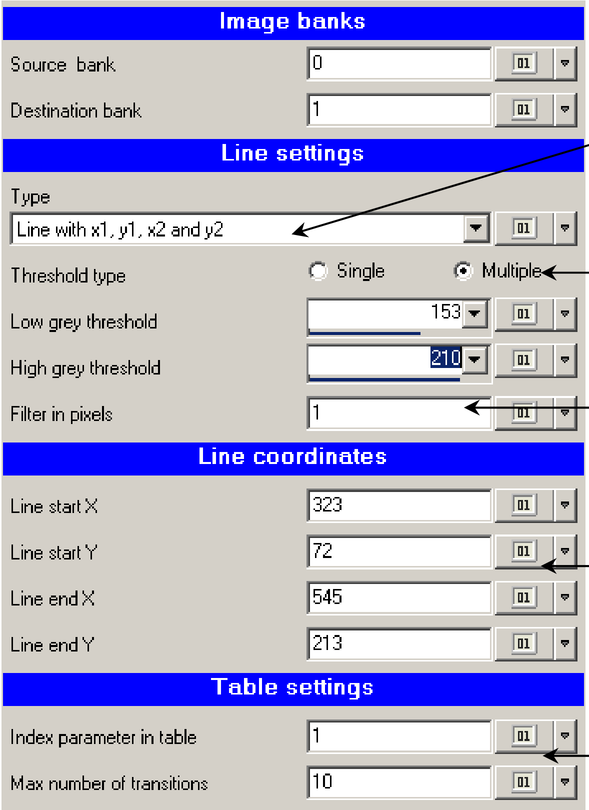


Image banks	
Source bank	0
Destination bank	1
Line settings	
Type	Line with x1, y1, x2 and y2
Threshold type	○ Single ● Multiple
Low grey threshold	153
High grey threshold	210
Filter in pixels	1
Line coordinates	
Line start X	323
Line start Y	72
Line end X	545
Line end Y	213
Table settings	
Index parameter in table	1
Max number of transitions	10

Selected geometrical interoperation for the start and end points are Cartesian coordinates

Evaluation Method 2: Detect absolute change of height values

Height values are averaged out of "one" pixel along the line.

Line start point:
X and Y coordinates

Line end point:
X and Y coordinates

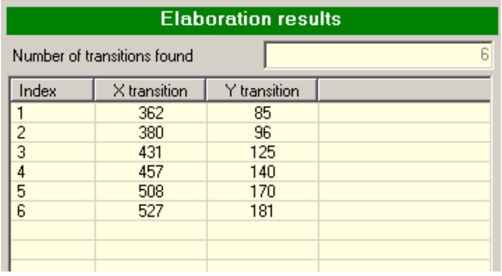
Values of coordinates start at table index 1.

Up to 10 found points will be

Figure – Screenshot of the input boxes to set the Input Parameters.

Results

The total number of found transitions is displayed in the field Number of transitions found. A table shows the table index number and the coordinates that are stored in the table beginning with the first found pixel. The maximum number of shown and stored coordinates depends on the selected value in the input field Max number of transitions.



Elaboration results

Number of transitions found: 6

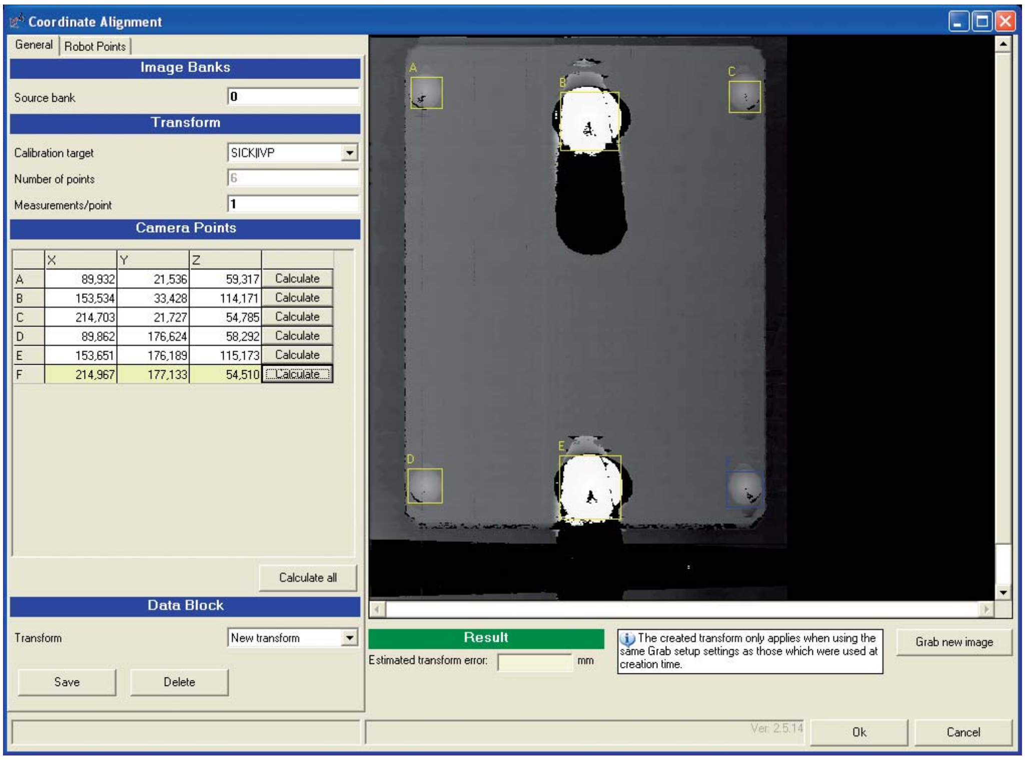
Index	X transition	Y transition
1	362	85
2	380	96
3	431	125
4	457	140
5	508	170
6	527	181

Figure – Screenshot of the result table

Coordinate Alignment

The Coordinate alignment tool is used for aligning the IVC-3D’s coordinate system to an external coordinate system (world coordinates).

The result from the tool is a transform, which is stored in a data block in the IVC-3D, and can be used later by the 'Get calibrated point' tool to get aligned measurement values.



Source bank: 0

Calibration target: SICK|IVP

Number of points: 6

Measurements/point: 1

	X	Y	Z	
A	89,932	21,536	59,317	Calculate
B	153,534	33,428	114,171	Calculate
C	214,703	21,727	54,785	Calculate
D	89,862	176,624	58,292	Calculate
E	153,651	176,189	115,173	Calculate
F	214,967	177,133	54,510	Calculate

Transform: New transform

Estimated transform error: mm

The created transform only applies when using the same Grab setup settings as those which were used at creation time.

Figure –The Coordinate alignment interactive setup window.

To create a transform with the Coordinate alignment interactive setup, do the following:

- Grab a 3D image of a reference object, for example the SICK IVP Reference object.

  1.You can use any 3D image stored in an image bank, or you can grab the 3D image directly from the interactive setup window.
- Mark the reference points in the 3D image of the calibration object.
- Import the world coordinates for the reference points into the interactive setup.
- Click Save to calculate the transform and save it in a data block in the IVC-3D’s working memory. When the transform is calculated, the estimated transform error is displayed in the window.

Handling Movement of Objects

If the objects are moved between being inspected by the IVC-3D and being handled by the external device, the external device should keep track of the movement, and should be able to compensate the coordinates it receives from the IVC-3D with the movement.

The IVC-3D can send a trigger pulse to the device when it starts grabbing the image. The device can use this trigger pulse to determine where the object is located at certain time, for example by resetting an encoder counter. To have the IVC-3D to send the trigger pulse, select the Trigger pulse option in the 'Grab setup' interactive setup.

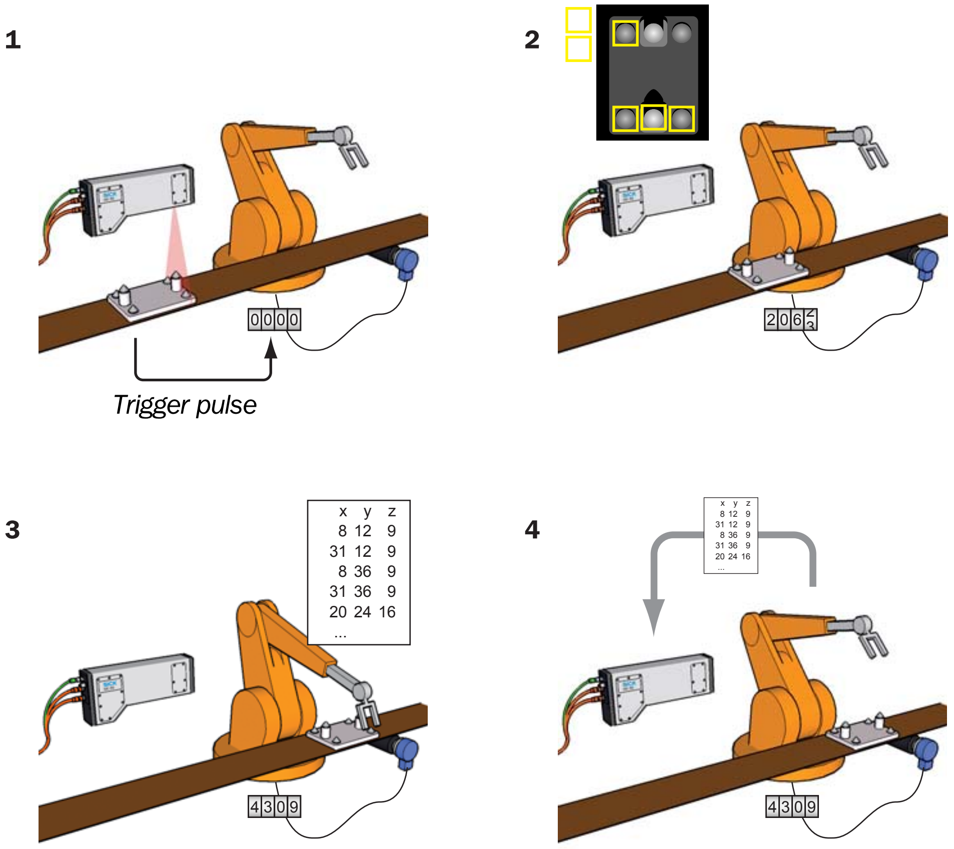


Figure –Aligning the IVC-3D to a robot's coordinates when objects move between being inspected and being handled by the robot:

