

D DATA SENSOR

Smart Vision Sensor



*The easy way
to machine vision*

INSTRUCTION MANUAL

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DECLARATION OF CONFORMITY



We

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declare under our sole responsibility that the product(s)

SVS2-XX-XX-XXX, SMART VISION SENSOR AND ALL ITS MODELS

To which this declaration relates in conformity with the following standard(s) or other normative document(s)

CEI IEC 60947-5-2, JANUARY 2004:

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR. PART 5: CONTROL CIRCUIT DEVICES AND SWITCHING. SECTION 2: PROXIMITY SWITCHES

CEI EN 55011, MAY 1999 + A1 (2000) + A2 (2003):

INDUSTRIAL, SCIENTIFIC AND MEDICAL (ISM) RADIO-FREQUENCY EQUIPMENT
RADIO DISTURBANCE CHARACTERISTICS
LIMITS AND METHODS OF MEASUREMENT

IEC 61000-6-2, OCTOBER 2006:

ELECTROMAGNETIC COMPATIBILITY (EMC).
PART 6-2: GENERIC STANDARDS – IMMUNITY FOR INDUSTRIAL ENVIRONMENTS

Following the provision of the Directive(s):

**2004/108 CEE (EMC), 2006/95 CEE (LV)
[73/23 CEE AND SUCCESSIVE AMENDMENTS, 93/68 CEE].**

Monte San Pietro, 13/11/2007

Giuseppe De Maria

Quality Assurance



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1. GENERAL INFORMATION

1.1. Conventions used in the Manual

This manual is intended as a clear, quick-reference guide on SVS2 system operation.

If you wish more detailed information on the algorithms and techniques referenced in the manual, the symbol (▶) throughout the text refers to Chap.17 that contains a specific TUTORIAL.

Boxed text provides definitions to ensure better understanding of the topic under discussion.

For other significant terms, please see the GLOSSARY in Chap.18.

Examples are printed in italic type.

1.2. General description



Datasensor S.p.A. SVS2 is an easy-to-use machine vision sensor (machine vision ▶) offering cutting-edge inspection features that make it suitable for a broad range of applications (such as quality control on manufacturing lines or automated material handling, just to name a few).

Basically, what it does is compare a digital image (▶) acquired at a certain instant (the "target image") with a stored reference image (the "master image").

Once the SVS2 sensor is connected to a Personal Computer and configured using the supplied software, it offers stand-alone (i.e. fully independent) operation. Digital outputs only operate in the stand-alone mode and are disabled during the configuration process or in off-line operation.

1.3. Available Models

| Item Number | Model | Description | | |
|-------------|----------------|-------------|------------------------------|-------------|
| | | Lenses | Connections | Controls |
| 959951050 | SVS2-06-DE-OBJ | 6mm | 1 input, 3 outputs, Ethernet | Recognition |
| 959951060 | SVS2-08-DE-OBJ | 8mm | 1 input, 3 outputs, Ethernet | Recognition |
| 959951070 | SVS2-12-DE-OBJ | 12mm | 1 input, 3 outputs, Ethernet | Recognition |

Models ending with 'OBJ' feature controls that are specifically designed for object recognition, whereas those ending with 'ID' feature controls typically used in identification applications.

1.4. Components

The SVS2 system includes:

- sensor body with lens and incorporated illuminator;
- configuration software.

2. ELECTRIC CONNECTIONS

M12 8-pole: (power supply and I/O)

| | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p>pin 1 : white : digital input 1 pin 2 : brown : 24 Vdc pin 3 : green : STROBE for external illuminator pin 4 : yellow : output 1 pin 5 : gray : output 2 pin 6 : pink : output 3 pin 7 : blue : GROUND pin 8 : red : external trigger</p> | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|

M12 4-pole Ethernet: (connectivity)

| | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p>pin 1: white/orange: RX+ pin 2: white/green: TX+ pin 3: orange: RX- pin 4: green: TX-</p> | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|--|

3. OPERATING DISTANCES

| Operating distance (mm) | SVS2-12-DE-OBJ | SVS2-08-DE-OBJ | SVS2-06-DE-OBJ |
|-------------------------|----------------|----------------|----------------|
| 50 | 17 x 12 | 25 x 20 | 42 x 30 |
| 80 | 25 x 20 | 40 x 30 | 60 x 41 |
| 110 | 33 x 25 | 55 x 40 | 80 x 55 |
| 140 | 45 x 35 | 70 x 50 | 98 x 69 |
| 170 | 53 x 38 | 85 x 60 | 118 x 83 |
| 200 | 60 x 50 | 100 x 70 | 138 x 92 |
| 300 | 90 x 65 | 145 x 103 | 201 x 140 |
| 400 | 121 x 82 | 186 x 132 | 265 x 189 |
| 500 | 150 x 110 | 236 x 167 | 330 x 232 |
| 600 | 185 x 130 | 282 x 232 | 385 x 270 |

4. INSTALLATION

4.1. Hardware connections

To ensure proper operation, never exceed device ratings (see Chap.9 for a complete list). Avoid spilling fluids on the device and make sure it is not exposed to strong vibration.

Connect power supply connector and communication cord to sensor.



There are four system operation LEDs on sensor body:

1. Network connection, green;
2. Digital output 2, orange;
3. Digital output 1, orange;
4. Power, green.



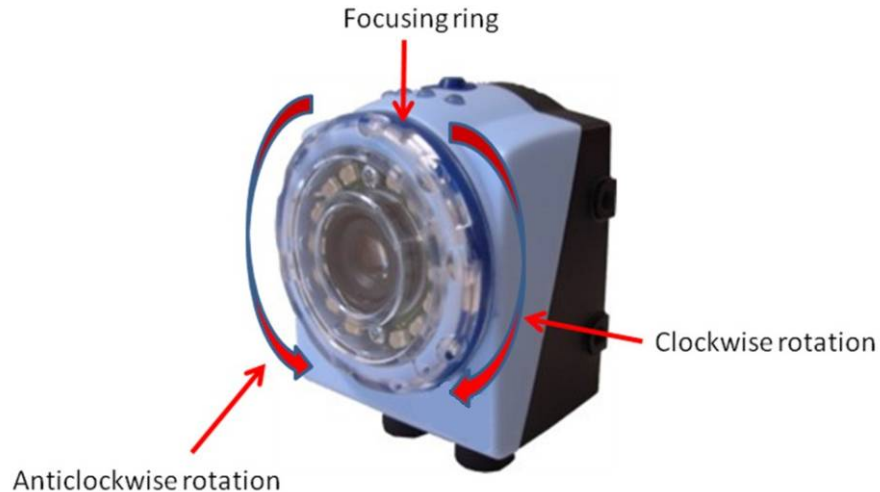
A teach-in push-button is also provided (its operation is discussed further below).

To check for proper operation of the system, install the software on the personal computer (see next paragraph) and start the program.

4.2. Focusing ring

In order to focus the area placed by the sensor you should use the transparent focusing ring on the front side of the SVS2 sensor.

Referring to the following picture, you must clockwise rotate the focusing ring in order to focus more distant points; you must anticlockwise rotate the focusing ring in order to focus less distant points.



4.3. Graphic User Interface installation and start-up

The supplied Graphic User Interface lets you configure the sensor and tailor its operation to meet the most varied application requirements.

This is done as follows:

- Install software on personal computer;
- Connect sensor to personal computer using the suitable cable;
- Start the Graphic User Interface. This may be done in one of two ways:
- double-click the icon on the desktop using the left mouse button;
- select Start → All programs → Datasensor and then select the program icon.

4.3.1. Minimum system requirements

Make sure your personal computer meets the following minimum requirements to ensure proper interfacing with the system:

- 1 GHz Pentium processor
- 512 MB RAM
- SVGA monitor (1024x768 pixel)
- 10/100 Mbps network board
- 25 - 30 MB space available on hard disk
- CD-ROM drive

These requirements are suggested for best performance:

- 2 GHz Pentium processor
- 1 GB RAM
- monitor with 1280x768 resolution as a minimum
- 100 Mbps network board
- 25 - 30 MB space available on hard disk
- CD-ROM drive

4.3.2. *Graphic User Interface Installation*

We recommend closing any programs that are currently running.

Insert the supplied CD-ROM into the personal computer drive. After a few seconds, the startup screen is displayed automatically.

Note: If the screen does not appear, launch the installation program manually. Select "Run..." from the START menu and type "X:\setup.exe", where "X" is the letter associated with the CD-ROM drive in your system.

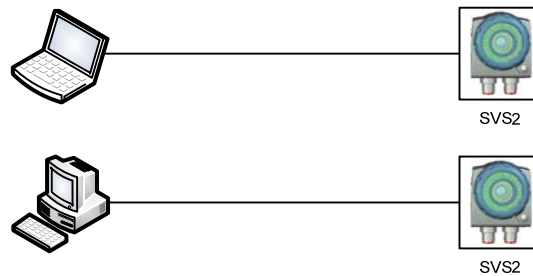
Select "Install SVS2 GUI" to start software upload to your hard disk and then simply follow the on-screen instructions.

Restart the system to complete installation.

4.4. Communicating with the sensor

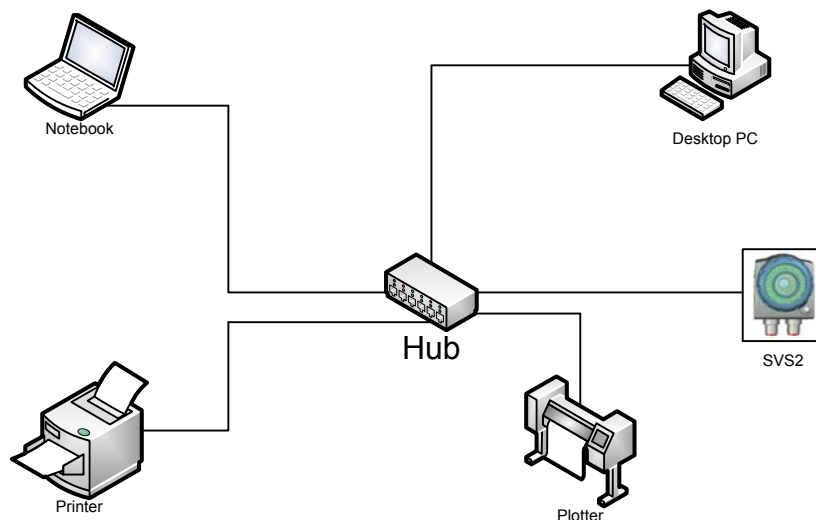
Communication with the sensor occurs via the Ethernet network.
Two types of connection are possible:

direct connection: personal computer is connected directly to device using a "[cross cable](#)".



Through LAN: use common network (non-cross) cables normally used to connect devices to routing hubs.

This network architecture is termed "star" configuration because all network cables are connected to a central HUB.



It is essential that the [IP addresses](#) of personal computer and device be compatible.

The Graphic User Interface offers a discovery feature that automatically searches for and locates any sensors in the network and displays their IP address and Subnet Mask information. After selecting the desired sensor, you may proceed to set inspection settings (see page 22).

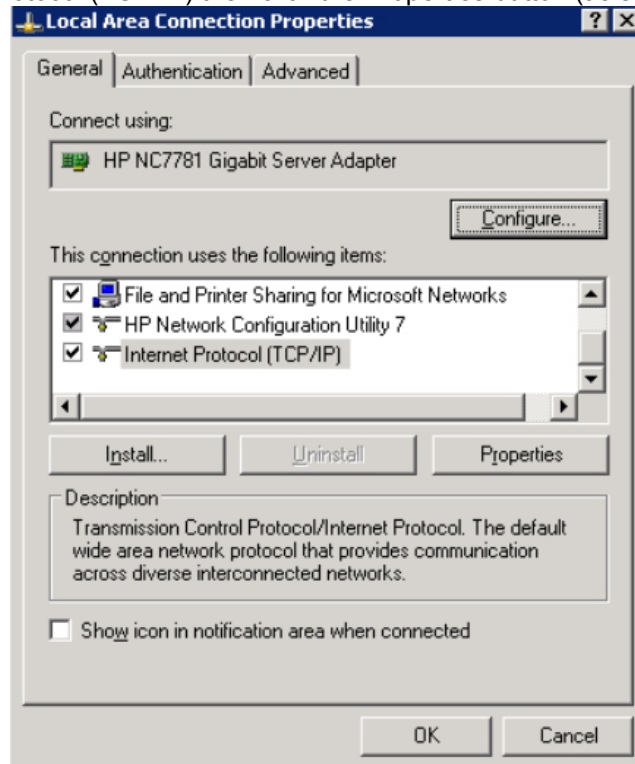
4.4.1. Check PC Network Settings

It is essential that the IP addresses of your personal computer are compatible to those of the sensor to successfully set up a communication.

Note: You need to have administrator rights established for the present user logged in to follow the next instructions. If this is not the case, please contact your local IT manager for assistance in creating this.

If you use a direct connection:

- From menu START select Control Panel → Network Connections → LAN Connection;
- Press the right mouse button and select Properties;
- Select Internet Protocol (TCP/IP) then click the Properties button (as shown below);



- Select Use the following IP Address option;
- Enter the following:
IP ADDRESS: 172.27.101.1;
SUBNET MASK: 255.255.0.0;

Note: no entries for Default Gateway or Use the following DNS Server Address are necessary.

- Click OK to close the dialog TCP/IP properties; then click OK at the LAN Properties dialog.

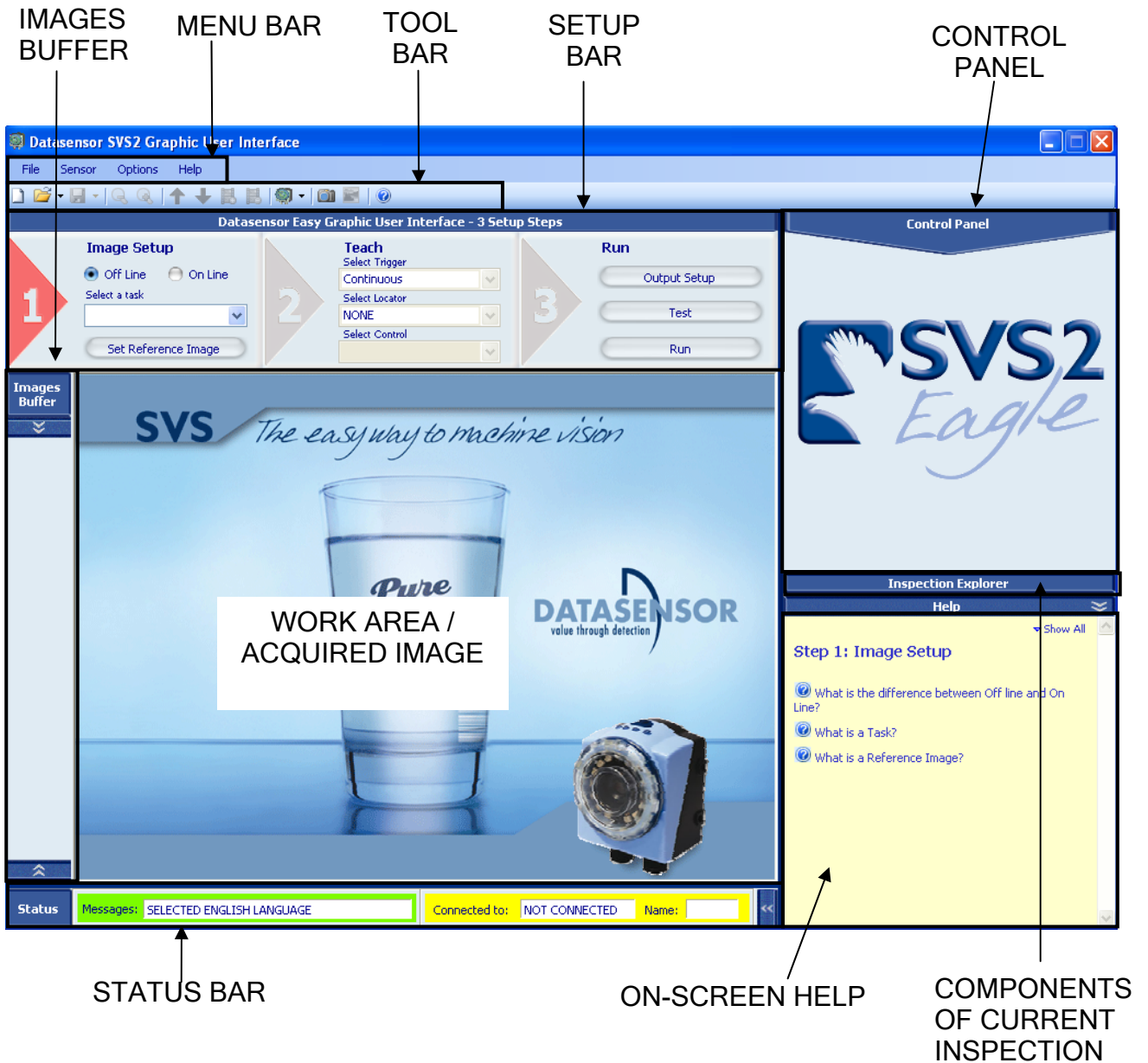
If you are connected to the sensor through a routing device you should first verify if the network hosts a DHCP server.

- If the network hosts a DHCP Server
 - From menu START select Control Panel → Network Connections → LAN Connections;
 - Press the right mouse button and select Properties;
 - Select Internet Protocol (TCP/IP) then click Properties button again;
 - Finally select Obtain an IP Address automatically.
- If the network doesn't host a DHCP Server:
 - Please contact your local IT manager for assigning an IP Address to your PC;
 - Follow the instructions for direct connection configuration (pag. 8).

5. SENSOR SETUP

5.1. Configuring an inspection through the Graphic User Interface

After launching the program, the following screen is displayed



The screen is divided into the following sections:

- menu bar
- tool bar
- setup bar
- control panel
- images buffer
- work area / acquired image
- components of current inspection
- on-screen help
- status bar

5.1.1. Menu bar

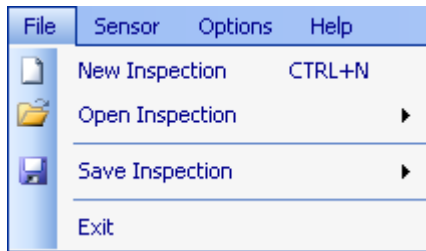


Lets you load or save the inspection in .XML format on your personal computer and choose Graphic User Interface mode.

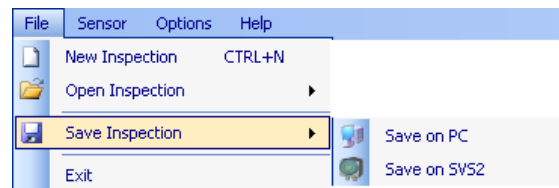
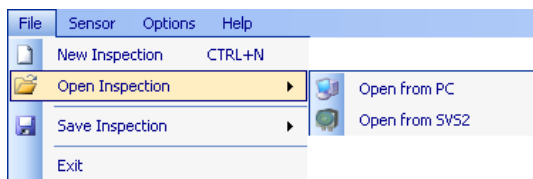
Files .XML can be used as exchange files to upload the same inspection to several sensors.

It includes the following menus:

File :

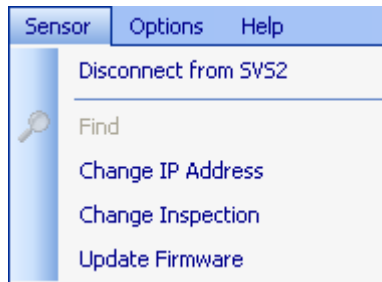


- **New Inspection:** Resets the interface returning it to the initial condition;
- **Open Inspection:** Loads an inspection stored on the personal computer or from sensor memory;
- **Save Inspection:** Saves current inspection on personal computer or on sensor memory;
- **Exit :** Closes Graphic User Interface.



From the 'Open' and 'Save' menus, you may access the files stored on the personal computer (**Open Inspection from PC, Save Inspection on PC**) or in sensor memory (**Open Inspection from SVS, Save Inspection on SVS**).

Sensor :



The icons in this menu let you:

- establish connection with sensor (**Connect to SVS**),
- access Live mode (**Live**),
- find sensor in the network (**Find SVS**),
- change IP address (**Change IP Address**),
- change inspection (**Change Inspection**),
- finally, update sensor firmware (**Firmware Update**).

Options :

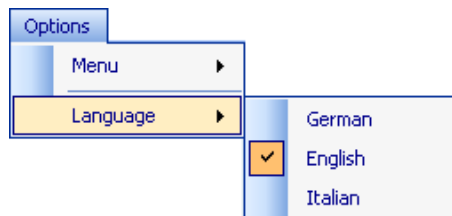


From this menu, you can:

- Select the "Standard" or "Expert" mode for the Graphic User Interface (Please note that certain inspection setup parameters are not available in both modes)



- Set interface display language



- Save images present in the Images Buffer while saving Inspection on PC. If this option is checked, all the images present in the Images Buffer are stored together with the Inspection script.

Help :



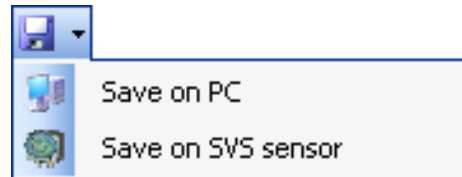
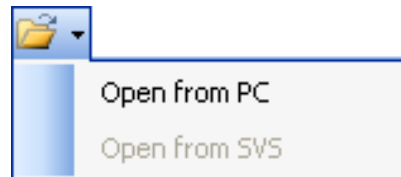
- **Contents** : Displays On-Screen Help;
- **Index** : Displays Help index;

5.1.2. Tool bar



Gives quick access to typical functions. It is divided into 4 sections:

- The first 3 icons access the same functions contained in the *File* menu. In the order: New, Open, Save;



The load and save operations can be performed on the PC or by transferring the current inspection directly from the memory or to sensor memory;

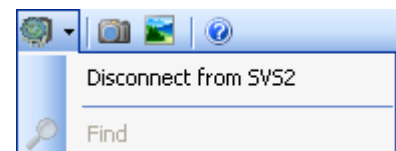
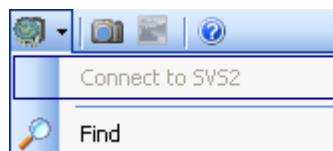
- The next 2 icons let you choose the magnification level for the image in the work area: the first is the 'Zoom Out' icon, that reduces magnification to provide a better overview of the image as a whole, the second is the 'Zoom In' icon, that magnifies the object to highlight details;
Note: Image scaling functionality will be available in release 1.2.0.



- The next 6 icons let you interact with the *Images buffer*. The first icon disables automatic image addition to the buffer during *Live mode*; the arrows scroll image thumbs; the third icon may be used to upend another thumbview to the list; the fourth icon removes the image corresponding to the currently selected thumbview from the list (*Note* : This will eliminate the link to the image, while the image remains stored on the personal computer); the last icon is used to save.



- The next two icons establish a connection with the sensor (**Connect to SVS**) after it has been located in the network (**Find SVS**), or let you connect to/disconnect from the simulator (**Connect to Simulator/Disconnect from Simulator**)



- The next two icons save screen shots of the Graphic User Interface screens (**Screen Shot**) or of the work area / acquired image (**Save Image**)

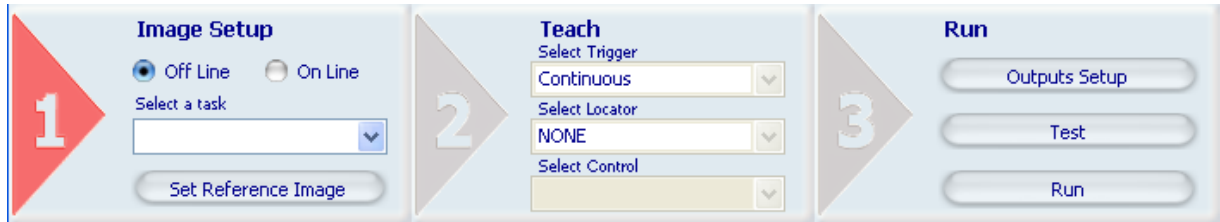


- Finally, the last icon gives access to Help



5.1.3. Setup bar

The Setup bar lets you complete the system configuration procedure in 3 steps.



The procedure is described in detail further below; to make it easier, it has been divided into three steps:

- Choose inspection mode (step 1);
- Set trigger signal, controls and locators (if needed) (step 2);
- Set outputs and Test and Run modes (step 3).

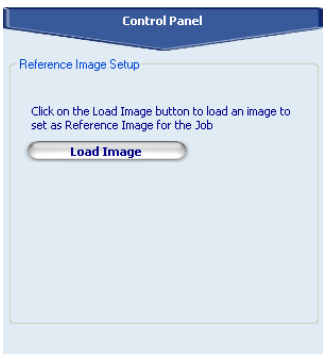
As you proceed through the setup process, your progress is visually highlighted by the step you have just reached activating and the number label turning red.

5.1.4. Control Panel

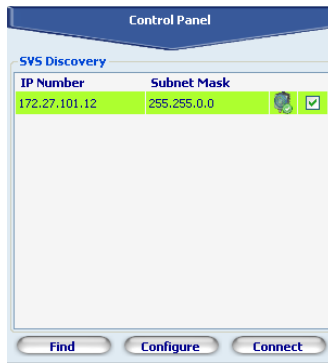
The control panel offers several different functions depending on the current setup step and the operation you are carrying out. For instance, it lets load and/or set up the reference image, or view and change the parameters of the controls in use.



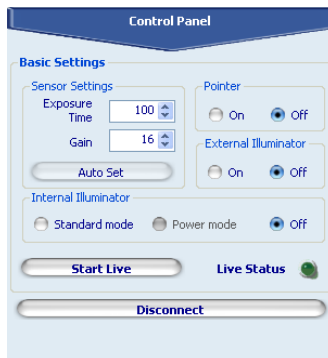
Initially, the control panel will be blank. The system is waiting for the user to choose how to start the setup process.



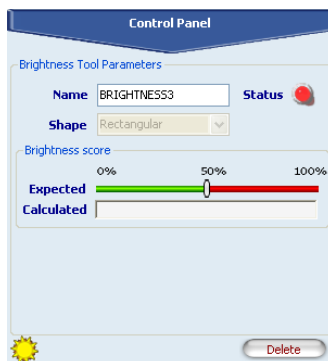
If you choose to start the setup process in the Off-Line mode, you will need to load a stored image and confirm that this is what you want to use as your reference image. The control panel will look like this. A stored image may also be loaded from here, besides from the Setup bar.



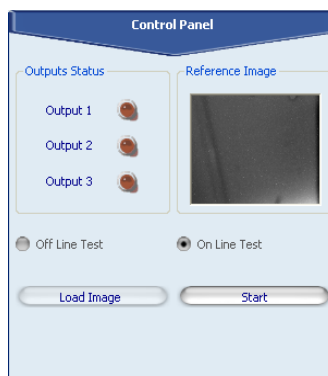
As you search for and select connected sensors, the control panel displays sensor name, IP address and subnet mask set previously and indicates whether a connection can be created using these settings, so you can enable connection to the desired sensor.



Once you have selected the sensor, the control panel lets you set the shooting parameters for the sensor, choose illuminator mode and select your reference image.



When configuring the controls, the control panel shows their key features, so they can be modified and checked in real time.



This is what the control panel looks like during the test stage: you will be asked to configure sensor outputs, load the image to be used for testing and then start the test process running all controls on that image.

5.1.5. Images Buffer

It lists the thumbs of images which have been previously acquired and/or downloaded from the personal computer.



As the images are loaded, their thumbs appear in the images buffer. The image currently displayed in the work area is highlighted with a red border. You may switch to a different image simply clicking the corresponding thumb or use the tool bar icons to scroll through the buffer, add new images or remove images from the list.

The image thumbs are also displayed in *Live mode*, while the sensor is connected and acquiring images.

5.1.6. Work area / acquired image

This area displays the live video flow from the sensor.

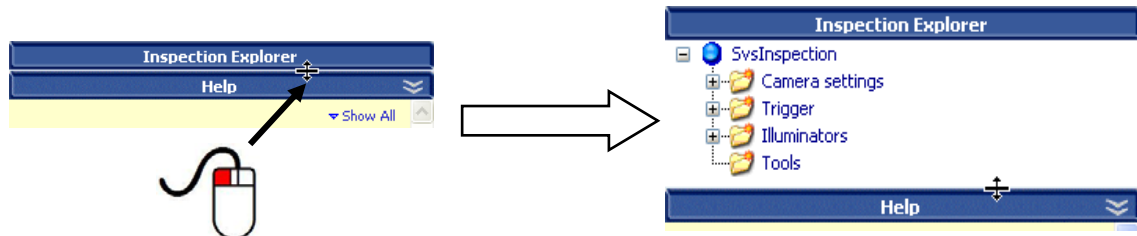
It is used actively during the control visual positioning process.



Once you have confirmed the reference image, you will have to set and position the desired controls: as you can see from the example, this is done graphically, directly on the reference image. Once you have positioned the control, the border of the ROI will change colour to show the outcome: Pass = green, Fail = red.


5.1.7. Inspection Explorer

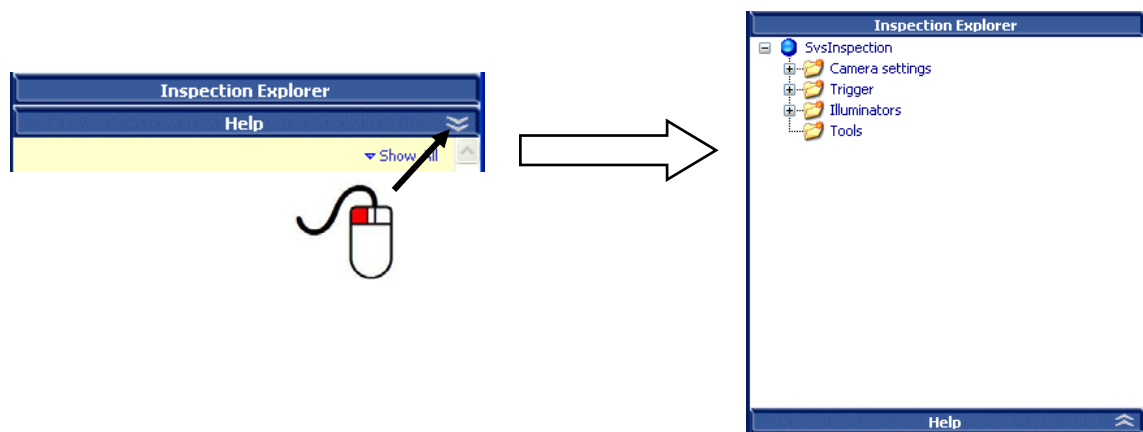
Move the mouse pointer to the upper edge of the Help window (pointer changes shape). Hold down the left mouse button and move the pointer up (to enlarge the window) or down (to make window smaller); the Inspection Explorer panel is now displayed.




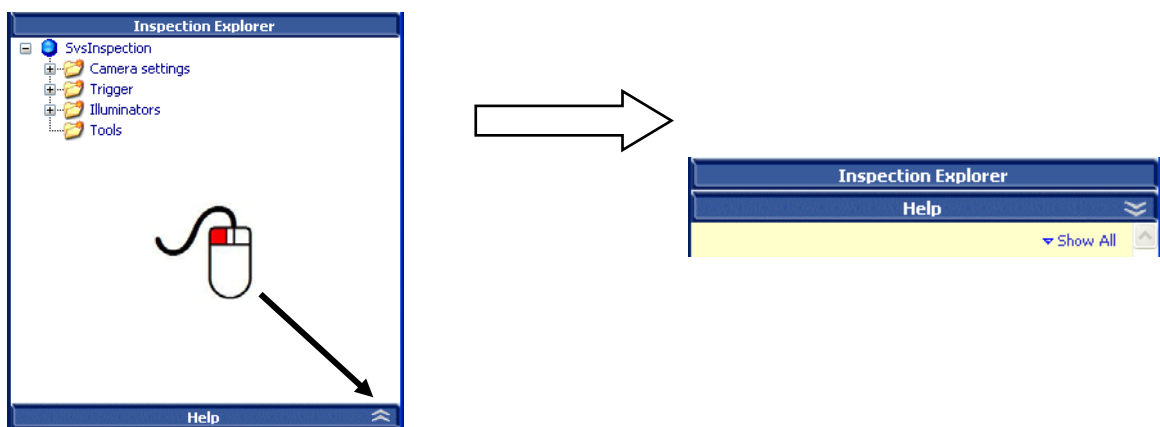
The Inspection Explorer panel shows:


- sensor settings;
- selected trigger;
- operating parameters of illuminators;
- control/measurement tools involved in current inspection and their parameter values.

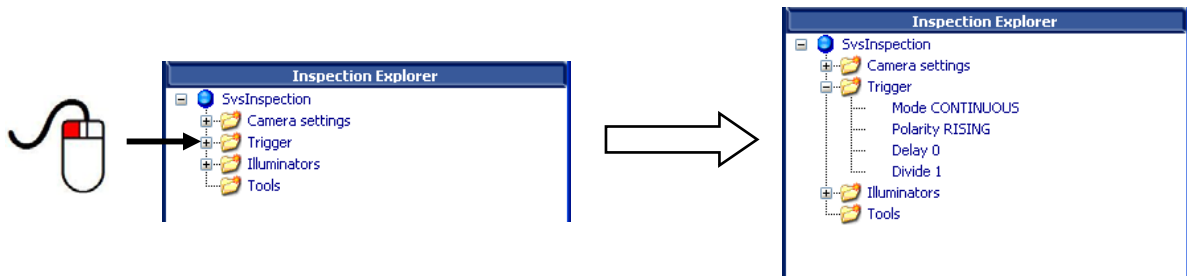
The Help window may be minimised by clicking the symbol  in the top right corner: the Help is minimised to a bar with its name, whereas the Inspection Explorer window is fully visible.



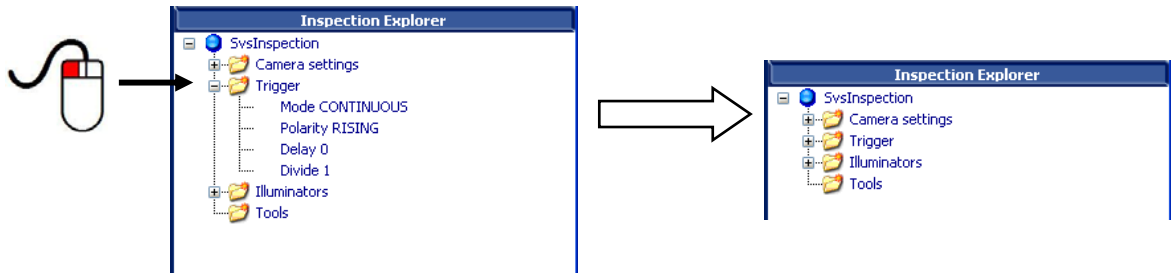
Simply click the symbol  to restore the Help window to original size and hide the Inspection Explorer window.