1. *Grab a 3D image of the reference object. The IVC-3D sends a trigger pulse to the robot when it starts grabbing.*
2. *Mark the reference points in the 3D image and move the object to the robot. The robot uses an encoder to keep track of the object's movement.*
3. *Get the robot's coordinates for the reference points.*
4. *Import the robot's coordinates – if necessary, adjusted by the movement – to the IVC-3D, and calculate the transform.*

Grabbing 3D Images

To grab a 3D image from the interactive setup window, an encoder must be connected to the IVC-3D, and the IVC-3D must be set up in the following way:

- Profile triggering is set to Encoder controlled
- Analysis is set to 3D image
- Image triggering is set to Trigger by input signal or Trigger by program step.

To grab a 3D image, click Grab image. If the IVC-3D is set to be triggered by a program step, the image grabbing will start immediately; otherwise the IVC-3D will wait for the external trigger input before the grabbing starts.

Note that the grabbed image will be stored in the image bank selected in the Image bank field, replacing any previous mage in that bank.

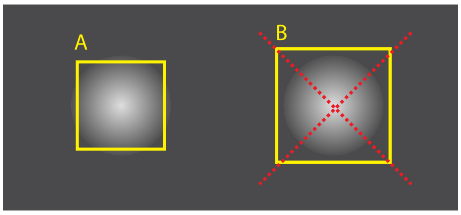
Marking Reference Points in IVC Studio

There are two different methods used for marking the reference points, depending on which calibration object that is used:

SICK (IVCAL) The interactive setup locates the reference points inside the ROIs that are placed over each point.

For the best result, each ROI should be placed so that it *almost* covers the cone. If the entire cone is inside the ROI, measurement data from the edge of the cone may affect the locating of the top of the cone.

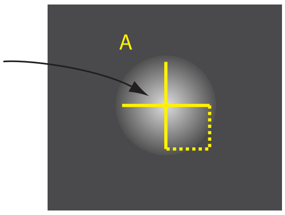
OK



Not recommended

Custom Mark the reference points by placing a cross on each point.

Reference point



A custom calibration object should have at least 4 reference points, which should not be located in the same plane. Ideally, the reference points should put up the entire volume in which to measure.

Regardless of which calibration is used, it is important that the order of the reference points is the same as the order in which the points are measured in the external coordinate system.

Figure – A SICK (IVCAL) calibration object.

Importing Coordinates from the External System

The world coordinates for each reference point can either be entered into the table on the Robot points tab in the interactive setup, or imported from a file.

To import external coordinates from a CSV file, do the following;

1. Make sure that the number of number of coordinates for each reference point is entered in the Measurements/point field on the General tab.
2. Click Import coordinates on the Robot points tab.

You can edit the imported values for each point directly in the table. If you should need to remove or add measurements from the list, you need to remove or add them in the file and import that file again. Note that when importing coordinated from a file, any existing values in the table will be replaced by the imported values.

The file containing the coordinates should have the following format:

$x_{A1};y_{A1};z_{A1};x_{A2};y_{A2};z_{A2};\ ...\ ;x_{An};y_{An};z_{An}$<return>

$x_{B1};y_{B1};z_{B1};x_{B2};y_{B2};z_{B2};\ ...\ ;x_{Bn};y_{Bn};z_{Bn}$<return>

$x_{C1};y_{C1};z_{C1};x_{C2};y_{C2};z_{C2};\ ...\ ;x_{Cn};y_{Cn};z_{Cn}$<return>

...

where:

x_{A1} is the x coordinate for the first measurement of reference point A,

x_{A2} is the x coordinate for the second measurement of reference point A,

x_{B1} is the x coordinate for the first measurement of reference point B,

etc.

Important: The following rules apply to the format of the file with external coordinates.

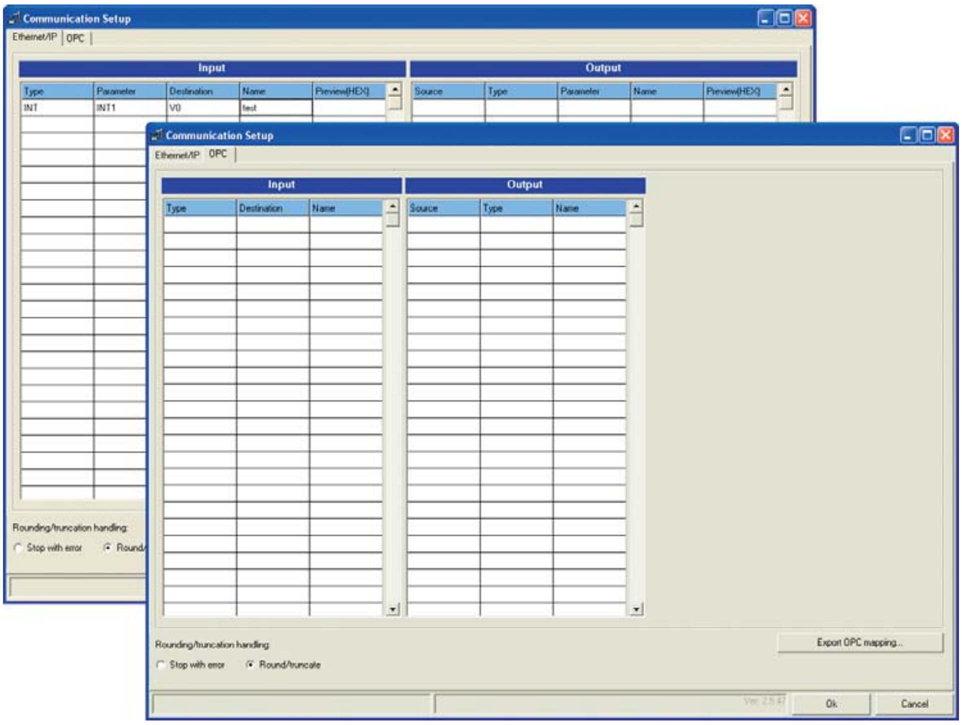
- Measurements for all reference points must be entered.
- All points must have the same number of measurements.
- There must be a <return> after the last line of values.
- Each value shall be separated by a semi-colon.
- There shall be no semi-colon after the last value on each line.

Communication Setup

The Communication setup tool is used for specifying which values the device should publish and subscribe to, and whether to use the Ethernet/IP or the OPC protocol for the communication.

This tool only specifies the values that should be read from or written to the network. The actual reading and writing of values occurs when a 'Communication Read/Write' tool is executed.

The Interactive Setup for this tool is not available when using the Emulator.



Input

Type	Parameter	Destination	Name	Preview(HEX)
INT	INT1	V0	test	

Output

Source	Type	Parameter	Name	Preview(HEX)

Input

Type	Destination	Name

Output

Source	Type	Name

Rounding/truncation handling:
○ Stop with error ● Round/truncate

Figure – The Communication Setup dialog box

Subscribing to and Publishing Parameters

The IVC device uses an internal buffer for sharing parameter values with other devices on the network. This buffer is divided into two parts:

Input — External devices can write parameter values to this part, which are then copied to the active table in the IVC device.

Output — The IVC device writes table values, program step results, or constant values to this part. The values can then be read from here by the external devices.

The 'Communication setup' tool is used for specifying which parameter in the buffer that should be mapped to a certain value in the IVC device's working memory. The synchronization between the buffer and the working memory is made when a 'Communication read/write' tool is executed.