Displayed information is arranged in a tree structure that includes several menu levels. Click the symbol  next to menu name to expand each level and view detailed information.



Click the symbol  to collapse level.




5.1.8. Help

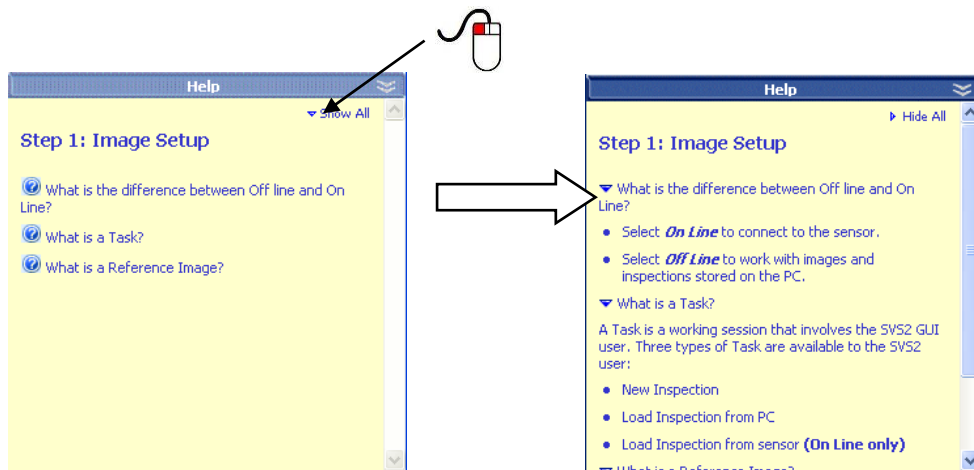
The Help Panel provide to the user an intuitive guide through the essential Inspection configuration phases. It is made up by several HTML pages, automatically viewed by the GUI depending on the task performed by the user.



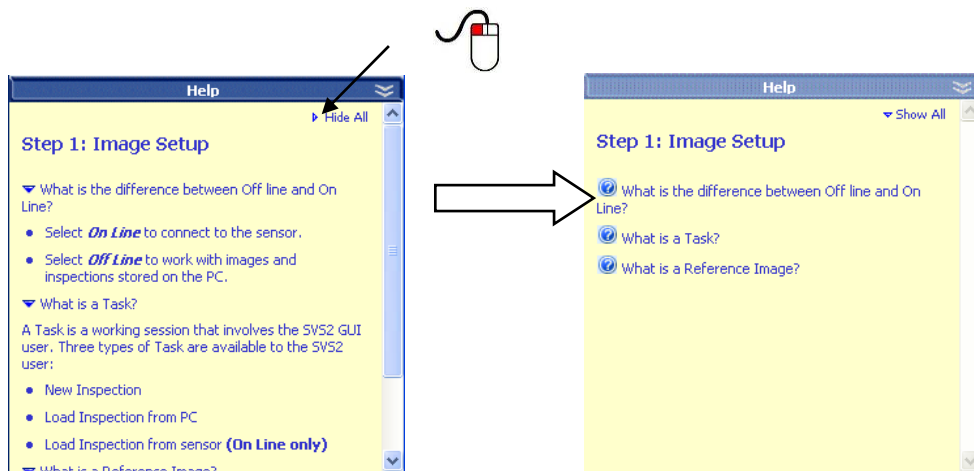
It presents a list of typical questions users are likely to ask when they come across certain situations.

Click the symbol  to the left of each question or question text to display the answer that provides in-depth information/useful tips/a solution to the problem.

You may expand all answers by clicking "Show All".




Simply click "Hide All" to return to standard view.



5.1.9. Status

It provides an instant overview of system status.

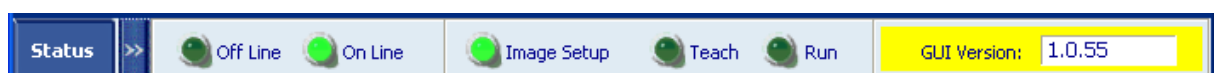
The bar shows a message on connection status, sensor IP address and the name assigned to the connected sensor.

The bar may be expanded by clicking the symbol .



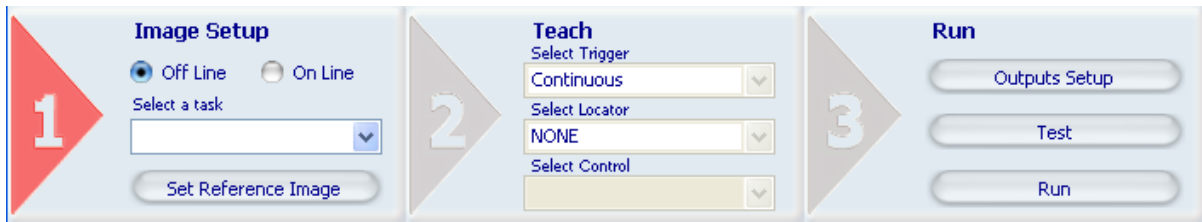
The bar shows sensor connection status, current operation and Graphic User Interface version.

Click symbol  to return to previous display.



6. EASY GRAPHIC USER INTERFACE - INITIAL SETUP

Before you can operate the SVS2 system, you will have to perform a preliminary configuration procedure. The "Easy GUI" lets you complete the procedure in three steps.



Each step is identified with a number: your progress through the configuration process is visually identified by a red label.

During the first step, you have to choose how to set up the inspection; you may set up an inspection from scratch or select an existing inspection and change its parameters as required.

In the second step, you have to set the triggers (to set inspection time instant) and tools (to perform controls and/or take measurements).

During the third and last step, you will have to set up the outputs and start a test to assess the effectiveness of selected controls.

Let us now discuss the individual steps with their options and selectable parameters.

6.1. General considerations

A correct configuration based on the acquisition of a good-quality reference image is a prerequisite to ensuring accurate inspection.

The term inspection means the set of operations the sensor performs to check the features of an object for compliance with certain specifications.

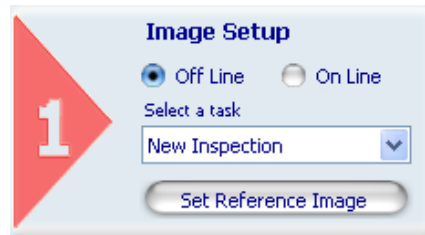
Each individual object is compared to the reference image to determine whether it meets the specified requirements.

For this reason, the sample in reference image must have neat contours and clearly visible features.

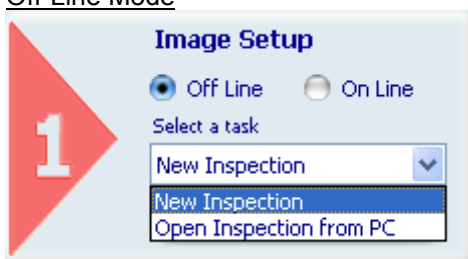
Here are a few tips to facilitate correct configuration:

- determine which product feature you want monitored;
- provide correct, even lighting: minimising the incidence of ambient light on the target area helps ensure correct image acquisition;
- provide sharp contrast between target object and background;
- choose the tools (or "controls") to be used for processing accurately, so as to provide the best result in the easiest, fastest way;
- accurately set the control parameters for the controls;
- it may be a good idea to run some preliminary tests to determine if any features are hard to identify and set tolerances accordingly;
- compare results to identify any inconsistencies.

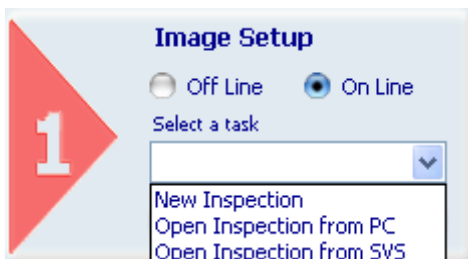
6.2. STEP 1



During this first step, you must decide how you want to go about the inspection configuration procedure. You may choose to connect to sensor first (**On-Line** mode) or choose local mode (**Off-Line** mode). Each mode offers different options:

Off-Line Mode

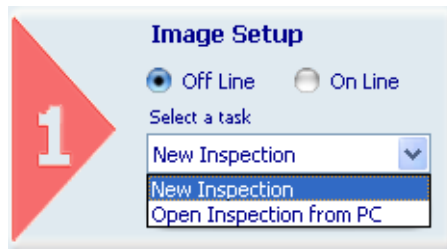
- *New Inspection* : Creates a new inspection;
- *Open Inspection from PC* : Loads parameters of an existing inspection saved on PC.

On-Line Mode

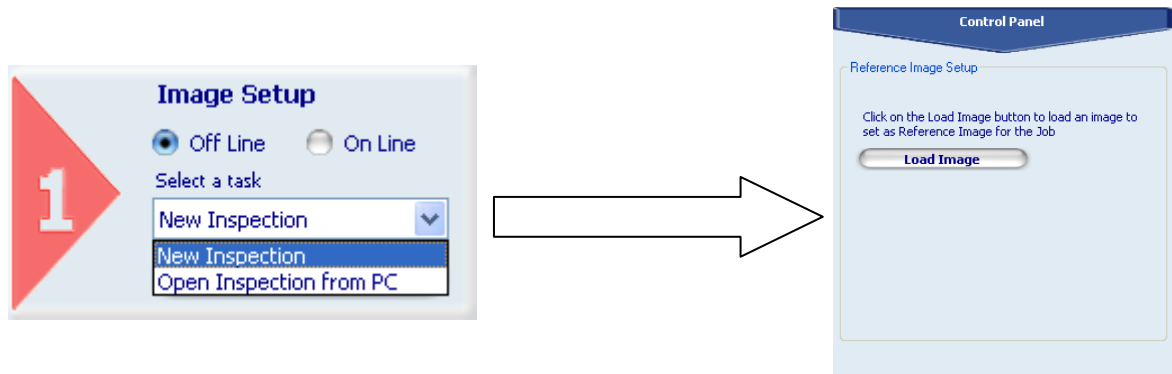
The system searches for connected sensor in the network and displays their network addresses (IP and Subnet Mask address). When connection is made, you may select one of three parameters:

- *New Inspection* : Creates a new inspection;
- *Open Inspection from PC* : Loads parameters of an existing inspection saved on PC;
- *Open Inspection from SVS* : Displays inspections from sensor to allow their configuration parameters to be imported to the graphic user interface.

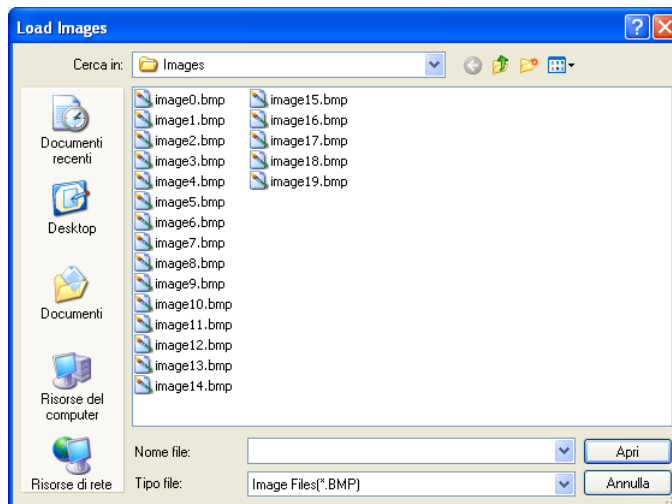
6.2.1. Off-Line Mode



The control panel is activated:

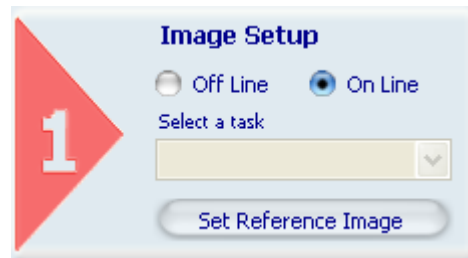


you need to define the "Reference Image". This may be done by loading an existing image stored previously (button "**Load Image**"):



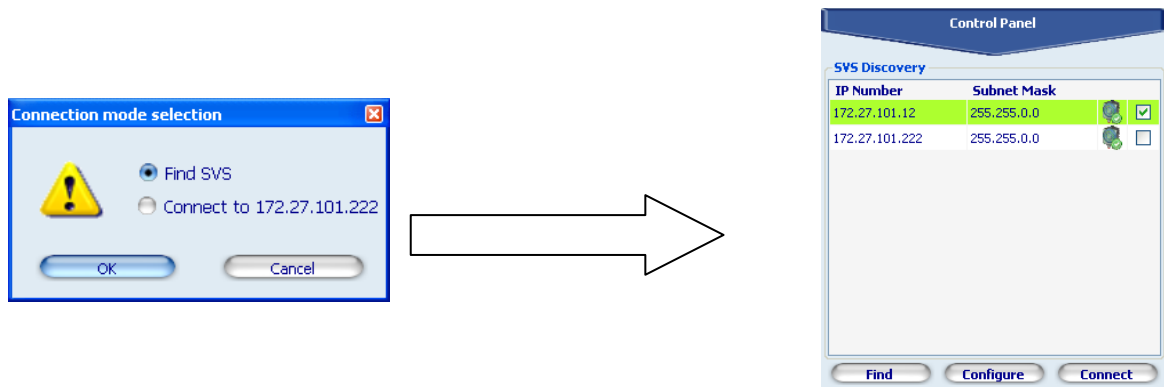
When you press the "**Open**" button, the image is displayed in the work area, while its thumbview is shown in the Images Buffer. You may load more than one image and then choose whichever seems best. As images are loaded, their thumbs are added to the Images Buffer and you may switch from one image to the next by simply clicking the thumbs. Once you have selected your reference image, click the "**Set Reference Image**" button to confirm. You may now proceed to STEP 2: the label turns red and the pull-down menus for trigger, control and locator selection become active.

6.2.2. On-Line Mode



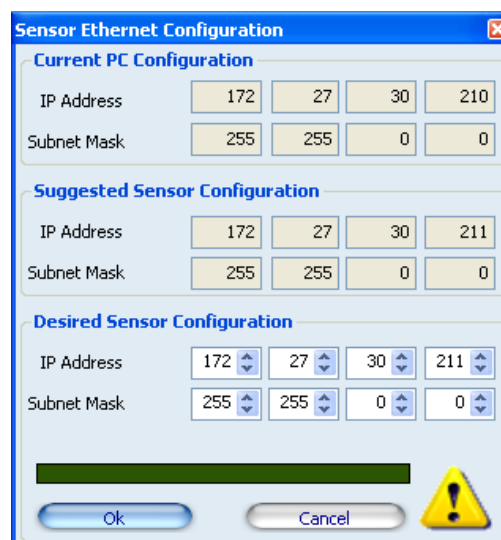
Here you need to select the sensor you wish to connect to.

When you select this mode, you will be asked to set connection mode. You may connect to an IP address stored previously or run a new search.

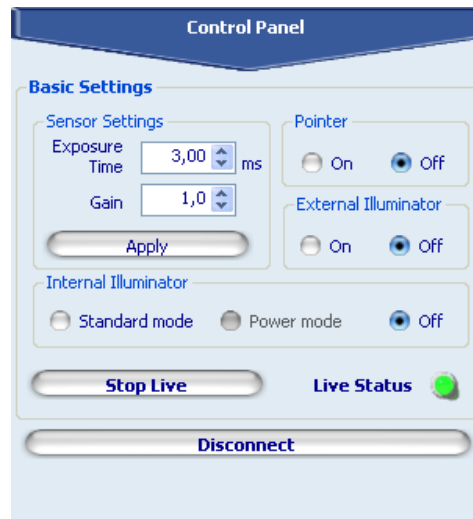


When you press the **Find SVS** button, the system searches for connected sensors in the network and displays their network addresses (IP and Subnet Mask address) and an icon indicates whether they are accessible using this information. After the desired sensor is added to list, if the icon is as shown in the figure, tick the box on the right end and click **Connect** to establish the connection.

You may also configure the selected connection (click "Configure").



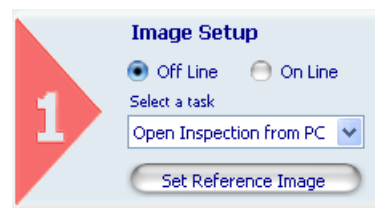
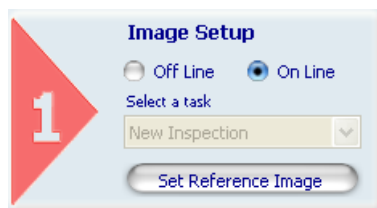
When you create a new inspection ("**New Inspection**") in On-Line mode, this acquisition parameter configuration panel appears:



- *Stop Live* : Stops transfer of video flow to PC Graphic User Interface activated by sensor (Live mode);
- *Live Status* : Indicates when Live mode is active;
- *Sensor Settings* : The result calculated by the exposure meter may not be satisfactory. The image might be too light or too dark. Image quality may be improved by manually adjusting exposure ("*Exposure Time*") and ("*Gain*") settings;
- *Pointer* : Turns Pointer on and off; this feature provides more accurate centring of the shot
- *External Illuminator* : Enables or disables external illuminator (if any) (connected to Strobe pin of M12 8-pole connector);
- *Internal Illuminator* : Enables or disables internal illuminator;

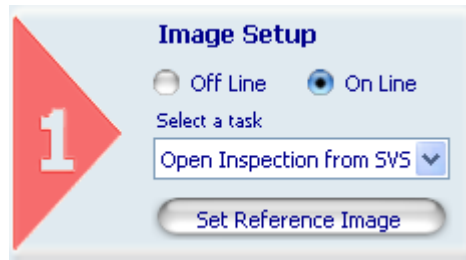
Set Reference Image : When you have selected the target object and set exposure parameters, you may set reference image by clicking this button in the Setup Bar.