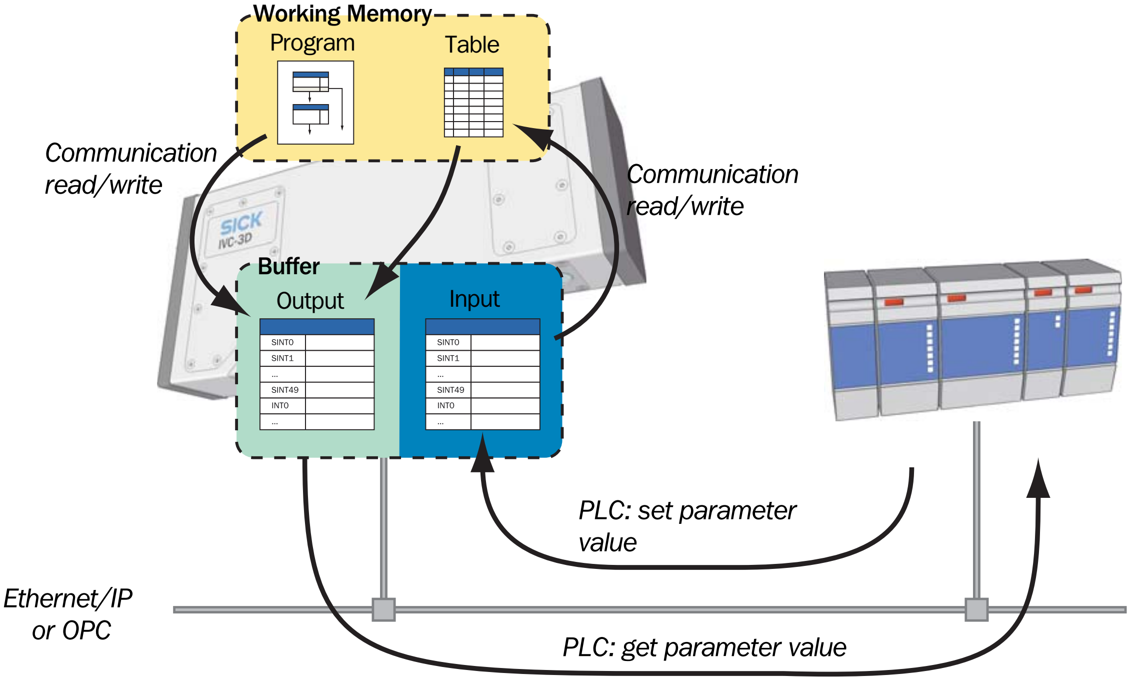


Figure – Reading and writing values in the IVC's buffer.

Parameter Types

Each parameter in the buffer can store values of a certain type. The following types are supported by the IVC devices:

• Short integer	SINT	-128 … 127
• Integer	INT	-32 768 … 32 767
• Double integer	DINT	-2 147 483 648 … 2 147 483 647
• Floating point	REAL	-3.40282347e+38 … 3.40282347e+38
• Short string	SSTRING	61 characters
• Long string	LSTRING	497 characters

Since an integer in the IVC's working memory is always represented as a double integer (4 bytes), integer values will automatically be converted when read or written between the IVC's working memory and the buffer, as long as the value fits into the value range of the parameter type in the buffer.

In a similar manner, the IVC device will try to convert between floating point values and integers, and between strings in the working memory (max 4096 characters), and SSTRING:s (61 characters) and LSTRINGS (497 characters) in the buffer.

If the value from the IVC device is outside the value range for a parameter, the IVC device will either round or truncate the value, or issue an error, depending on the settings in the 'Communication setup' tool. For example, the result from trying to publish the following values from a table in the working memory depends on what was selected in the 'Communication setup' interactive setup:

Value in IVC table	Buffer parameter	Stop with error	Round/truncate
314	SINT	Err = 8103	127
-65 536	INT	Err = 8103	-32 768
1.7	SINT	Err = 8103	2
“A string”	INT	Err = 8104	Err = 8104
“An extremely long string with more than 61 characters for demonstrating.”	SSTRING	Err = 8103	“An extremely long string with more than 61 characters for dem”

Note that the maximum length of strings in the buffer is either 61 characters (SSTRING) or 497 characters (LSTRING), but when read from the buffer by an external device, the strings will occupy 64 bytes and 500 bytes respectively. The format of the strings when read from the buffer is shown in the following figure:

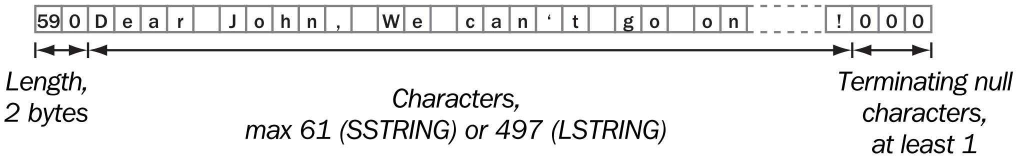

59 0 D e a r J o h n , W e c a n ‘ t g o o n ! 0 0 0
Length, 2 bytes
Characters, max 61 (SSTRING) or 497 (LSTRING)
Terminating null characters, at least 1

Figure – Format of strings in the buffer

OPC

To use the OPC protocol for reading and writing data on an IVC device, the OPC server from SICK must be running on a PC in the network. The OPC server is included with the installation of IVC Studio, and the setup file is stored in the folder `OPC Server` in the installation folder for IVC Studio. Note that IVC Studio must be installed on a PC for the OPC server setup to be available.

When reading and writing values using OPC, the parameters are referred to by the name specified in the Communication setup interactive setup. Before these names can be used with the OPC server, they must first be exported from IVC Studio, and then imported to the OPC server.

The names are exported by clicking Export OPC mappings on the OPC tab in the Communication setup interactive setup. For information on how to import the names to the OPC server, see the documentation that comes with the server software.

Ethernet/IP

When reading and writing to the IVC buffer using Ethernet/IP, there are a number of assemblies available that are defined in the IVC device.

When using the assemblies from a PLC, you select assembly type by specifying the assembly instance number. This number is different depending on whether the assembly is used for input or for output.

Note: "Input" and "output" here means from the IVC device's point of view – that is, the input assembly should be used when writing data to the IVC device, and the output assembly is used for reading data from the IVC device.

The assemblies available when communicating with the IVC device using Ethernet/IP are listed in the following table:

Name	Description	Input assembly instance (to IVC device)	Output assembly instance (from IVC device)
Allround	All types represented (except long string)	100	101
No strings	More room for numbers	102	103
Large string	One long string	104	105
Small	Small set with all types	106	107

Please contact tech support if an assembly of another size/type is required.

Allround

Type	No. of values	Parameters	Offset to first parameter (bytes)	Size per value
SINT	10	SINT0 … 9	0	1 byte
INT	10	INT0 … 9	10	2 bytes
DINT	10	DINT0 … 9	30	4 bytes
REAL	10	REAL0 … 9	70	4 bytes
SSTRING	6	SSTRING0 … 5	110	64 bytes
LSTRING	–	–	–	500 bytes
Total size				**494 bytes**

No strings

Type	No. of values	Parameters	Offset to first parameter (bytes)	Size per value
SINT	50	SINT0 … 49	0	1 byte
INT	50	INT0 … 49	50	2 bytes
DINT	30	DINT0 … 29	150	4 bytes
REAL	50	REAL0 … 49	270	4 bytes
SSTRING	–	–	–	64 bytes
LSTRING	–	–	–	500 bytes
Total size				**470 bytes**

Large string

Type	No. of values	Parameters	Offset to first parameter (bytes)	Size per value
SINT	–	–	–	1 byte
INT	–	–	–	2 bytes
DINT	–	–	–	4 bytes
REAL	–	–	–	4 bytes
SSTRING	–	–	–	64 bytes
LSTRING	1	LSTRING0	0	500 bytes
Total size				**500 bytes**

Small

Type	No. of values	Parameters	Offset to first parameter (bytes)	Size per value
SINT	10	SINT0 … 9	0	1 byte
INT	10	INT0 … 9	10	2 bytes
DINT	10	DINT0 … 9	30	4 bytes
REAL	10	REAL0 … 9	70	4 bytes
SSTRING	1	SSTRING0	110	64 bytes
LSTRING	–	–	–	500 bytes
Total size				**174 bytes**

Using the Interactive Setup Dialog Box

Type
Specifies the type of the parameter in the buffer,

Parameter
(Ethernet/IP only) Specifies which parameter in the buffer to map to. Parameters are made available by first selecting the parameter type in the Type column.

Source/Destination
The table row, program step result or constant value to be written to the selected parameter in the output buffer, or the table row in which to write the value from the parameter in the input buffer.

Name
For Ethernet/IP, the name is only used for display in the interactive setup dialog box.

For OPC, the name is the name that is used for referring to the parameter from the external device.

Preview
Shows the current value of the selected parameter in the buffer.

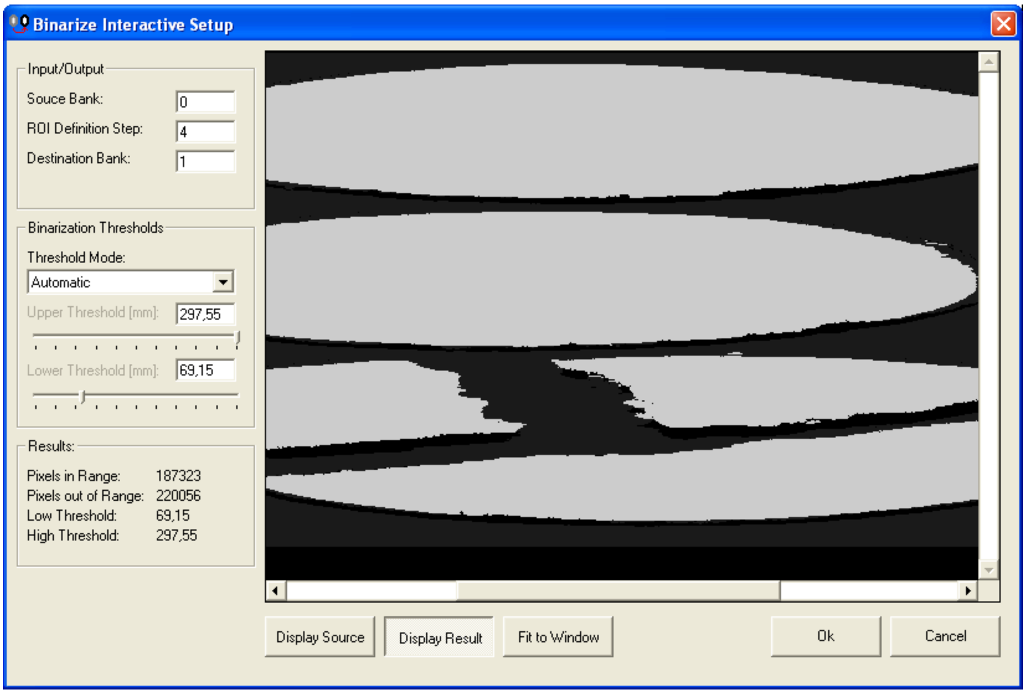
A 'Communication read/write' tool must have been executed before opening the interactive setup dialog box, otherwise this column will be empty.

Export mapping as text
Saves the settings made in this interactive setup to a text file.

Rounding/truncation handling
Specifies whether the IVC device should, if necessary, round or truncate the value before writing the value to the buffer.

Binarize Setup

The Binarize Interactive Setup creates binary images based on images in the Source Bank. For an introduction to the tool, see Binarize on page **83**.



Binarize Interactive Setup

Input/Output

Souce Bank: 0
ROI Definition Step: 4
Destination Bank: 1

Binarization Thresholds

Threshold Mode: Automatic
Upper Threshold [mm]: 297,55
Lower Threshold [mm]: 69,15

Results:

Pixels in Range: 187323
Pixels out of Range: 220056
Low Threshold: 69,15
High Threshold: 297,55

Figure – The Binarize Interactive Setup window.

Input/output

Choose an image for the Binarize tool by typing the number of the **Source bank** that contains the desired image. Also choose a storage place for the resulting binarized image by typing the number of a **Destination bank.**

Select a ROI from a previous program step.

Binarization Thresholds

Select a **Threshold Mode** for setting the upper and lower thresholds for the binarization operation. Choose `Manual` to set the upper and lower thresholds yourself by dragging the threshold bars. Choose an automatic mode when you know that the threshold level will shift from scan to scan. You can use an automatic mode first to find suitable thresholds while configuring the tool, and then switch to manual mode. The manual thresholds are updated to the values found by the automatic method.

Note: Using the automatic threshold options makes the tool a bit slower.

Display

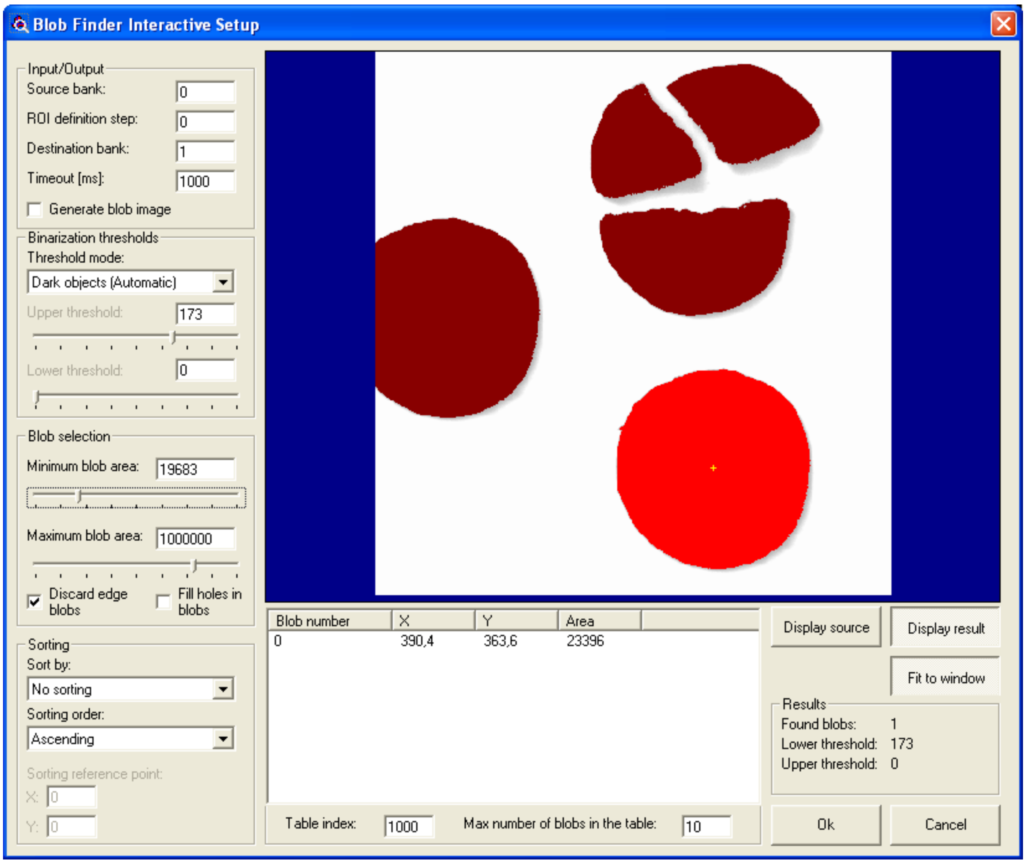
Click the **Display Source** button to display the source image.

Click the **Display Result** button to display a visual representation of the results. Pixels within the range are white, unless the inverted threshold mode is used.

The image is by default stretched to fill the preview window. Click the **Fit to Window** button to toggle between showing a stretched image and showing the image in its original size. The stretching does not preserve the aspect ratio of the image. It is only when showing the image in its original size that one pixel on the screen represents one pixel of the image.

Blob Finder Setup

The Blob Finder tool finds connected pixels, called blobs, within a specified value range. For an introduction to the tool, see Blob Finder on page **126**. All found blobs are stored internally, and can be analyzed by the Blob Analyzer tool.



Input/Output

Source bank: 0

ROI definition step: 0

Destination bank: 1

Timeout [ms]: 1000

☐ Generate blob image

Binarization thresholds

Threshold mode: Dark objects (Automatic)

Upper threshold: 173

Lower threshold: 0

Blob selection

Minimum blob area: 19683

Maximum blob area: 1000000

☑ Discard edge blobs ☐ Fill holes in blobs

Sorting

Sort by: No sorting

Sorting order: Ascending

Sorting reference point: X: 0 Y: 0

Blob number	X	Y	Area
0	390,4	363,6	23396

Results

Found blobs: 1

Lower threshold: 173

Upper threshold: 0

Table index: 1000 Max number of blobs in the table: 10

Figure - The interactive setup window for Blob Finder.

Left side *Input parameters for the Blob Finder tool*

Image area *Displays either the source image or the result. In the figure, the area outside the Region of interest is blue. One blob is found with the current parameter settings, and it is marked in bright red. The dark red areas are blobs that are discarded, one because it is an edge blob and the others because their areas are too small.*

Blob list *The blobs found with the current settings are listed below the image, sorted according to the Sorting-settings. The number of blobs listed depends on the Max number of blobs in table setting.*

Input/Output

Choose an image for the Blob Finder by typing the number of the **Source bank** that contains the desired image. Also choose a storage place for the resulting image with found blobs by typing the number of a **Destination bank**. Make sure that the evaluation bank is different from the destination bank.

Select a ROI from a previous program step. ROIs of any form are possible to use. The **Timeout** sets the maximum time for how long your program keeps looking for blobs.

Enable the parameter **Generate Blob Image** to store a binary image of the blobs (white) on black background in the destination bank. This function makes the Blob Finder step suitable as a pre-processing step to other tools. You can create a binary image where only objects of appropriate sizes are included. Disable this option to allow for faster execution of the tool if you do not intend to use the output image.

Binarization Thresholds

Select a **Threshold Mode** for setting the upper and lower thresholds for the binarization operation. Choose `Manual` to set the upper and lower thresholds yourself by dragging the threshold bars. Choose an automatic mode when you know that the threshold level will shift from scan to scan. You can use an automatic mode first to find suitable thresholds while configuring the tool, and then switch to manual mode. The manual thresholds are updated to the values found by the automatic method.

Note: For 3D images: If there is a need to include missing data in the binarization, set the Lower threshold to zero by typing 0 in the input field. For a better resolved scale, the range of the slider only covers the height of the chosen FOV, and therefore the slider cannot be pulled to zero.

Note: Using the automatic threshold options makes the tool a bit slower.

Blob Selection

Limit the result to blobs of adequate sizes by setting a Maximum Blob Area and a Minimum Blob Area. The area is measured in pixels. If holes are filled, the examined area includes the holes.

Check the **Discard edge blobs** checkbox to ignore blobs that are partly outside the ROI or that are touching the border of the ROI.

Note: If edge blobs are not discarded, only the part of the blob *inside the ROI* is detected and compared with the **Minimum blob area** and **Maximum blob area** parameters.