If you select item "**Open Inspection from PC**"

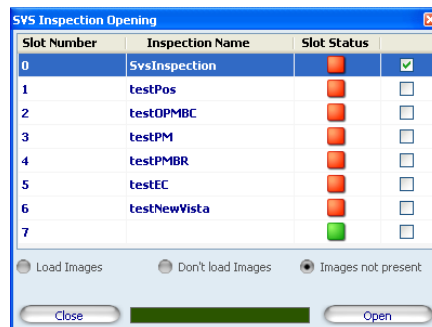


either in Off-Line or On-Line mode, will open a previously stored inspection. A window opens where you are asked to select the file that contains the inspection. After making your selection, press the "**Open**" key and the Graphic User Interface is initialised using those parameters.

Finally, selecting "**Open Inspection from SVS**" (available only in On-Line mode)

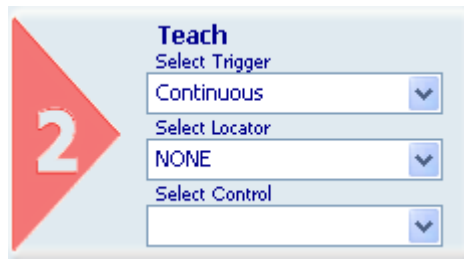


gives access to sensor internal memory: a list of stored inspections is displayed and you may load their parameters to the Graphic User Interface and change them as required at a later time.



6.3. STEP 2

The section of the Setup bar dedicated to step 2 looks like this:



Select Trigger

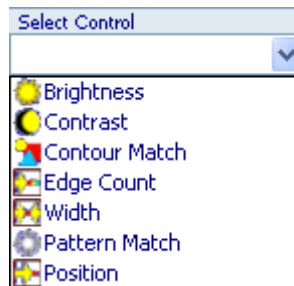
Set the type of trigger used to define inspection time instants (for trigger description, see paragraph 8.2). Your selection is added to the Inspection Explorer, in menu level Trigger:



"Continuous" trigger is the default trigger: even if you make no selections from the corresponding menu, the system will set up to analyse the image flow continuously. Images are scanned uninterruptedly.

Select Control (selection of measurement/control tools)

Select the control you want to add to the inspection process. Once you have chosen the desired control from the pull-down menu, it is added to current inspection and displayed in Inspection Explorer in menu level "Tools". You may use this method to associate several controls to current inspection.



Once selected, the control must be positioned on the reference image in the work area: this is done graphically by positioning and sizing its ROI.

When finished, the control panel displays the corresponding parameters that default to standard settings: use the sliders or type the desired values in the number fields to customise control settings.

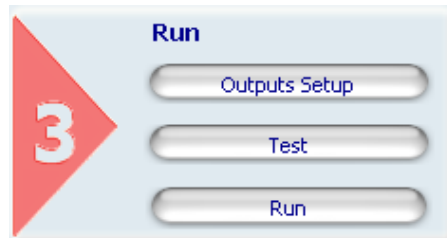
Control outcome is visually indicated by a STATUS indicator turning green or red. The border of the ROI plotted on the image takes on the same colour.

How to position the individual controls has been mentioned earlier; see the relevant paragraphs for more details.

6.4. STEP 3

In this final step of the configuration process, you may:

- set output settings (**Set Up Outputs**);
- start a **Test**, i.e. run set controls on stored images;
- activate **Run**, i.e. run set controls on the images from the sensor;
- turn on monitor mode (**Start** button), which displays system statistics.

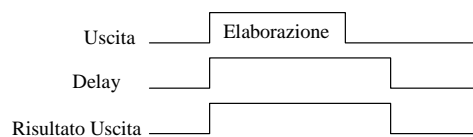


Please note that the outputs are disabled in *Run* mode and images are still processed on the personal computer. The sensor simply acquires the images: no specified inspection instruction stored in its memory will be altered. This is an advanced test mode that allows selected controls to be tested straight in the inspection line to determine their effectiveness.

6.4.1. Outputs Setup

Once selected, the system shows the configuration panel for sensor outputs in the Control Panel; the sensor has three configurable digital outputs and you can set the behaviour, duration and delay for each output; duration and delay are available for all three outputs.

- **Mode** Associates a certain output value to a given result (part OK, reject, toggle, Busy-Ready, etc.), using positive or negative logic.
- **Duration** Determines how long (ms) the output is to retain the last value acquired; only makes sense in Part Detect, Part Pass and Part Fail modes.
- **Delay** Determines how long the output should wait before displaying the last result acquired.



L'opzione *Salvataggio Immagini* permette di salvare nella memoria del sensore fino a 10 immagini. Il parametro *Pulsante Teach*, infine, consente di abilitare o disabilitare la funzione di Teach del pulsante sul sensore.

Option *Save Images* lets you save up to 10 images to sensor memory.

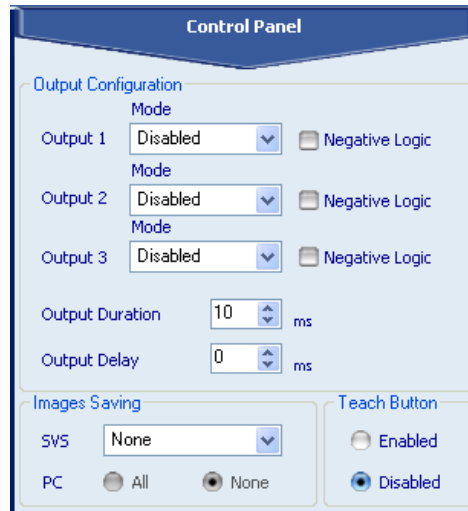
The *Teach Button* parameter lets you enable or disable the Teach function of the button on the sensor.

The control panel lists the three digital outputs, which may be set individually.

As a matter of fact, the system lets you connect the following items to one or more outputs:

- result of a control;
- result of whole inspection in AND operation;
- result of whole inspection in NAND operation;
- a toggle signal alternately switching to high or low;

Open the pull-down menu to display the different Output Modes.



Output is *Disabled* by default.

The other options are:

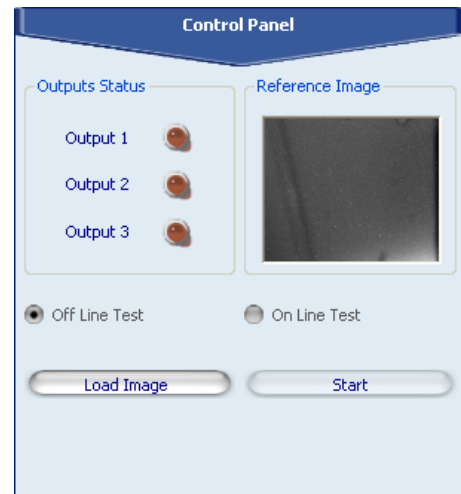
- **Toggle:** Output toggles between logic values 1 and 0;
- **Part Pass:** Inspection as a whole is considered. The statuses of individual controls are taken into account: the output acts as the logic AND for these statuses (in other words, the output will only be Pass when all involved controls return a Pass result);
- **Part Fail:** Inspection as a whole is considered. The statuses of individual controls are taken into account: the output acts as the logic NAND for these statuses (in other words, the output will only be OK when at least one of the involved controls returns a FAIL result);
- **Busy–Ready:** Output may take on logic values 1 and 0;
- **Error:** Indicates an error in the inspection.

6.4.2. Test

In this mode, inspection can be run in two different modalities:

- **Offline:** using previously stored images which must be selected one by one.
- **Online:** sensor is simply used as a camera: acquired images are sent to the PC that processes them using the current inspection controls.

It may be used to test the controls included in the inspection.



6.4.3. Run

Before you can activate it, one inspection must be stored on the sensor.

This mode provides an effective test method for controls: images sent by the sensor are processed and output behaviour is simulated. This way, you may check the behaviour of these outputs without them physically affecting other devices.

The control panel offers status indication for the three digital outputs (indicator colour) and the two inspection verification options:

- **Graphic Enabled:** This is the graphic verification method that provides a graphic verification of the control for each image sent by the sensor. The result is calculated immediately and indicated by the colour of ROI border.
- **Graphic Disabled:** In place of the image sent by the sensor, this mode displays a set of information that may be used to evaluate the performance of the inspection currently performed by the sensor. This is the text verification method: for each image sent by the sensor, it shows the outcome of each control as well as global inspection outcome, in addition to the time taken to perform them.



To start this mode, simply click Start.

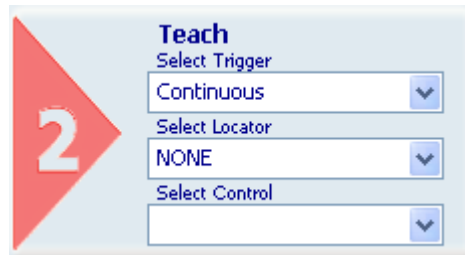
7. EASY GRAPHIC USER INTERFACE - EXPERT MODE

So far, we have discussed Graphic User Interface operation in the STANDARD mode, which is the default mode when you access the configuration program.

If you choose EXPERT mode:



in the second inspection setup step, you may set a locator in addition to trigger and control:



Select Locator

This menu lets you select locators. Your selection is displayed in Inspection Explorer, in menu level "Tools".

8. GRAPHIC USER INTERFACE

8.1. Modes of operation

There are two modes of operation available:

- *On Line* with active sensor connection;
- *Off Line* in which you may process images previously stored on the personal computer.

The latter mode lets you simulate inspection using previously stored images instead of the video flow sent by the sensor. This way, you may focus your attention on the controls to determine which ones are best suited for a given inspection and set their parameters.

8.2. Trigger

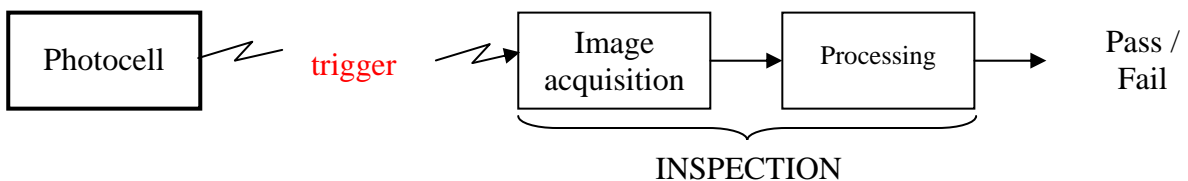
The term trigger means a signal generated by an event that triggers another event.

In our instance, the trigger is a signal generated by a device that triggers image acquisition.

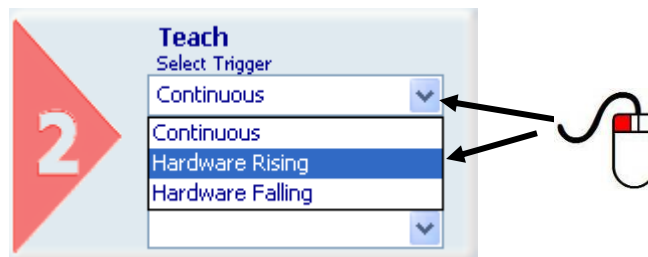
When the sensor is used to inspect moving objects, it is important to ensure that the object is inside the shot area at the precise instant the image is captured for processing. To this end, the system offers three types of triggers in step 2 of the inspection configuration process:

- **Continuous.**
- **Hardware Rising;**
- **Hardware Falling;**

Trigger hardware: The image capture signal is supplied by an external device (e.g., a photocell); obviously enough, the signal has a rise and a fall edge (Rising and Falling).



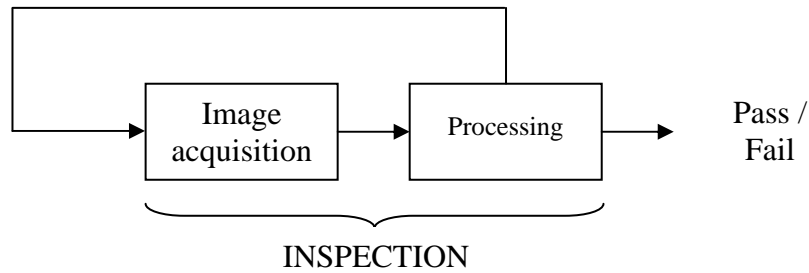
If you select “Hardware Rising” from the pull-down menu, the image capture signal follows the rising edge of the external device:



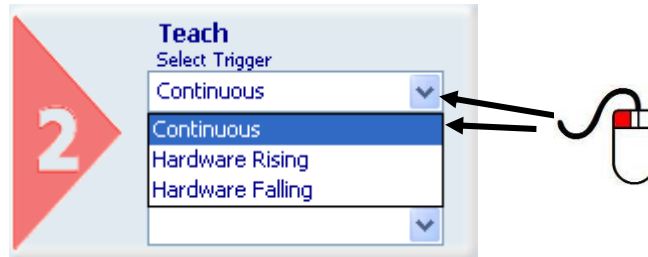
If you select “Hardware Falling” from the pull-down menu, the image capture signal follows the falling edge of the external device:



Continuous trigger: The images to be processed are acquired at the highest speed possible. Each individual image is acquired and immediately processed; as soon as the sensor is ready, the next image is acquired and so on.



This option may be selected from the pull-down menu



This type of trigger comes handy, when used in *RUN* mode, to test inspection parameters: this way, you will see how the controls are run directly on the images acquired by the sensor.

8.3. Controls for the inspection

These controls play a key role in the inspection process: they are used to perform controls and measurement on acquired images. Entering the controls is an operating step of the inspection.

Most of these tools are positioned graphically on the work area using the mouse. When you create a control, the control panel displays the whole set of configuration parameters with their default values expressed in pixels. Positioning and sizing may be performed by changing these numeric parameters.

The application of one of these tools provides two types of results:

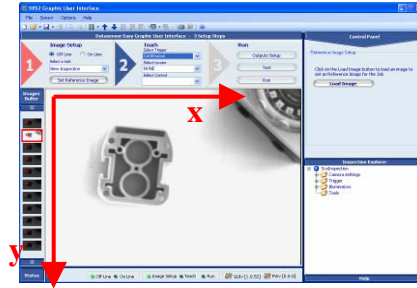
- numeric value;
- status:
 - Pass : control gave a positive outcome
 - Fail: control gave a negative outcome or control/measurement could not be performed

If you set a control for the verification of an area, possible state/outcome may be:

- **Pass**, if the measurement of the area was found to conform to set specifications;
- **Fail**, if such measurement does not meet specifications or could not be taken.

The target area for the controls may cover the whole image or be limited to the so-called ROI (region of interest), i.e. just a portion of the acquired image, which benefits speed and evaluation accuracy. During the inspection, the area outside the ROI is ignored, although it is displayed in the work area.

The controls use an absolute reference system, with the origin located in the top left corner of the work area.



8.4. Locators

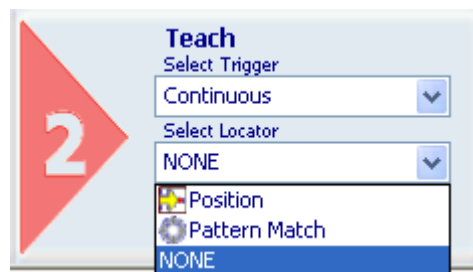
Normally, the "inspection area" covers the whole work area detected by the camera. The locator lets you reduce the size of the inspection area, for instance to include just an object or a portion of it.

Locators are only available in expert mode. Otherwise, inspection area always covers the whole acquired image.

SVS2 offers two types of locators, or no locator:

- **Position Locator** (also known as 'edge locator');
- **Pattern Match Locator**

Locators may be selected from the pull-down menu



The following paragraphs provide a description of the two locators with the following details

- Description: target of locator;
- Selection: menu from which locator is selected;
- Pointer shape: to facilitate positioning, each locator uses a different pointer;
- Positioning: how to position and size the ROI;
- Parameters: description of configuration parameters;
- Result: description of outcome;
- Example: Explains full procedure, from selection, to setup, through to output settings.

8.4.1. Position Locator

Description

It is also known as edge locator.

Edge: Border of object displayed.

This locator identifies the transition between:

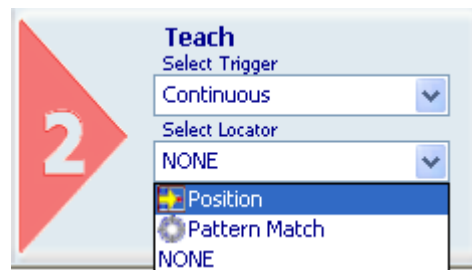
- a light and a dark area (negative edge)
- a dark and light area (positive edge)

in the image under examination. For instance, picture a dark object on a light background: object contour is identified as the edge, i.e. the set of dark pixels lying next to light pixels. However, it takes a sharp tone variation for the light-to-dark transition to be interpreted as an edge; the extent of the transition is determined by a threshold. (Edge detection ►)

Once the position of an edge has been set, it may be used as a parameter for the next controls applied.