Check the **Fill Holes in Blobs** checkbox when you know that a part of the blob may consist of missing data due to patterned or shadowed objects, or to occlusion or poor reflectance on your scanned object. It is also useful if you wish to compute the area of the full object, including the holes inside the blob.

Sorting

Blobs can be sorted in different ways using the parameter **Sort By**: The following options are available:

`Vertical position`
`Horizontal position`
`Distance to Sorting Point`
`Blob Area`
`No sorting`

If Distance to Sorting Point is chosen, you must set the **Sorting Point** X- and Y-coordinates.

The **Sorting Order** has two options:

`Ascending` The sorting is done in increasing order, for example from small to large or from bottom to top.

`Descending` The sorting is done in decreasing order, for example from large to small or from top to bottom.

Display

Click the **Display Source** button to display the source image.

Click the **Display Result** button to display a visual representation of the results:

- Pixels within the threshold range are white.
- Pixels within the specified area range are red.

- Pixels out of range are left as they are in the source bank. This simplifies threshold tuning.
- Pixels not part of the ROI are blue.

The image is by default stretched to fill the preview window. Click the **Fit to Window** button to toggle between showing a stretched image and showing the image in its original size. The stretching does not preserve the aspect ratio of the image. It is only when showing the image in its original size that one pixel on the screen represents one pixel of the image.

Table

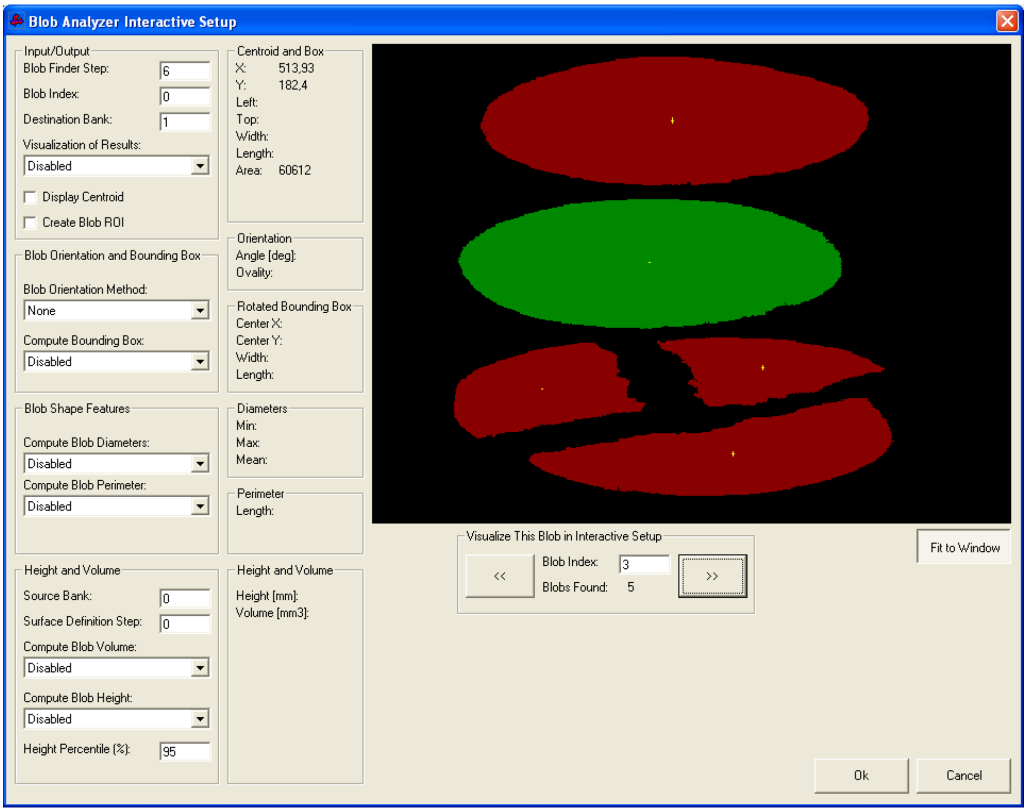
Use the **Table Index** to set the starting position (row number) in the table for where the found blob centroids and areas are stored. The default value is `1000`.

Note: This is only an extra option. All blobs are always stored internally and are thus accessible using the 'Blob Analyzer' tool. Storing in the table is intended for simple applications where only centroids and area are desired.

The **Max number of blobs in the table** limits the number of blobs that are stored in the table. This value also determines the number of listed blobs in the Interactive Setup window, since that list uses the table values for display. If the maximum number of blobs in the table is set to 5, then the list will contain 5 blobs as well. However, all blobs are still stored internally.

Blob Analyzer Setup

This tool analyzes blobs found by the ‘Blob Finder’ tool. It analyzes one blob at a time and is typically used in a for loop to analyze a number of blobs in sequence. For an introduction to the tool, see Blob Analyzer on page **128**.



Blob Analyzer Interactive Setup

Input/Output
Blob Finder Step: 6
Blob Index: 0
Destination Bank: 1
Visualization of Results: Disabled
□ Display Centroid
□ Create Blob ROI

Blob Orientation and Bounding Box
Blob Orientation Method: None
Compute Bounding Box: Disabled

Blob Shape Features
Compute Blob Diameters: Disabled
Compute Blob Perimeter: Disabled

Height and Volume
Source Bank: 0
Surface Definition Step: 0
Compute Blob Volume: Disabled
Compute Blob Height: Disabled
Height Percentile (%): 95

Centroid and Box
X: 513,93
Y: 182,4
Left:
Top:
Width:
Length:
Area: 60612

Orientation
Angle [deg]:
Ovality:

Rotated Bounding Box
Center X:
Center Y:
Width:
Length:

Diameters
Min:
Max:
Mean:

Perimeter
Length:

Height and Volume
Height [mm]:
Volume [mm3]:

Visualize This Blob in Interactive Setup
Blob Index: 3
Blobs Found: 5

Figure – The interactive setup window for the Blob Analyzer. The currently selected blob is shown in green. The blobs that are not selected is shown in red color.

Use the input parameters on the left of the interactive setup window to select the blob to be analyzed, and to select what features to compute for it. The results of the settings for a specific blob can be visualized in the image display.

Setting input and output parameters

Enter the **Blob Finder Step** where the Blob Analyzer can find the blob information to use, and a valid **Blob Index** number. The **Destination Bank** determines in which image bank the resulting image will be stored. If you enable **Visualization of Results**, the results are visualized in the Destination Bank. If **Display Centroid** is enabled the centroid of the blobs will be displayed.

A ROI can be generated from the blob. The blob ROI can be referred to in later steps by other tools. This means that you can perform any analysis or filtering operation that takes a ROI as input, and run it on the blob area of the picture only. You can for instance run another blob finder step on the current blob to find blobs inside the blob.

Only one blob at the time is analyzed. To analyze several blobs in an image, include it in a for loop and use the loop index as blob index. For example, if your for loop is located in step number 14, then type `=s14r1` to refer to the current blob index number. If you want to analyze all blobs in an image, set the for loop to loop from number 0 to the total number of found blobs -1.

All numeric results in the setup are based on the blob that is currently selected (by using the << and the >> navigation controls). Thus, the **Blob Index** number is not used when running the tool from the interactive setup. This means that you can visualize one blob in the interactive setup when configuring the tool, but use other blobs when running the program, which is useful since the Blob Index number is likely to be a reference to a for loop counter.

Blob Orientation and Bounding Box:

There are two **Blob Orientation Methods** to calculate the orientation of a blob. The `Area Based` method calculates the orientation based on all the pixels in the specific blob, while the `Boundary Based` only uses the pixels on the external perimeter of the blob. An XY-bounding box is always computed (based on results from the Left Edge, the Top Edge, the Width and the Length) and is drawn if no blob orientation method is chosen.

Which method will be best suited for your application depends on the shape of your blobs. For a rectangular blob containing holes, the boundary-based method is most suitable. For solid objects of arbitrary shapes the area-based method is often good. For perfect circles and squares it is not relevant to calculate an orientation since they have no orientation (blob ovality = 1).

In the **Compute Bounding Box** field, choose if to calculate a boundary box and if to visualize it. The bounding box will get different colors depending on which blob orientation method is selected. The `Boundary Based` method renders green boundary boxes, the `Area Based` method yellow, and if no blob orientation method is active the box will be blue.

Blob Shape Features

The **Compute Blob Diameters** measure computes the maximum, the minimum and the average diameters of the blob. It is only relevant for fairly circular blobs, since there simply is no reasonable definition of diameter of, for example, a U shaped object. The measured values are obtained by computing the diameter for all lines through the centroid of the blob, starting and stopping at the two most distant points in the blob.

The **Compute Blob Perimeter** measure computes the length of the external perimeter of the blob. Computing the perimeter length in a discrete image is an ambiguous task. The measure returned by this function is fairly invariant to orientation, but the value may vary with a few pixels from one scan to another on apparently identical objects due to sensor noise, lighting conditions etc.

Height and Volume

To compute the height or the volume of a blob you must define which **Source Bank** that contains the image, and which **Surface Definition Step** that defines the reference surface for the measurement. The reference surface is typically the background (conveyor) plane from which your blob is “sticking out”.

The **Height Percentile** defines what blob pixel values to consider when computing the blob height. This parameter makes the measurement more robust to noise and to reflection artefacts that typically appear along the borders of a 3D object.