After the type of edge (positive/negative) to be identified has been specified, the locator processes the ROI (in this case the plotted line) and stops as soon as it comes across an edge that meets set specifications.

Selection



Pointer shape



Positioning

Click any point inside the work area to create a rectangular ROI with a small white square at the bottom right corner.

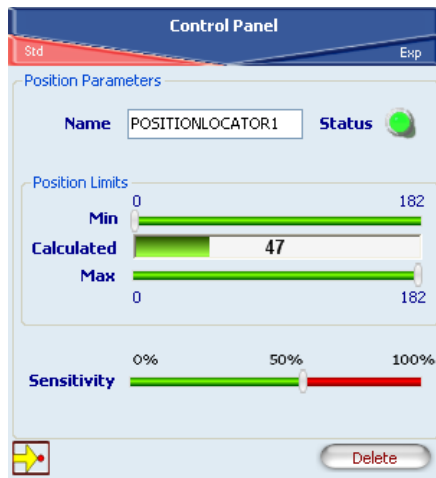


To change ROI size, left-click and drag the square.

To move the ROI, place the pointer on any side of the ROI. The pointer changes to a cross. Press and hold the left mouse button and drag the rectangle to the desired position.

Parameters

After clicking in the work area to create the ROI, the control panel displays the set of parameters that enable control customisation. Please note that different parameters are available in the STANDARD and EXPERT modes:



STANDARD mode





EXPERT mode

- **Name** : Name assigned to control in Inspection Explorer. Maximum length is 256 characters;
- **Status** : see "Result" further below;
- **Position Limits** :
- **Min, Max**: Minimum and maximum value of detectable position. These thresholds must be compatible with the value found (shown in the "Calculated" bar). This means Min must be less than or equal to "Calculated", and Max must be greater than or equal to "Calculated".
- **Sensitivity**: This is the degree of accuracy provided when searching for the edge. Set sensitivity affects processing results: the lower the sensitivity, the greater the accuracy.
- **Variation Type** : Determines how the edge point is to be identified during image scanning. Possible values are:
 - White to Black: point is treated as an edge point when the first white-to-black transition is detected;
 - Black to White: point is treated as an edge point when the first black-to-white transition is detected;
 - Both: point is labelled as edge point at both white-to-black and black-to-white transitions;
 - Auto: automatic edge point recognition.
- **Noise rejection** : Reduces noise in the edge identification process. The threshold is a function of the first derivative and establishes the minimum brightness variation for a point to be considered as an edge point;
- **Direction**: Determines the search direction and versus. Possible values are:
 - Left to right;
 - Right to left;
 - Up to down;
 - Down to up.
- **Delete** : Deletes control from inspection.

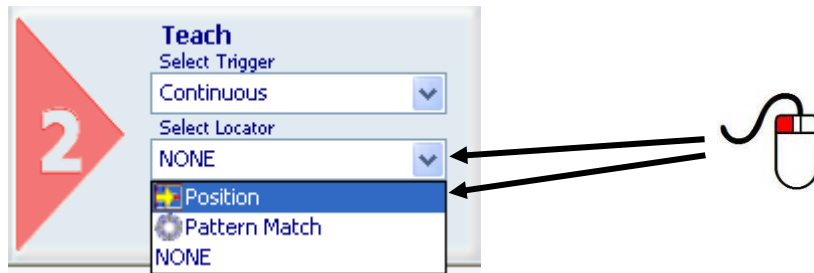
Result

Graphically displayed by the *Status* indicator; shows control result:

- **Status**  : system detected an edge in the acquired image and number is within the range set in "Match limits" ;
- **Status**  : system found no edge or number is outside the specified limits.

Example

Add a position locator to current inspection.
 Select "Position" from the pull-down menu:



Position the control on the reference image in the work area: the pointer changes shape as soon as it enters the work area. Left-click once at any position to create a default rectangular ROI. At the same time, the control features and the result of its application to the reference image appear in the control panel. Set ROI size and position as required, as explained above.

The result indicated by STATUS is also highlighted by the ROI border changing colour. As soon as values change, result is calculated without delay.



A yellow horizontal bar appears in the ROI with a small dot marking the position of the identified edge. In this example, the edge was set as light-to-dark transition. If edge is not recognized correctly, move the slider to adjust Sensitivity. Or you may switch to EXPERT mode and change the advanced parameter "Noise Rejection".

Another example of application is presented in the figures below, Fig. A and Fig. B. In particular, the Fig. A shows how the Position Locator is forcible to detect an horizontal translation of a coffee pod among the scene. As shown, the locator application shifts the control tool to the right and the inspection process is correctly achieved.

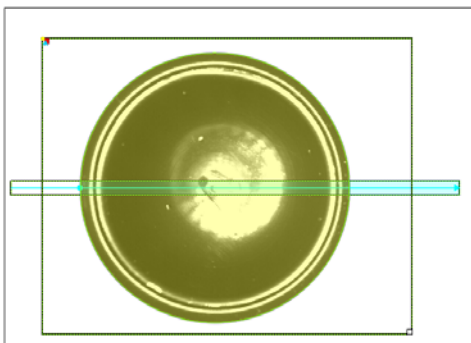


Fig. A Coffee Pod Position Locator: Reference Image

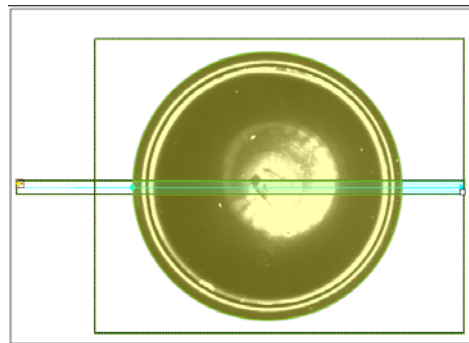


Fig. B Coffee Pod Position Locator: Effect on a right translated object

8.4.2. Pattern Match Locator

Description

In pattern match operation, sample object and target object are compared to determine if they are similar. (Pattern match ►)

The locator searches for the sample through 360° inside the inspection area and determines its position. In this way it is possible to detect the horizontal translations and either the vertical displacement of the object among the inspection area.

Graphically, the locator looks like two rectangles, one inside the other:

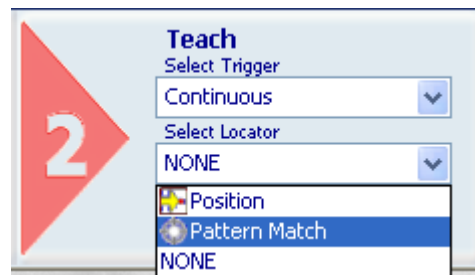
- The outer blue rectangle is the search area;
- the smaller inner rectangle (orange) represents the sample.

During the setup process, you need to define the sample to be identified. The system stores the brightness value of each composing pixel.

During the inspection, the locator will search for the sample in the region of interest. When it finds the sample, it will highlight it with an orange rectangle.

Degree of similarity and accuracy may be set from the control panel.

Selection



Pointer shape



Positioning

Click any point inside the work area to create a rectangular ROI with a small white square at the bottom right corner.

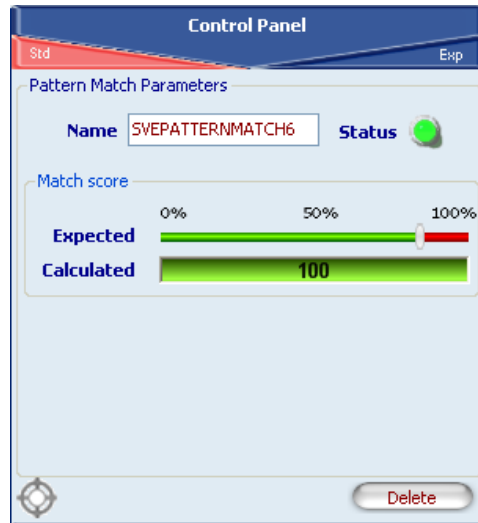


To change ROI size, left-click and drag the square.

To move the ROI, place the pointer on any side of the ROI. The pointer changes to a cross. Press and hold the left mouse button and drag the rectangle to the desired position.

Parameters

After clicking in the work area to create the ROI, the control panel displays the set of parameters that enable control customisation.





STANDARD mode

- **Name** : Name assigned to control in Inspection Explorer. Maximum length is 256 characters;
- **Status** : see "Result" further below;
- **Match score** :
 - **Expected** : Threshold used for inspection result evaluation. It indicates how closely the areas found in the search ROI must resemble the master image of the reference ROI in order to be considered valid (100% = perfect match, 0% ...). This value may be set automatically by the system or you may set it manually using the slider;
 - **Calculated** : Provides a graphic display of the degree of similarity, in percent, between the areas found in the search ROI compared to the master image of the reference ROI based on the number and location of detected features.
- **Delete** : Deletes control from inspection.

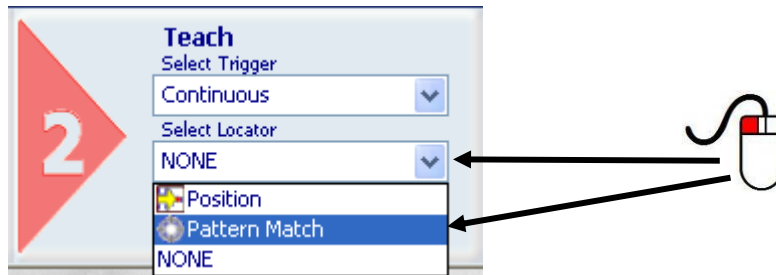
Result

Graphically displayed by the *Status* indicator; shows control result:

- **Status**  : Calculated ROI contrast is lower than set threshold (Expected);
- **Status**  : Calculated ROI contrast is higher than set threshold;

Example

Add a Pattern Match locator to current inspection.
Select "Pattern Match" from the pull-down menu:



Position the control on the reference image in the work area: the pointer changes shape as soon as it enters the work area. Left-click once at any position to create a default rectangular ROI. At the same time, the control features and the result of its application to the reference image appear in the control panel.

Set ROI size and position as required, as explained above.

The result indicated by STATUS is also highlighted by the ROI border changing colour. As soon as values change, result is calculated without delay.

Hereafter, the Figure A and B show a working example of the Pattern Match Locator. In this particular case, the Pattern Match Locator search for the postal stamp position, then a Contrast Control is applied (see Section 8.5.2 for details). As shown, this locator is capable to detect both the horizontal and vertical translation of the envelope in the inspection area.



Fig. A Pattern Match Locator: Reference Image

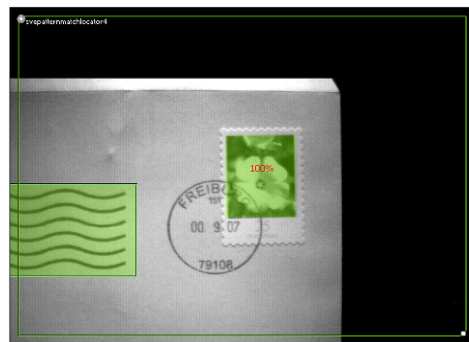


Fig. B Pattern Match Locator: Effect on a translated object

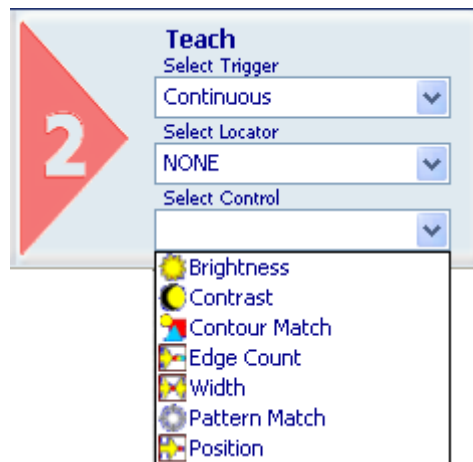
8.5. Controls

The controls are tools used to set inspection specifications.

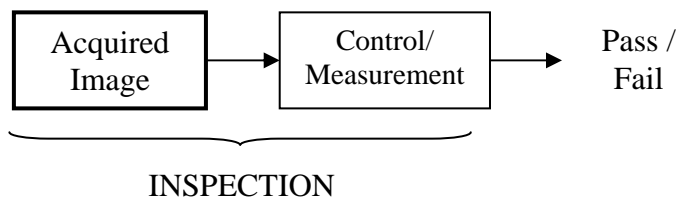
The SVS2 system offers a broad range of controls:

| Name | Available in OR version | Available in AOR version |
|-------------------------|-------------------------------------|-------------------------------------|
| Brightness | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Contrast | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Contour Match | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Edge Count | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Width | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Pattern Match | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Position | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Geometric Pattern Match | <input type="checkbox"/> | <input checked="" type="checkbox"/> |

This way, the system can be adapted to meet specific inspection requirements. Controls may be selected from the pull-down menu:

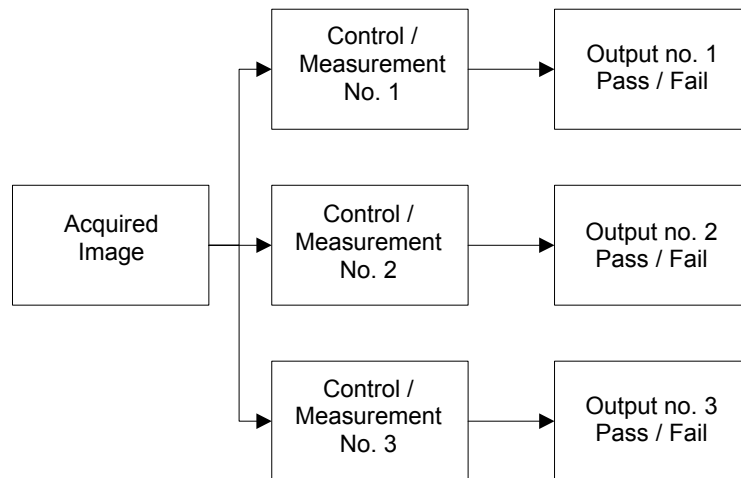


In its most basic version, the inspection process may be simplified as follows:

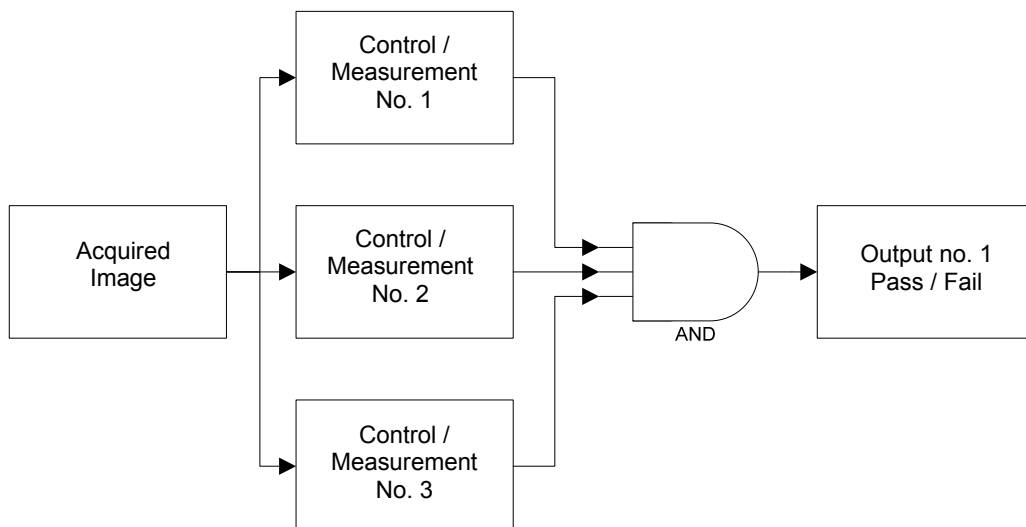


This simple control consists in acquisition and one single measurement/control, which will return a certain result.

It is possible to set more complex inspection processes, with acquired images processed in parallel undergoing simple or complex measurements/controls at the same time, with the results connected to different outputs:



Or the output may be dependant on the result of all controls/measurements: if so, the inspection will only give a positive outcome when all controls/measurements included in it return a positive result.



The following paragraphs provide a description of each individual control with the following details:

- Description: Control operation;
- Selection: menu from which control is selected;
- Pointer shape: to facilitate positioning, each control uses a different pointer;
- Positioning: how to position and size the ROI;
- Parameters: description of configuration parameters;
- Result: description of outcome;
- Example: Explains full procedure, from selection, to setup, through to output settings.

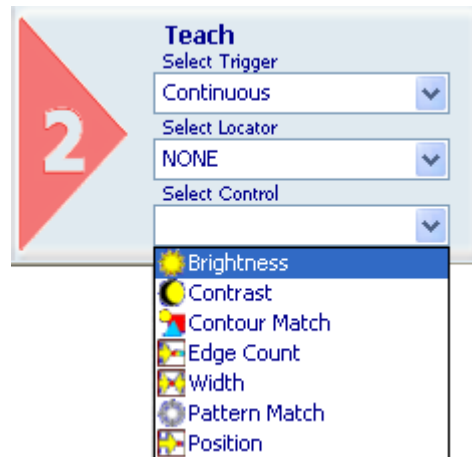
8.5.1. Brightness

Description

The term brightness signifies the "brightness" attribute of an image.

Once the ROI has been set, the control calculates mean pixel brightness inside the ROI.