For example, if you enter the height percentile value `95`, then the top 5% of the pixel values are removed before locating the maximum height above the reference surface.

Visualize This Blob in Interactive Setup

Click the << and the >> buttons to navigate between the blobs in the image, or enter a **Blob Index** number.

The visualization in the interactive setup is different from the visual results you get when executing the Blob Analyzer step in RUN or DEBUG mode. The visual representation of the results are interpreted as follows:

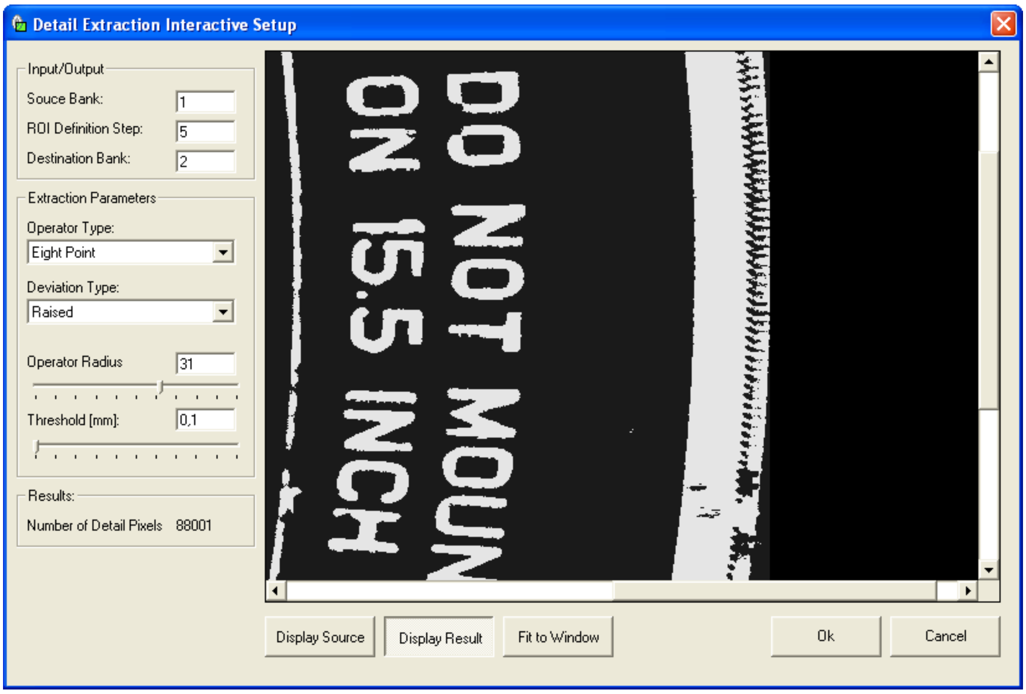
- The currently examined blob is green.
- All other blobs are red.
- The centroid of the currently examined blob is displayed as a red + sign.
- All other blob centroids are displayed as yellow + signs.

Note: The blob visualization is only a setup aid. It is not related to which blob that is analyzed when the tool executes. This means that you can visualize one blob in the interactive setup when configuring the tool, but use other blobs when running the program.

The image is by default stretched to fill the preview window. Click the **Fit to Window** button to toggle between showing a stretched image and showing the image in its original size. The stretching does not preserve the aspect ratio of the image. It is only when showing the image in its original size that one pixel on the screen represents one pixel of the image.

Detail Extraction Setup

The Detail Extraction Setup finds details in images that "stick out" from the background. For an introduction to the tool, see Detail Extraction on page **92**.



Detail Extraction Interactive Setup

Input/Output
Souce Bank: 1
ROI Definition Step: 5
Destination Bank: 2

Extraction Parameters
Operator Type: Eight Point
Deviation Type: Raised
Operator Radius 31
Threshold [mm]: 0,1

Results:
Number of Detail Pixels 88001

Figure – The Interactive Setup window for Detail Extraction.

Input/Output

Choose an image for the Detail Extraction by typing the number of the **Source bank** that contains the desired image. Also choose a storage place for the resulting filtered image by typing the number of a **Destination bank.**

Select a ROI from a previous program step.

Extraction parameters

Use the extraction parameters to define which details to extract from the image. Details that deviate from the background are extracted. To check if a point deviates from the background, it is compared to all or a limited set of its neighbouring points. The **Operator Type** defines which set of neighbouring points that shall be considered, for example horizontal, vertical or diagonal neighbours. Choose `Horizontal` to identify vertical patterns in an image, and `Vertical` to identify horizontal patterns; choose `Four points` or `Eight points` to identify smaller deviations of any form. It is also possible to consider all points (`Full region`), but this slows down the program.

The **Deviation Type** defines in what way the details shall deviate from the background, that is, if they are higher or lower than the background (or both).

Drag the **Operator Radius** bar to set the radius within which to pick neighbouring points for comparison. Drag the **Threshold** bar to define the minimum difference between the current point and the compared neighbours that is allowed to consider the point a detail. The visual representation of the result image in the interactive setup window is of good help when searching for suitable radius and threshold values.

Display

Click the **Display Source** button to display the source image.

Click the **Display Result** button to display a visual representation of the results:

- Detail pixels are high.
- Other pixels are low.

The image is by default stretched to fill the preview window. Click the **Fit to Window** button to toggle between showing a stretched image and showing the image in its original size. The stretching does not preserve the aspect ratio of the image. It is only when showing the image in its original size that one pixel on the screen represents one pixel of the image.

6 Troubleshooting

This section contains information that may be helpful when troubleshooting problems with the IVC camera.

If it is not possible to solve the problem using the information in this section, please contact technical support in your SICK sales subsidiary. Ask your SICK sales representative for guidance if needed.

When reporting a trouble, please write a trouble report as described at the end of this section. The purpose of the trouble report is to shorten the response time and enable more qualified support.

If technical support cannot assist, it may be necessary to send the camera in for repair. In this case, the same type of trouble report information should be attached.

6.1 Connecting to Devices

No devices in the device list.

Only a few devices are listed, and everyone show error.

A firewall may be blocking all or some of the communication between the device and IVC Studio.

If the PC has multiple network connections (for example has two Ethernet cards, or is also equipped with wireless network) IVC may be using the wrong network.

Solutions

Try the following:

- Check network connections.

  The PC must be connected to the device either through a switch or directly with a crossover cable. The IVC devices do not support wireless connections or connections through a hub.
- Choose Options → Configuration → Ethernet Devices, and check that the IP address shown in the dialog box (Local IP = ...) is correct.
  If the address is wrong, choose the correct IP address from the Local IP field if possible, or check the network settings on the PC.
- In the IVC Studio Configuration dialog box, click Ethernet Device Configuration.
  If the devices are not in the list of connected devices, check the network settings on the PC.
- If you know the IP address of the device, open a command prompt (Start → Programs → Accessories → Command Prompt), and type the following command:

  ```
  ping <IP address>
  ```

  where `<IP address>` is replaced with the IP address of the device. If the device does not reply there may be something wrong with the network configuration.
- Disable the firewall on the PC, or create an exception for IVC Studio.

Device shows error and cannot be connected to. Restarting the device does not help.	If a program stored in bank 0 in the flash memory is malfunctioning, for example not being compatible with new firmware, that program will stop with an error, making it impossible to connect to the device. Restarting the device will not help, since program 0 is automatically started when the device is powered up. **Solution** 1. Connect a high input signal (supply voltage) to pin 8 on the IVC-3D RS485 connector, and restart the device. The device should now start without running the program in bank 0. 2. Connect to the device and delete the program in bank 0.
Connecting to a device results in a lot of error messages. Sometimes the PC will crash	Make sure that the device is not used from any other PC. Only one PC at a time can be connected to a device, for viewing live images or editing programs.
PLC communication fails	The communication between the device and a PLC can be disturbed if there is a lot of traffic on the network. Try the following: • Use a separate network for the PLC communication, or at least try to isolate the PLC-IVC network from the rest of the network environment. • Do not run the device with F6 from IVC Studio. In this mode, there is a lot of communication between the device and IVC Studio, e.g. images, and this may disturb the PLC communication. Try to start the device in standalone-mode instead by choosing **Start Program** from the context menu in the Device list).
Function LED is flashing Red, Green, Yellow and the camera cannot be accessed	If the initialization of the Flash File System (FFS) fails when the camera is powered up, the camera stops and signals an error. In this situation there are two options: 1. Restart the camera by cycling the power off and on. If the problem with the FFS initialization was intermittent, the camera will now start normally. 2. Apply 24V to the digital input In3. This will force a complete formatting of the FFS, and all user specific information (e.g. IP-configuration settings, programs and data blocks) will be lost. After the formatting of the FFS, the camera will restart automatically. Note that the calibration files for the IVC-3D camera will also be lost. These files can be requested from tech support by referring to the serial number of the camera. If none of the above suggestions work, the camera must be sent to repair, as the flash is permanently damaged. Note that it is only in this flash error state, indicated by the LED color switching, that the flash will be erased by setting In3 high. The normal function of In3 remains, i.e. setting it high at power-up by-passes the starting of program in flash position 0.

6.2 Saving to Flash

How the flash works

The flash disk consists of a number of sectors. A sector can only be written to once. This means that if a file is edited, the sectors containing the previous version of the file are marked as “dead space”, and a complete copy of the new version of the file is written to one or more new sectors. I.e. the amount of “dead space” will increase each time something is written to the flash disk.

To be able to access the sectors marked as “dead space”, the flash must be “defragmented”. This is normally performed using the “Clear Unused Memory” option from the Flash menu of the device in the Device list.

Saving to Flash results in ”ITF Error = 2”.	The execution time for saving large data blocks or images to the flash may be longer than the time-out that is set in IVC Studio. In that case, IVC Studio will report that it lost contact with the device when the device is in fact busy saving. **Solution** • Increase the R/W command timeout limit in Options → Configuration → Timeout. When saving images, the values in the ‘Save Image to Flash’ tool description can be used as a rough guideline. Set the new timeout to several 100 ms above the max value to avoid time-out errors.
Saving to Flash suddenly takes much longer time.	If the execution time for saving to flash using 'Save data block to flash' or 'Save image to flash' suddenly increases, the device may have run out of free flash memory blocks (also known as sectors). In this case the device needs to clear a previously used (but now unused) memory block before saving, something that takes some time. The execution time can in this case be shortened by manually clearing the unused memory. **Solution** • Check the amount of free memory on the device by right-clicking the device in the device list and choosing Device Management → Device information. • If `FFS free size` is low and `FFS dead size` is large, clear unused (dead) memory by right-clicking the device and choosing Flash → Clear unused memory. Note that excessive writing to the flash memory may shorten its working life. The flash memory is specified for 100 000 re-writings.
To access the flash disk of the Emulator	The flash disk of the Emulator is found on the PC under My Documents (Documents in Vista) for the current user. The default path to the Emulator flash is: My Documents\SICKIVP\SmartCameras\IVC Studio x.x\ Emulator\flash

Automatic defragmentation

All tools that write to the flash disk can automatically clear dead space and perform a defragmentation of the flash disk. This functionality is controlled by the parameter **DeadSpaceThreshold** in the Smartreader.ini configuration file. It is also possible to configure the parameter in the **Ethernet Device Configuration** dialog, available on the **Options→Configuration→Ethernet Devices** menu of IVC Studio. If the amount of dead space exceeds the threshold, the flash disk will be cleared from dead space before the information is written to the disk. This means that the tools may take substantially longer to execute in some situations. In general, it is not recommended to use these tools in the normal measurement loop of the program. An error code will be returned when the tools are executed by F5/F8 if the amount of dead space exceeds the threshold.

The threshold is specified as (**amount of dead space**)/(**amount of dead space** + **free space**) in percent. The functionality for automatic defragmentation can be disabled by setting the threshold to -1. The lower limit for the threshold is set to 20%, and the upper limit is set to 80%. The reason for not allowing less than 20% is that the defragmentation shall not be performed too often. The default value for the threshold is set to 50%.

If the automatic defragmentation is enabled, the camera may perform a defragmentation of the flash disk when powered up. During this operation, the function LED is set to yellow. Note that the time to start the camera will in this situation be longer than usual.

6.3 Grabbing 3D Images

Grab setup returns an error when executed.

If a program was created on one device and loaded into another, the image grabbing settings may not be valid for the other device since the maximum FOV may differ between individual devices.

Solution

If the program was created on a device of the same type, open the 'Grab setup' interactive setup, and change the field of view settings to make them valid for the device.

If the program was created on a device of another type, the ‘Grab Setup’ step must be removed and a new one inserted for the current device type. From version 3.0 of IVC it is no longer possible to open the interactive setup for ‘Grab Setup’ with settings for another device type, e.g. it is not possible to open the interactive setup with an IVC-3D 100 if the step was created on an IVC-3D 200 device.

Grab tool fails to capture images when debugging.

Grab tool captures partial images when debugging.

If the **Timeout** parameter is set to -1 (infinite timeout), the 'Grab' tool will return immediately when executed with Execute step or Step by step, instead of waiting for a 3D image to be ready. If there was no 3D image ready when the tool returned, no image is placed in the image bank, and Lost images is -1.

If the device is set to capture overlapping images, the tool may also place an incomplete image in the image bank before returning.

Solution

Set the **Timeout** parameter to a value other than -1 when debugging the program, and set it to -1 when the program is ready to be used stand-alone..

6.4 Running IVC Studio

Online help window cannot be closed.

Adobe Acrobat may be blocked by a dialog box saying that it is about to check for updates. This dialog box is placed under the window with the online help, making it impossible to close.

Solution

Turn off Acrobat’s function for automatically checking for updates:

1. Start Acrobat.
2. Choose Edit → Preferences from Acrobat’s main menu.

   The Preferences dialog box is displayed.
3. Click on Updates in the list to the left.
4. *Acrobat 5 & 6:* Choose Manually from the Check for Updates menu.

Acrobat 7: Select Do not automatically check for critical updates.

5. Click OK to close the Preferences dialog box.

6.5 Debugging Step Programs

The results of previous steps are lost during editing and debugging	The entire contents of the step program are transmitted to the camera when the step program name is clicked in the tree-view. If this is done during editing of the step program, the results from previous steps, e.g. ROI:s, may be lost. **Solution** Execute the step again to restore the result in the camera.

6.6 IVC Emulator

The IVC Emulator cannot be closed from IVC Studio	If the IVC Emulator is enabled while the active network is changed in IVC Studio, it is not possible to disable the emulator from IVC Studio. **Solution** The emulator must be terminated using the Task Manager. 1. Open **Task Manager** (e.g. by pressing Ctrl+Alt+Del) 2. In the tab Processes, select *IVCEmulator.exe* in the column **Image Name**. 3. Click **End Process** 4. Click **Yes** in the dialog with the warning message.
The IVC Emulator is not visible in IVC Studio	Some VPN clients and firewalls block the network traffic for the emulator. **Solution** Contact your IT department for a solution how to configure your VPN client or firewall in a safe way.

6.7 Trouble report

The trouble report is the key to successful troubleshooting by somebody else. Therefore, if you need help from technical support or repair, the quality of the trouble report will determine the quality of the help you will get.

The required detail and quality of the trouble report depends on the status of the troubleshooting, especially if it is before or after the point where the problem is reproducible.

Examples of content are:

- Brief application description
- System configuration
  - Firmware version, i.e. IVC version
  - Hardware type code and serial number
  - Network architecture
- Expected behavior
- Observed symptoms
  - What happens and how often does it happen
- How to reproduce, step by step
- Log files with system info from when the failure occurred

    - The log file from IVC Studio can be found in the folder (on XP) <My Documents\SICKIVP\SmartCameras\IVC Studio x.x\>
- Camera images, both normal and troublesome if possible
- Camera step program

Appendix

A Mathematical Expressions

It is possible to create strings that contain mathematical expressions. This is useful for performing calculations in a program that cannot be performed by the tools.

A mathematical expression always begins with an equal sign (=). String parameter values that begin with an equal sign will be treated as expressions. If a string parameter needs to begin with an equal sign, preceed it with a single quotation mark, for example `'=Hello`.

When using strings in expressions, the strings must always be enclosed in single quotation marks, for example `'Hello world'`. If you need to include a single quotation mark in a string, preceed it with a backslash (`'\'Hello\', she said.'`).

Note: If fractional values are used in expressions, the decimal delimiter must always be a dot (.), regardless of any local settings made on the PC. Commas (,) are always used in expressions for separating parameters.

The following operands are used for referring to table and parameter values:

Operand	Meaning
`Vx`	Value in table row x
`V(x*n)`	Value in table row (x * n)
`Sa`A*b*	Argument (input parameter) b of Step a *
`Sa`R*b*	Result b of step a *

* a and b are arbitrary integers

A.1 Arithmetic Operators

You can use the following operators:

Symbol	Meaning
`-`	Subtraction
`+`	Addition
`*`	Multiplication
`/`	Division
`%`	Modulo, the remainder from a division of two integers. For example: `10%3` = `1`
`^`	Power. For example: `2^3` = `8`
`<`	Less than
`>`	Greater than
`Sin(x)`	Sine, x is the angle in radians
`Cos(x)`	Cosine, x is the angle in radians
`Tan(x)`	Tangent, x is the angle in radians

Symbol	Meaning
`Asin(x)`	Arcsine, result is in radians
`Acos(x)`	Arccosine, result is in radians
`Atan(x)`	Arctangent, result is in radians
`Sinh(x)`	Hyperbolic sine
`Cosh(x)`	Hyperbolic cosine
`Tanh(x)`	Hyperbolic tangent
`Exp(x)`	Exponential (e^x)
`Log(x)`	Natural logarithm (ln)
`Log10(x)`	Base 10 logarithm
`Sqrt(x)`	Square root
`Floor(x)`	Integer part of a decimal value. For example: `Floor(3.1415)` = 3
`Ceil(x)`	The smallest integer that is larger than or equal to a decimal value. For example: `Ceil(3.1415)` = 4
`Round(x, decimals)`	Rounds off a value to a specified number of decimals
`Abs(x)`	Absolute value
`Deg(x)`	Conversion from radians to degrees
`Rad(x)`	Conversion from degrees to radians
`Min(x, y, ...)`	Minimum
`Max(x, y, ...)`	Maximum
`Equ(x, y)`	Equality
`Not`	Logical not
&	Bitwise and
|	Bitwise or
<>	Not equal to
=	Equal to
<=	Less than or equal to
>=	Greater than or equal to
`!`	Logical not
~	Bitwise not
>>	Bitwise shift to left
<<	Bitwise shift right
`( )`	Parenthesis, used for giving priority to operands
`.`	Dot. Separates the integer part of a number from the fractional part
`,`	Separator, for example `Max(5,7) = 7`