Selection



Pointer shape



Positioning

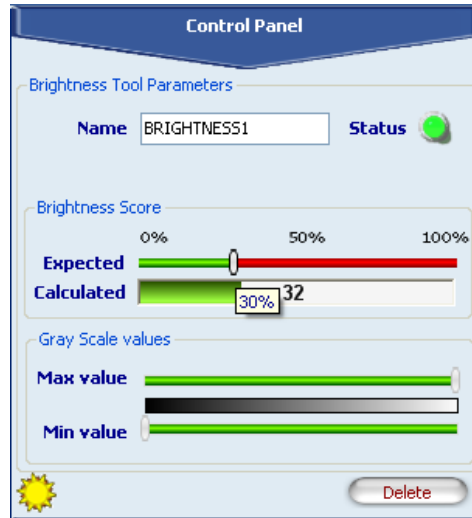
Click any point inside the work area to create a rectangular ROI with a small white square at the bottom right corner.



Parameters

After clicking in the work area to create the ROI, the control panel displays the set of parameters that enable control customisation.



Please note that different parameters are available in the STANDARD and EXPERT modes:



- **Name** : Name assigned to control in Inspection Explorer. Maximum length is 256 characters;
- **Status** : see "Result" further below;
- **Brightness score**:
 - *Expected* : Threshold used for inspection result evaluation. It is compared to calculated mean brightness: if this value is below the threshold, the result is positive (STATUS indicator and ROI border turn green); if it is higher, the result is negative (indicator and ROI border turn red);
 - *Calculated* : The mean brightness (percent) of the pixels inside the ROI is graphically displayed;
- **Gray scale values**: the range of gray scale values used to calculate brightness score.
 - *Max value* : The maximum value used; the default value is 255.
 - *Min value* : The minimum value used; the default value is 0.
- **Delete** : Deletes control from inspection.

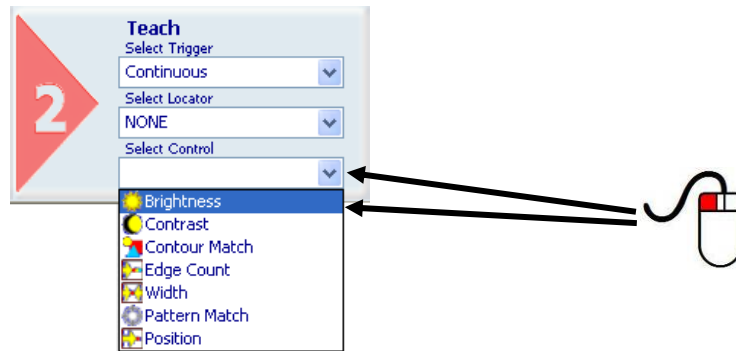
Result

Graphically displayed by the *Status* indicator; shows control result:

- **Status**  : Mean brightness of ROI is lower than set threshold (Expected);
- **Status**  : Mean brightness of ROI is higher than set threshold.

Example

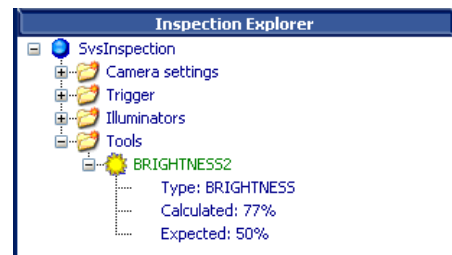
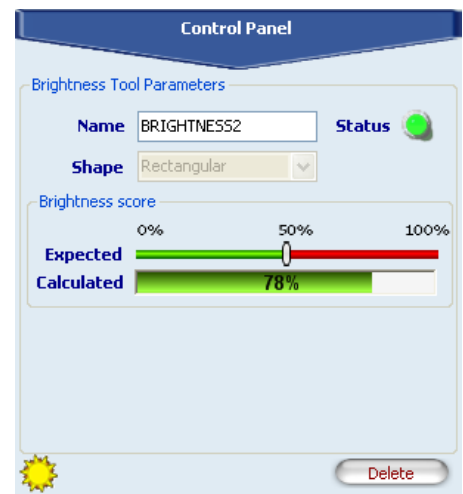
Add "Brightness" control with rectangular ROI to current inspection.
 Select "Brightness" from the pull-down menu:



Position the control on the reference image in the work area: the pointer changes shape as soon as it enters the work area. Left-click once at any position to create a default rectangular ROI. At the same time, the control features and the result of its application to the reference image appear in the control panel. Set ROI size and position as required: in this example, ROI shape is left unchanged. Set ROI position and size as explained above.

The result indicated by STATUS is also highlighted by the ROI border changing colour. As soon as values change, result is calculated without delay.

The control thus added to current inspection is also displayed in the Inspection Explorer: its name is listed under "Tools" (name specified in the Name field). If you expand that menu level (click symbol **+** next to the name), you will see the parameters set previously.



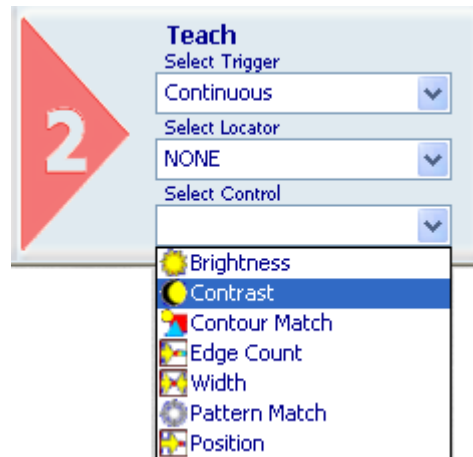
8.5.2. Contrast

Description

The term contrast signifies the ratio of lightest to darkest pixel brightness in an image.

When contrast is too sharp, an image will mostly be made up of white and black areas, whereas weak contrast will turn out a greyish image.

Selection



Pointer shape



Positioning

Click any point inside the work area to create a rectangular ROI with a small white square at the bottom right corner.



Parameters

After clicking in the work area to create the ROI, the control panel displays the set of parameters that enable control customisation.



Please note that the same parameters are available in the STANDARD and EXPERT modes:



- *Name* : Name assigned to control in Inspection Explorer. Maximum length is 256 characters;
- *Status* : see "Result" further below;
- *Contrast score* :
 - *Expected* : Threshold used for inspection result evaluation. It is compared to calculated ratio: if this "Expected" value is below the threshold, the result is positive (STATUS indicator and ROI border turn green); if it is higher, the result is negative (indicator and ROI border turn red);
 - *Calculated* : The contrast (percent) of the pixels inside the ROI is graphically displayed;
- *Sensitivity* : Contrast sensitivity, i.e. the degree of accuracy in measuring the difference between dark and light levels. Set sensitivity affects processing results: the lower the sensitivity set on the image, the lower the calculated value.
- *Delete* : Deletes control from inspection.

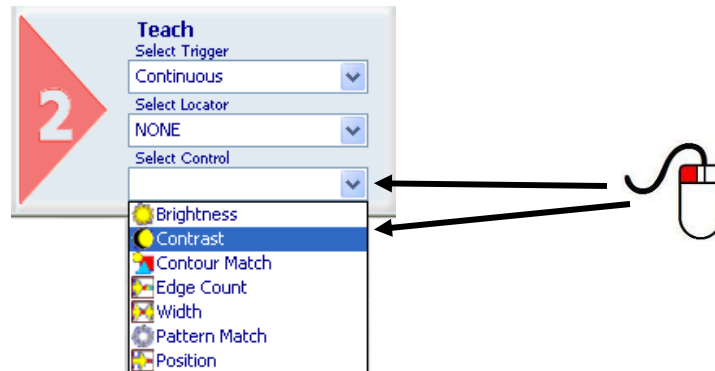
Result

Graphically displayed by the *Status* indicator; shows control result:

- **Status**  : Calculated ROI contrast is lower than set threshold (Expected);
- **Status**  : Calculated ROI contrast is higher than set threshold;

Example

Add "Contrast" control with rectangular ROI to current inspection.
Select "Contrast" from the pull-down menu:



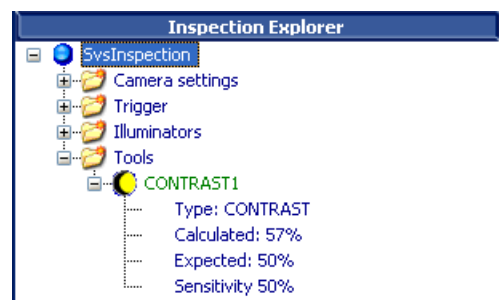
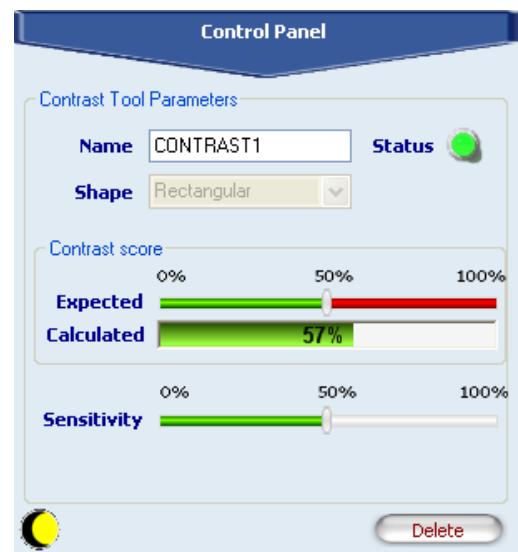
Position the control on the reference image in the work area: the pointer changes shape as soon as it enters the work area. Left-click once at any position to create a default rectangular ROI. At the same time, the control features and the result of its application to the reference image appear in the control panel.

Select "Circular" from the Shape menu: the ROI will immediately change to a circle. Its position and size may now be set as explained above.

The result indicated by STATUS is also highlighted by the ROI border changing colour.

As soon as values change, result is calculated without delay.

The control thus added to current inspection is also displayed in the Inspection Explorer: its name is listed under "Tools" (name specified in the Name field). If you expand that menu level (click symbol \oplus next to the name), you will see the parameters set previously.



Hereafter is presented a possible usage scenario for the Contrast Control Tool. In this particular inspection it's needed to check the presence of a postal printing on the envelope. If the postal printing is correctly placed, the overall contrast of the ROI increases its value, if the printing is not present the contrast value should be very low (the contrast of a uniform area is null). The Fig. A shows a successful check, the Fig. B on the contrary shows a failure.

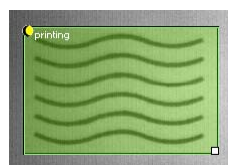


Fig. A: SUCCESS



Fig. B: FAILURE

8.5.3. Contour Match

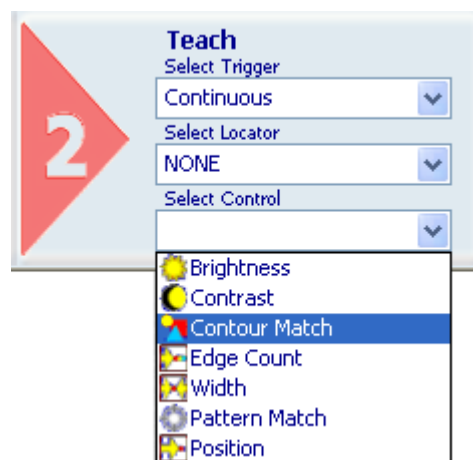
Description

The contour match operation consists in comparing the contour of a sample object with that of a target object to determine their similarity. (Contour match ►)

After an initial setup stage designed to set the master contour on the reference image, it's very important that the ROI contains a closed shape entirely. Then, the system will search for this contour through 360° in target images as they are acquired. A numeric value (score) is returned by the tool, the more high the more the processed shape is similar to the reference one.

Inspection tolerance may be modified.

Selection



Pointer shape



Positioning

Click any point inside the work area to create a rectangular ROI with a small white square at the bottom right corner.



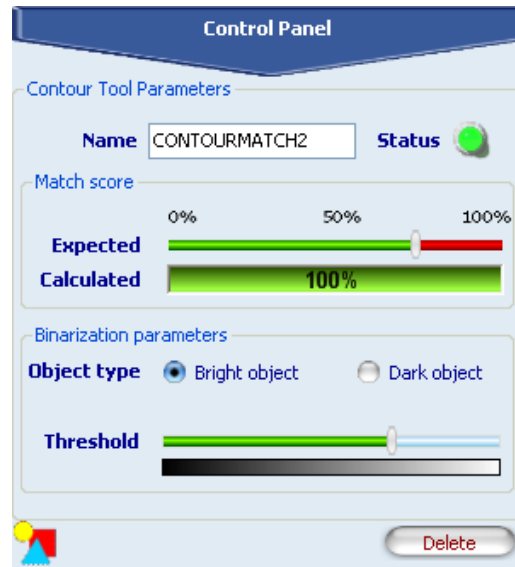
To change ROI size, left-click and drag the square.

To move the ROI, place the pointer on any side of the ROI. The pointer changes to a cross. Press and hold the left mouse button and drag the rectangle to the desired position.

Parameters

After clicking in the work area to create the ROI, the control panel displays the set of parameters that enable control customisation.



Please note that different parameters are available in the STANDARD and EXPERT modes:



- **Name** : Name assigned to control in Inspection Explorer. Maximum length is 256 characters;
- **Status** : see "Result" further below;
- **Match score** :
 - *Expected* : You may specify to what degree (percent) detected contour must be similar to reference contour in order to be considered valid (100% = perfect match, 0% ...). This value may be set automatically by the system or you may set it manually using the slider;
 - *Calculated* : Provides a graphic display of the degree of similarity, in percent, between the contour detected in the ROI and the reference contour.
- **Binarization parameters** :
 - Object type* : You may specify the features of object subject to contour recognition. Possible options are:
 - Bright Object : Object is lighter than the background;
 - Dark Object : Object is darker than the background.
- **Threshold** : Threshold on gray scale that determines whether a point is part of the object or not. It is compared to the value detected on the acquired image: if this value is lower than the threshold, the point is not considered part of the object; if the opposite is true, the point is considered part of the object. An automatically calculated threshold value may be selected by choosing the appropriate control;
- **Delete** : Deletes control from inspection.

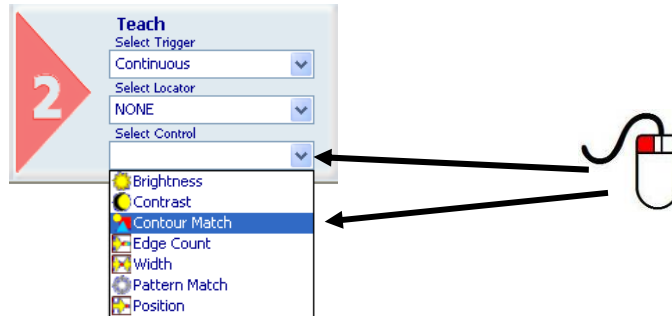
Result

Graphically displayed by the *Status* indicator; shows control result:

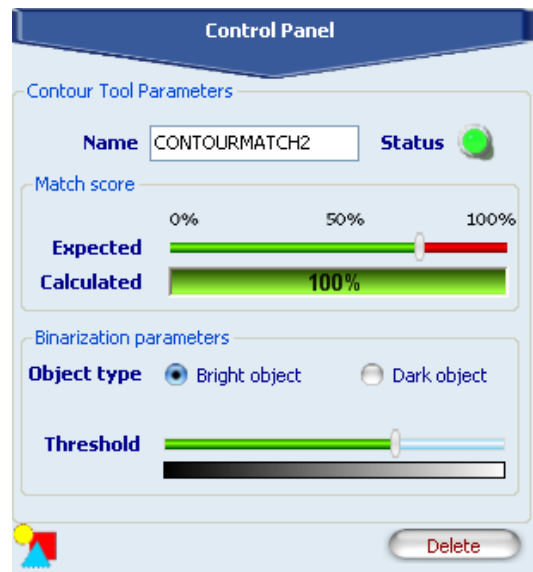
- **Status**  : A contour similar to the reference contour was identified;
- **Status**  : No contours similar to the reference contour were identified;

Example

Add "Contour Match" control to current inspection to detect the contour of a bright object on a dark background.
 Select "Contour Match" from the pull-down menu:

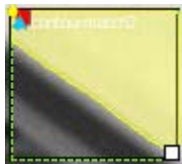


Position the control on the reference image in the work area: the pointer changes shape as soon as it enters the work area. Left-click once at any position to create a default rectangular ROI.
 At the same time, the control features and the result of its application to the reference image appear in the control panel.
 Set ROI size and position as required, as explained above.



The result indicated by STATUS is also highlighted by the ROI border changing colour.
 As soon as values change, result is calculated without delay.

The object and its contour are highlighted in yellow inside the ROI:



as can be seen from the example image, the bright object is highlighted as specified at parameter Object type, which was set to "Bright object".
 More specifically, the portion of the bright object situated inside the ROI is highlighted: since the ROI does not encompass the entire object, part of the ROI borders are treated as object orders.

Let's see another example of application. In this particular task we want to control the circular shape of a coffee pod. The coffee pod is seen from the top side. The Contour Match searches for a closed shape into the ROI area and compares it with the reference shape previously set. The Fig. A shows a successfully check, the Fig. B shows a negative match.