A.2 String Operators

Symbol	Meaning
+	Concatenation
=	Comparision. Returns 1 if both strings are identical.
`Asc(char)`	Returns the ASCII code for the specified character. For example `asc('A')` returns the value 65.
`Chr(number)`	Returns the character for the specified ASCII code. For example `chr(66)` returns `'B'`.
`Sub(str, index)`	The character at position `index`. Note that the first character in the string has index `0`. Negative values will count the positions from the end, for example `-1` will return the last character.
`Sub(str, start, stop)`	A substring with the characters at positions from `start` to `stop-1`. Note that the first character in the string has index `0`. If `start` is empty, all characters from position 0 to `stop` are returned. If `stop` is empty, all characters from position `start` to the end of the string are returned. For example `sub('Hello World', 0, 5)` returns `'Hello'` and `sub('Hello World', 6, 11)` returns `'World'`.
`Len(str)`	The number of characters in the string.
`Eval(str)`	Evaluates the string as if it were an expression. For example `eval('1+2+3')` returns 6.
`Str(number)`	A string representation of the number. For example `Str(1.23)` returns the string `'1.23'`
`Repr(number)`	A string representation of the number that can be re-evaluated to its original value. For example `Repr(1.23)` returns the string `'1.230000e+000'`

A.3 Time stamps

It is possible to access the current time from a step program by using a string operator. Two operators are available, one that returns the UTC time and one that returns the time and date as a string. For the string operators to return the correct time, a time server IP address need to be set up (see Time server in Appendix B). If the Emulator is used the time from the computer will be used and the supplied timezone will not be used.

Symbol	Meaning
`time(timeZone)`	Returns the local time in seconds, UTC time with offset. timeZone is the local offset from UTC time in hours.
`timestr(timeZone, format)`	Returns the local time and date as a string, timeZone is the local offset from UTC time in hours. Three formats are possible: **Format value** — **Example** 0 — 2008-10-02 14:27:42 1 — 02.10.2008 14:27:42 2 — 10/02/2008 02:27:42 PM

A.4 Operator Priority

The operators have the following priority:

Highest priority	`( )`
	`.`
	`V`*`x`* *`SaAb SaRb`*
	Functions, for example `sin(`*`x`*`)`
	`* / %`
	`+ -`
	`< >`
Lowest priority	`,`

Example

```
=Not( S3R1 * V( 5 * S2R1 ) < 10 )
```

This expression uses the first result from program step 3 (`S3R1`), and a value from the table (`V( 5 * S2R1 )`). Which table row to get the value from is calculated by using a result from program step 2.

Assume that we have the following values:

	Variable	Value
Result 1 from step 2	`S2R1`	7
Result 1 from step 3	`S3R1`	6
Row 35 in the table	`V35`	2

The expression is resolved in the following way:

```
=Not( S3R1 * V( 5 * S2R1 ) < 10 )
=Not( S3R1 * V( 5 * 7 ) < 10 )
=Not( S3R1 * V35 < 10 )
=Not( S3R1 * 2 < 10 )
=Not( 6 * 2 < 10 )
=Not( 12 < 10 )
=Not( 0 )
1(TRUE)
```

B Setting Device Parameters

The parameters described in the table below are available in the dialog **Ethernet Device Settings**:

- Choose **Options -> Configuration** from the IVC Studio menu bar.
- A window containing a tree view is displayed.
- Select **Ethernet Devices** in the tree view.
- Ethernet devices are displayed in the right pane in the window.
- Click the **Ethernet Device Configuration** button.
- The **Ethernet Device Settings** window is displayed containing a list of available devices.
- Select a device from the list. The parameters in the table below are displayed for the selected device.

Modifications to the parameters are stored in the device by clicking the “Update” button. Please note that this will restart the device.

Parameter category	Parameter name	Parameter explanation
Network Parameters	IP	Specifies the IP address of the network interface. It can be set manually or automatically through the DHCP if this protocol is enabled. The number must be written in the following format aaa.bbb.ccc.ddd. The default value is 192.168.0.110. We recommend that the number 255 is not used for the four parts of the address in order to avoid that the device is not recognized. Each device must have a unique IP address.
	Netmask	Specifies the netmask of the sub-network. The number must be written in the following format aaa.bbb.ccc.ddd. The default value is 0.0.0.0. In the event that this parameter is not necessary, it should be set to 0.0.0.0 or an empty string.
	Gateway	Specifies the network Gateway address. The number must be written in the following format aaa.bbb.ccc.ddd. The default value is 0.0.0.0. In the event that this parameter is not necessary, it should be set to 0.0.0.0 or an empty string.

Parameter category	Parameter name	Parameter explanation
	DNS	Specifies the Domain Name Server address. The number must be written in the following format aaa.bbb.ccc.ddd. The default value is 0.0.0.0. In the event that this parameter is not necessary, it should be set to 0.0.0.0 or an empty string.
	WINS	Specifies the WINS server address. The number must be written in the following format aaa.bbb.ccc.ddd. The default value is 0.0.0.0. In the event that this parameter is not necessary, it should be set to 0.0.0.0 or an empty string.
	Time Server	Specifies the IP address of the Time Server, in accordance with the SNTP protocol (UDP port 123). The number must be written in the following format aaa.bbb.ccc.ddd. The default value is 0.0.0.0. In the event that this parameter is not necessary, it should be set to 0.0.0.0 or an empty string.
	DHCP	Specifies if the DHCP is enabled. The default value is 1 (enabled). The accepted values are 1 = enabled, 0 = disabled. If the DHCP client is enabled the following parameters are set automatically: IP, Netmask, Gateway, DNS, WINS, TimeServer.
	DHCP Wait Save	Specifies the time, in seconds, in which the network parameters set by the DHCP are saved in the configuration file.
	DHCP IP Auto Configuration	Specifies what the computer does in the case DHCP does not answer the camera or does not assign it an IP address. If the flag is 1 the camera gets the IP 0.0.0.0. If the flag is zero the camera gets the IP that was last assigned to it. The last assigned address is stored in the device.ini file.

Parameter category	Parameter name	Parameter explanation
Device Parameters	ID	Unique ID to distinguish each device for the user. Every device must have a unique ID. If two devices have the same value, they are not visible in the main window and the system displays an alert message highlighting the problem. The value must be between 1 and 65535.
	Net Bios	Specifies the identification string of the device. As it is governed by the system, the string must not contain empty spaces. If this is not set by the user, it is made up as ID_#, where # is the ID parameter.
	FTP Server Enabled	Specifies that access to the flash memory content is allowed through ftp, when it is set to 1. To view the files present in the system's flash memory, enter *ftp://<IP-address_of device>/* in the address bar of Internet Explorer and login with user name `anonymous` and password `guest.`
	HTTP Server Enabled	Specifies that access to a web page in flash memory is allowed, when it is set to 1. This enables to monitor the selected parameters during runtime using the Web Status Page tool.
	Communication Enabled	Specifies if the Ethernet/IP and OPC communication shall be enabled. Note that the performance of the camera may be affected when the communication is enabled (i.e. set to 1).
	Dead Space Threshold	Specifies the amount (in %) of dead space on the flash that is allowed before the camera performs an automatic defragmentation. Allowed values are between 20 and 80%. The value -1 will disable the functionality.
	Image Banks	Specifies the number of image banks to be used for 2D or 3D images, depending on the type of device. If there is not sufficient memory in the device, the previous value is restored.

Parameter category	Parameter name	Parameter explanation
	Profile Banks (IVC-3D only)	Specifies the number of image banks to be used for profiles in the IVC-3D camera. The image banks with the lowest numbers are used for 3D images, and the remaining image banks are used for profiles.

Handling of invalid IP addresses

The device verifies the IP address specified in the IP field. If the value is invalid, e.g. if an invalid character is entered in the field, the device will set the default IP address (192.168.0.110), and activate the FTP server. The FTP server is activated to allow direct access to the configuration files of the device.

The following addresses are not allowed by the device

0.0.0.0	No address
127.0.0.1	Loopback address
255.255.255.255	Broadcast address
224.x.x.x – 239.x.x.x	This range holds multicast addresses

C Missing Data in Certain Tools

The tools listed below handles pixels with missing data in a 3D image as having a height value of 0.

If this is not desired, you can use the 'Missing data' tool to fill in the areas of missing data and avoid having these tools being affected by the missing data.

In addition, these tools work with a height resolution that differs from the native resolution of the used device. The used resolution depends on the height of the FOV, and can be calculated with the following formula:

$$\frac{\text{Height of FOV}}{243}$$

Edge

- Find Row Edge
- Find Column Edge
- Find Row
- Find Column
- Find Line Edge
- Find Subpixel Edge
- Find Multiple Edges
- Find Mean of Edges
- Find Circle Edges

Measure

- Centroid
- Single Blob Analysis
- Area
- Blob Analysis
- Count Deviating Points
- Perimeter

Matching

- Teach Rotation
- Match Rotation
- Teach Shape
- Match Shape

Circular

- External Perimeter
- Internal Perimeter
- Check Circular Surface

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