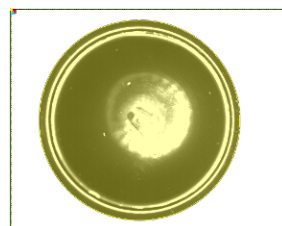


Fig. A: SUCCESS

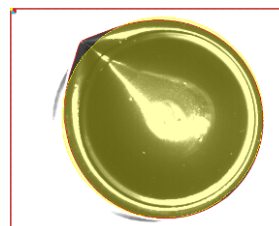


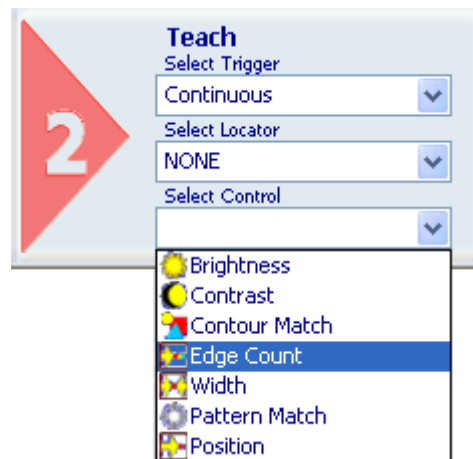
Fig. B: FAILURE

8.5.4. Edge Count

Description

This control identifies all edges (edge detection ►) located inside the ROI. Based on the first derivative of the pixel brightness variation function, the maximum positive peak is identified if control is targeting a positive edge, or the maximum negative peak is identified when targeting a negative edge. A point is considered an edge point when its brightness variation exceeds this threshold, which is a function of the peak value found;

Selection

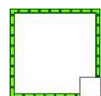


Pointer shape



Positioning

Click any point inside the work area to create a rectangular ROI with a small white square at the bottom right corner.



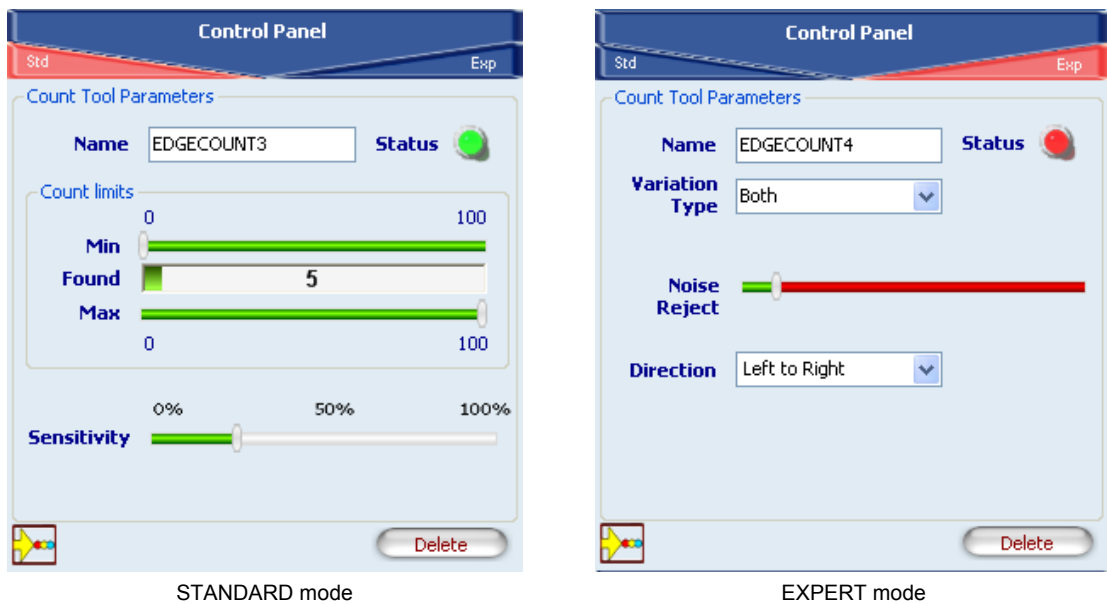
To change ROI size, left-click and drag the square.

To move the ROI, place the pointer on any side of the ROI. The pointer changes to a cross. Press and hold the left mouse button and drag the rectangle to the desired position.

Parameters

After clicking in the work area to create the ROI, the control panel displays the set of parameters that enable control customisation.

Please note that different parameters are available in the STANDARD and EXPERT modes:





STANDARD mode

EXPERT mode

- **Name** : Name assigned to control in Inspection Explorer. Maximum length is 256 characters;
- **Status** : see "Result" further below;
- **Counts limits** : Lets you specify the minimum and maximum number of edges that can be detected;
 - Min, Max: These parameters let you specify the minimum and maximum number of edges that can be detected. These thresholds must be compatible with the value found (shown in the "Found" bar). This means Min must be less than or equal to "Found", and Max must be greater than or equal to "Found".
- **Sensitivity**: This is the degree of accuracy provided when searching for the edges. Set sensitivity affects processing results: the lower the sensitivity, the greater the accuracy, hence, the more edges will be found.
- **Variation Type** : Determines how an edge point is to be identified during image scanning. Possible values are:
 - White to Black: point is treated as an edge point when a white-to-black transition is detected;
 - Black to White: point is treated as an edge point when a black-to-white transition is detected;
 - Both: point is labelled as edge point at both white-to-black and black-to-white transitions;
 - Auto: automatic edge point recognition.
- **Noise reject** : Reduces noise in the edge identification process. The threshold is a function of the first derivative and establishes the minimum brightness variation for a point to be considered as an edge point;
- **Direction**: Determines the search direction and versus. Possible values are:
 - Left to right;
 - Right to left;
 - Up to down;
 - Down to up.
- **Delete** : Deletes control from inspection.

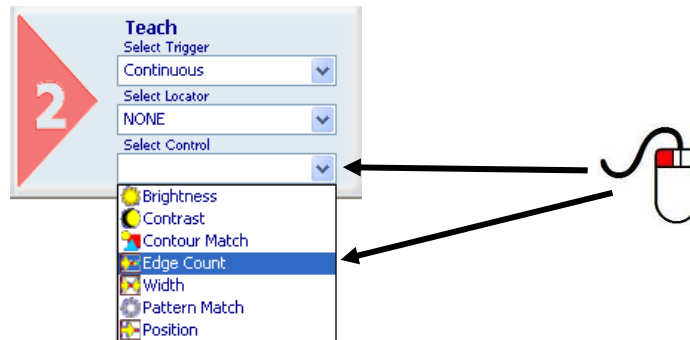
Result

Graphically displayed by the *Status* indicator; shows control result:

- **Status**  : system detected some edges in the acquired image and their number is within the range set in "Match limits" ;
- **Status**  : system found no edges or their number is outside the specified limits.

Example

Add an "Edge count" control to current inspection to identify up to two edges. Select "Edge Count" from the pull-down menu:



Position the control on the reference image in the work area: the pointer changes shape as soon as it enters the work area. Left-click once at any position to create a default rectangular ROI.

At the same time, the control features and the result of its application to the reference image appear in the control panel. Set ROI size and position as required, as explained above.

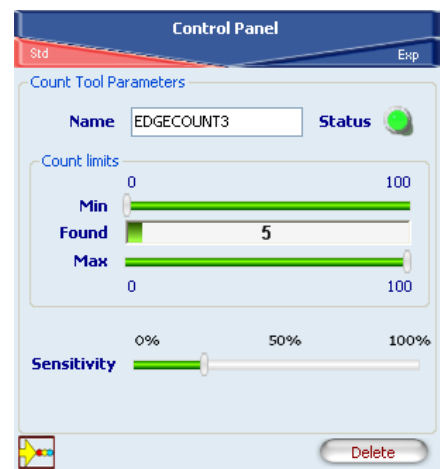
The result indicated by STATUS is also highlighted by the ROI border changing colour.

As soon as values change, result is calculated without delay.

Set up system to recognise all light-to-dark and dark-to-light brightness variations as edges. In addition, set the maximum



number of edges to be detected to '2' (this value can be viewed by placing the mouse pointer on the corresponding bar). In the example figure, five edges with the specified features have been recognized. The control will return a Fail status, identified by the red Status and ROI border.

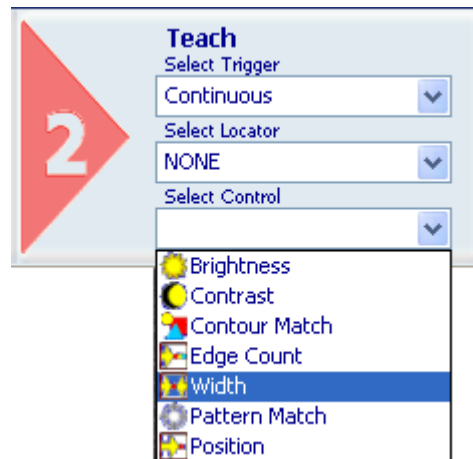


8.5.5. Width

Description

This control is also termed "gauge" and lets you measure the distance between two points. It uses the edge detection technique to identify object edges and then calculates the distance between the edges.

Selection

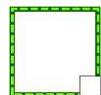


Pointer shape



Positioning

Click any point inside the work area to create a rectangular ROI with a small white square at the bottom right corner.



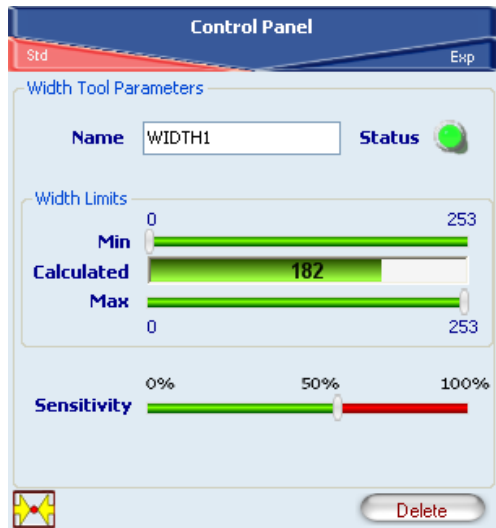
To change ROI size, left-click and drag the square.

To move the ROI, place the pointer on any side of the ROI. The pointer changes to a cross. Press and hold the left mouse button and drag the rectangle to the desired position.

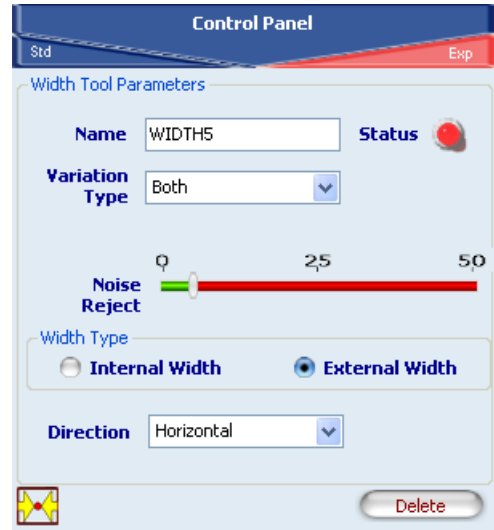
Parameters

After clicking in the work area to create the ROI, the control panel displays the set of parameters that enable control customisation.

Please note that different parameters are available in the STANDARD and EXPERT modes:



STANDARD mode





EXPERT mode

- **Name** : Name assigned to control in Inspection Explorer. Maximum length is 256 characters;
- **Status** : see "Result" further below;
- **Width limits** :
 - Min, Max: These parameters let you specify the minimum and maximum width value that can be detected. These thresholds must be compatible with the value found (shown in the "Calculated" bar). This means Min must be less than or equal to "Calculated", and Max must be greater than or equal to "Calculated".
- **Sensitivity**: Based on the first derivative of the pixel brightness variation function, the maximum positive peak is identified if control is targeting a positive edge, or the maximum negative peak is identified when targeting a negative edge. A point is considered an edge point when its brightness variation exceeds this threshold, which is a function of the peak value found;
- **Variation type** : You may choose how edges are to be identified. Possible options are:
 - White to Black: point is treated as an edge point when a white-to-black transition is detected;
 - Black to White: point is treated as an edge point when a black-to-white transition is detected;
 - Both: point is labelled as edge point at both white-to-black and black-to-white transitions;
 - Auto: automatic edge point recognition.
- **Noise reject**: Reduces noise in the edge identification process. The threshold is a function of the first derivative and establishes the minimum brightness variation for a point to be considered as an edge point;
- **Width Type** : Determines in which direction the system searches for the edges to calculate distance. Options are:
 - Internal width: Search from the middle out;
 - External width: Search from the outside towards the middle.
- **Direction**: Determines the search direction. Possible values are:
 - Horizontal;
 - Vertical.
- **Delete** : Deletes control from inspection.

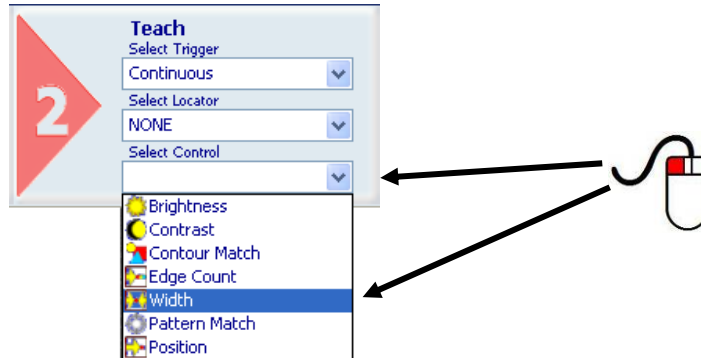
Result

Graphically displayed by the *Status* indicator; shows control result:

- **Status**  : System identified edges and such a condition to allow for distance between two points to be calculated;
- **Status**  : It was not possible to identify any edges for distance calculation.

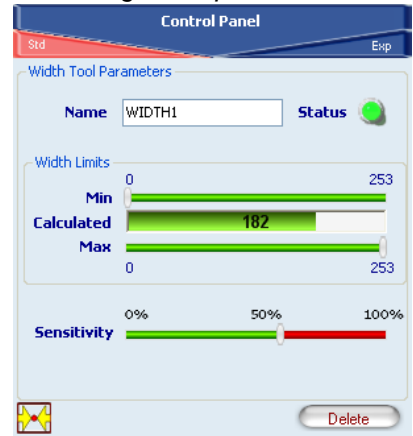
Example

Add a "Width" edge to current inspection using the Graphic User Standard in STANDARD mode. Select "Width" from the pull-down menu:



Position the control on the reference image in the work area: the pointer changes shape as soon as it enters the work area. Left-click once at any position to create a default rectangular ROI.

At the same time, the control features and the result of its application to the reference image appear in the control panel. Set ROI size and position as required, as explained above.

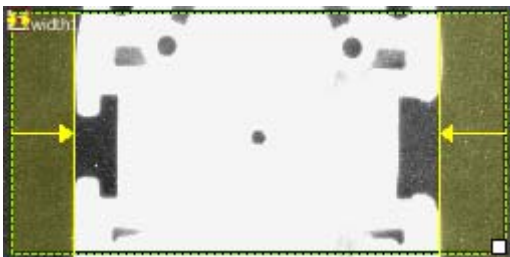


The result indicated by STATUS is also highlighted by the ROI border changing colour.

As soon as values change, result is calculated without delay.

Let us assume that our reference is to be the distance between points that are part of a bright object on a dark background. A yellow line appears inside the ROI on the edges found; edges are displayed as yellow dots that identify the limit values for distance calculation.

Now use the sliders of the Min and Max fields to specify how far the measurements taken on master images are allowed to deviate from the measurement you have just set and still be considered acceptable (i.e. without triggering a control "Fail" status).



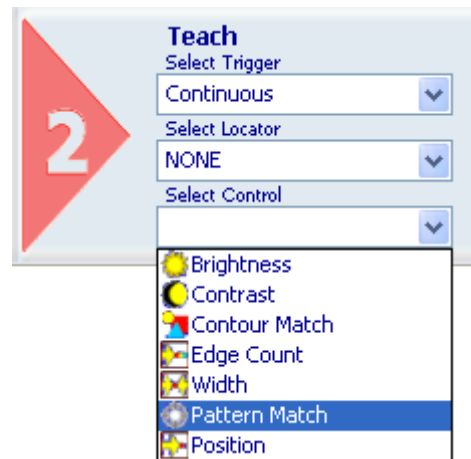
8.5.6. Pattern Match

Description

The term pattern match signifies a process that searches for a pattern similar to the master image inside the target image using its brightness matrix. (Pattern match ►)

Once the ROI has been set, the control calculates the edge points (features) that show significant differences in pixel brightness. All features are displayed in the form of small yellow squares.

Selection



Pointer shape



Positioning

Click any point inside the work area to create two rectangular ROIs; the innermost ROI is the reference ROI, the outermost ROI is the search ROI. Both ROIs feature a small white square in the bottom right corner.

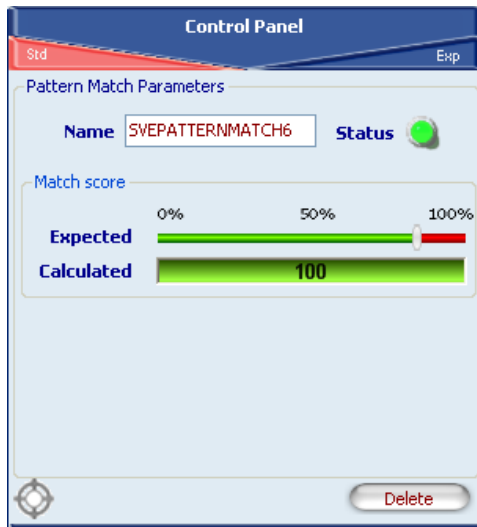


To change ROI size, left-click and drag the square.

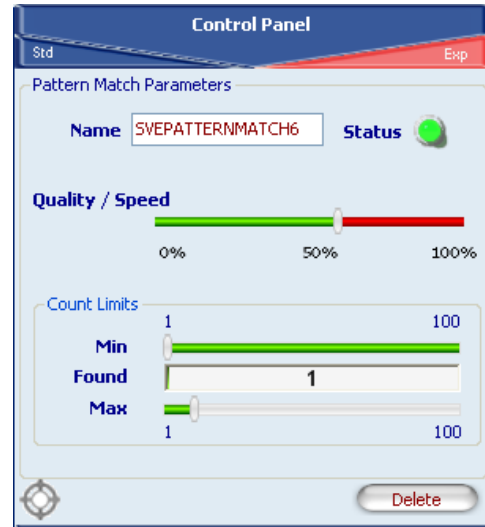
To move the ROI, place the pointer on any side of the ROI. The pointer changes to a cross. Press and hold the left mouse button and drag the rectangle to the desired position.

Parameters

After clicking in the work area to create the ROI, the control panel displays the set of parameters that enable control customisation.



STANDARD mode



EXPERT mode

- **Name** : Name assigned to control in Inspection Explorer. Maximum length is 256 characters;
- **Status** : see "Result" further below;
- **Match score** :
 - *Expected* : Threshold used for inspection result evaluation. It indicates how closely the areas found in the search ROI must resemble the master image of the reference ROI in order to be considered valid (100% = perfect match, 0% ...). This value may be set automatically by the system or you may set it manually using the slider;
 - *Calculated* : Provides a graphic display of the degree of similarity, in percent, between the areas found in the search ROI compared to the master image of the reference ROI based on the number and location of detected features.
- **Quality/Speed**: This is the degree of accuracy/speed provided when searching for the features. Set this parameter affects processing results: the lower the speed, the greater the accuracy, hence, the more features will be found.
- **Count limits** :
 - **Min, Max**: These parameters let you set limits for the number of areas similar to the area in the reference ROI to be found. These thresholds must be compatible with the value found (shown in the "Found" bar). This means Min must be less than or equal to "Found", and Max must be greater than or equal to "Found".
- **Delete** : Deletes control from inspection.

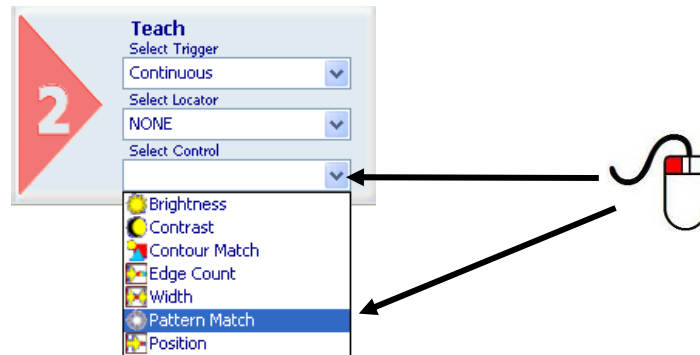
Result

Graphically displayed by the *Status* indicator; shows control result:

- **Status** : Calculated ROI contrast is lower than set threshold (Expected);
- **Status** : Calculated ROI contrast is higher than set threshold;

Example

Add a "Pattern Match" control to current inspection.
Select "Pattern Match" from the pull-down menu:



Position the control on the reference image in the work area: the pointer changes shape as soon as it enters the work area. Left-click once at any position to create two default rectangular ROIs. At the same time, the control features and the result of its application to the reference image appear in the control panel.

Set size and position of ROIs as required, as explained above.

The result indicated by STATUS is also highlighted by the ROI border changing colour.

The value of parameter "Calculated", which indicates the degree of similarity in percent, is reported inside the areas inside the search ROI found to be similar to the master image of the reference ROI.

As soon as values change, result is calculated without delay.

Another two possible example of application of the Pattern Match Control Tool are presented.

In the first one, the tool is used to control the orientation of a shampoo bottle. In particular, we want to check that the bottle plug is on the front of the camera. In Fig. A is shown a successful check, on the contrary the Fig. B shows a failure. In Fig. A, please note the presence of the two different region, the search region (the bigger one) and the matching one (the smaller one).

In the second example the investigation intent is to verify the presence of the postage stamp on the envelope. As shown in Fig. C, the reference pattern is set to entirely cover the postage stamp graphics, whereas the search region is wider and completely contains the pattern region. The Fig. D shows an unsuccessful check.

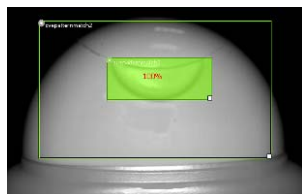
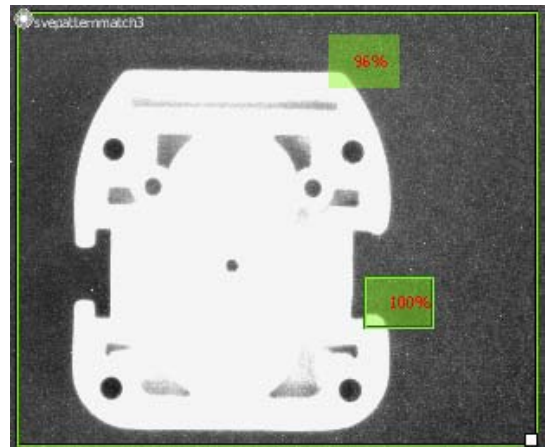


Fig. A: SUCCESS



Fig. B: FAILURE

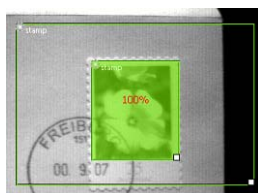


Fig. C: SUCCESS

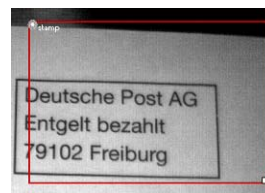


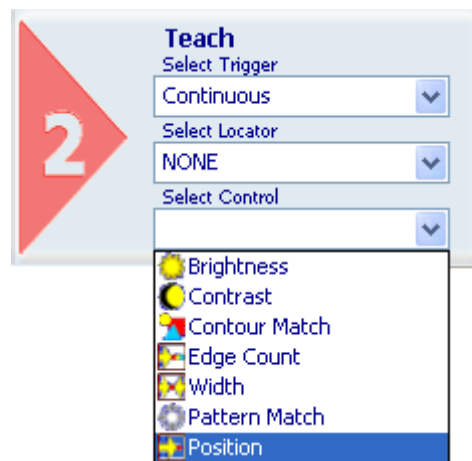
Fig. D: FAILURE

8.5.7. Position

Description

This control identifies the object position edge (edge detection ►) located inside the ROI. Based on the first derivative of the pixel brightness variation function, the maximum positive peak is identified if control is targeting a positive edge, or the maximum negative peak is identified when targeting a negative edge. A point is considered an edge point when its brightness variation exceeds this threshold, which is a function of the peak value found;

Selection



Pointer shape



Positioning

Click any point inside the work area to create a rectangular ROI with a small white square at the bottom right corner.



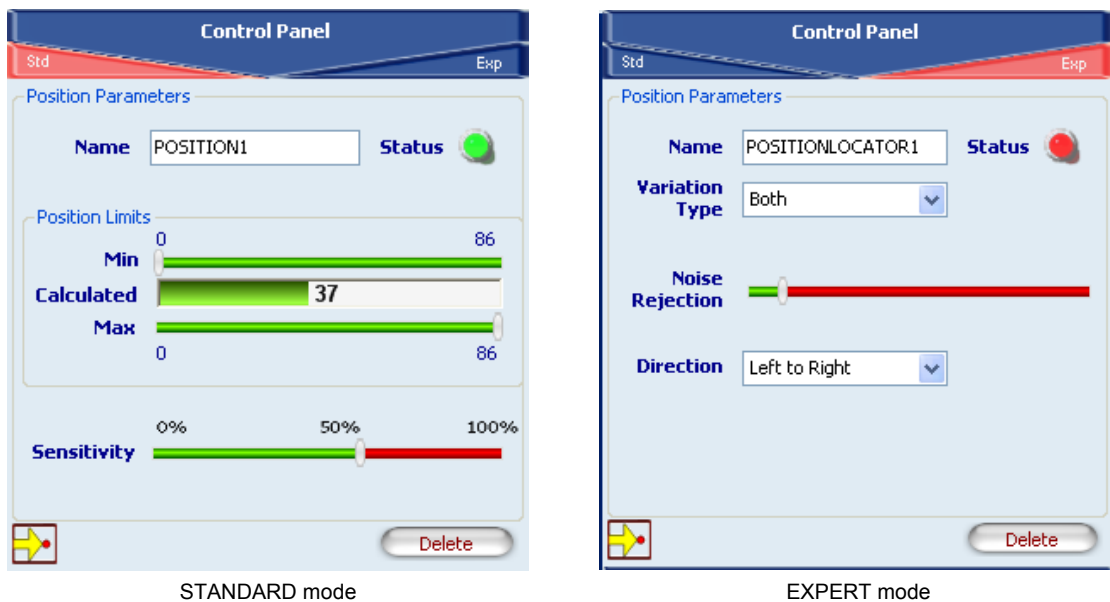
To change ROI size, left-click and drag the square.

To move the ROI, place the pointer on any side of the ROI. The pointer changes to a cross. Press and hold the left mouse button and drag the rectangle to the desired position.

Parameters

After clicking in the work area to create the ROI, the control panel displays the set of parameters that enable control customisation.

Please note that different parameters are available in the STANDARD and EXPERT modes:



- **Name** : Name assigned to control in Inspection Explorer. Maximum length is 256 characters;
- **Status** : see "Result" further below;
- **Position Limits** :
 - Min, Max: Minimum and maximum value of detectable position. These thresholds must be compatible with the value found (shown in the "Calculated" bar). This means Min must be less than or equal to "Calculated", and Max must be greater than or equal to "Calculated".
- **Sensitivity**: This is the degree of accuracy provided when searching for the edge. Set sensitivity affects processing results: the lower the sensitivity, the greater the accuracy.
- **Variation Type** : Determines how the edge point is to be identified during image scanning. Possible values are:
 - White to Black: point is treated as an edge point when the first white-to-black transition is detected;
 - Black to White: point is treated as an edge point when the first black-to-white transition is detected;
 - Both: point is labelled as edge point at both white-to-black and black-to-white transitions;
 - Auto: automatic edge point recognition.
- **Noise rejection** : Reduces noise in the edge identification process. The threshold is a function of the first derivative and establishes the minimum brightness variation for a point to be considered as an edge point;
- **Direction**: Determines the search direction and versus. Possible values are:
 - Left to right;
 - Right to left;
 - Up to down;
 - Down to up.
- **Delete** : Deletes control from inspection.

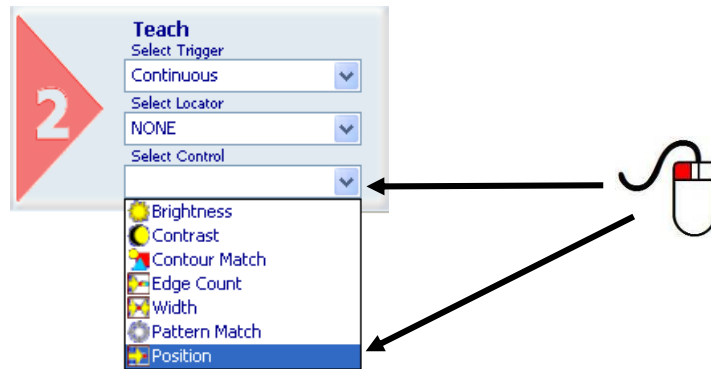
Result

Graphically displayed by the *Status* indicator; shows control result:

- **Status** : system detected an edge in the acquired image and number is within the range set in "Match limits" ;
- **Status** : system found no edge or number is outside the specified limits.

Example

Add a "Position" control to current inspection to identify up to two edges.
 Select "Position" from the pull-down menu:



Position the control on the reference image in the work area: the pointer changes shape as soon as it enters the work area. Left-click once at any position to create a default rectangular ROI. At the same time, the control features and the result of its application to the reference image appear in the control panel.

Set ROI size and position as required, as explained above.

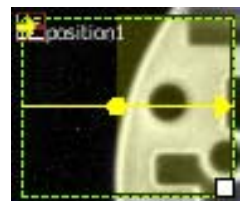
The result indicated by STATUS is also highlighted by the ROI border changing colour.

As soon as values change, result is calculated without delay.

Set up system to recognise all dark-to-light brightness variations as edges. In addition, set the maximum number of positions to be detected to '40'.

A yellow line appears inside the ROI on the edges found; edges are displayed as yellow dots that identify the limit values for distance calculation.

Now use the sliders of the Min and Max fields to specify how far the measurements taken on master images are allowed to deviate from the measurement you have just set and still be considered acceptable (i.e. without triggering a control "Fail" status).



In this second example another possible usage scenario is presented. In this particular task, it's needed to verify the correct placement of the beak of a bottle of water-closet detergent. As shown in Fig. A and B, with the Position Control Tool it's possible to achieve this task. The Fig. A shows a correct placement, on the contrary the Fig. B shows a wrong placement.

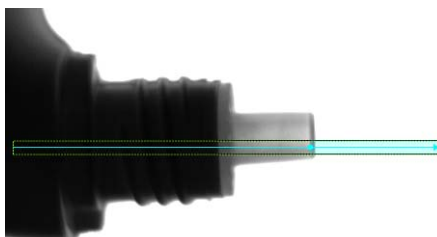


Fig. A: SUCCESS

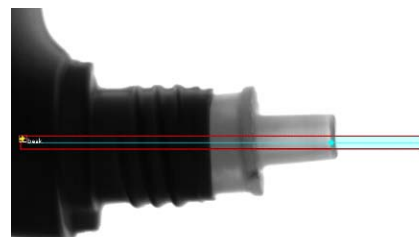


Fig. B: FAILURE

TEACH BUTTON

On the top of the sensor body there is a very important button with many functionalities. In the section Output Setup->Teach Button in the Graphic User Interface it is possible to enable its functions. However, the Teach Button functions are available only when the sensor is not connected with the GUI.



Recovery Mode

Whenever the sensor suffers a crash due to a bad inspection definition, it is possible to load a recovery firmware with a basically communication service to restore a working environment.

To launch this recovery routine hold down the Teach Button during the sensor powerup until the outputs leds start blinking, signalling that the recovery firmware is running.

Under the recovery condition, it is possible to overwrite an inspection file loading another inspection in the desired flash memory slot using the GUI.

Use the command File -> Open Inspection -> Open from SVS2 to display a list of the inspections currently stored in the sensor. The running inspection, the most probably crash source, has a checked checkbox on the right of this list.

Once the problem with the inspection is fixed, overwrite the inspection file with the command File -> Save -> Save on SVS2 and choose the correct slot in the flash memory.

This function it's always available and it's not necessary to enable the Teach Mode trough the GUI to activate the Recovery Mode.

Teach Mode

The Teach Mode allow the definition of a new reference image for the running inspection without the connection between the GUI and the sensor. In this way the reference image can be updated "on the fly" directly in the place where the sensor is working.

To update the reference image do as follow:

1. Press shortly the teach button.
 - the sensor stop its process and activate the pointer (made of four green light that mark out the field of vision of the sensor). The led Output 1 lights on as well.
 - the sensor waits for a second button pressure.
2. Press down the teach button for more than one second.
 - the Led Output 1 lights off and the Led Outputs 2 lights on.
 - the sensor grabs the current scene and updates the reference image for the running inspection.
 - after few seconds the sensor starts again its activity.

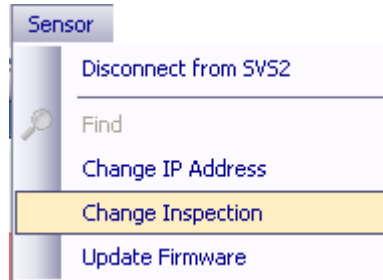
After the step 1, if the button is not pressed again or is pressed for less than 1 second the sensor returns in run mode and starts again its activity.

10. INSPECTION SELECTION

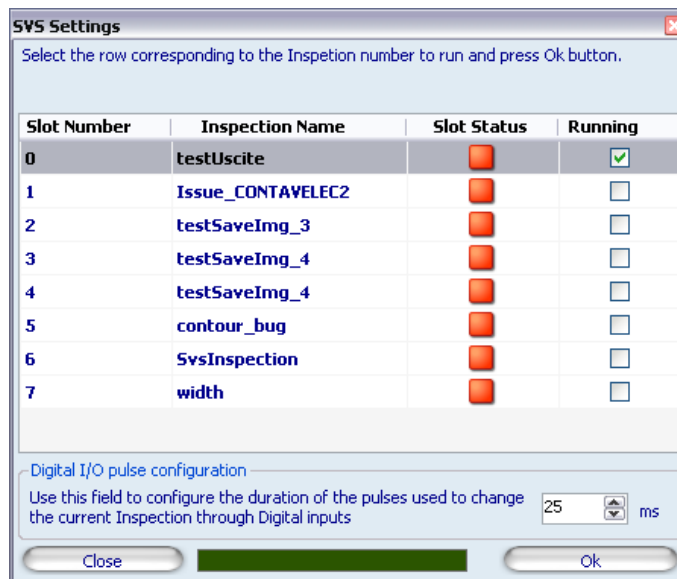
In order to change the current Inspection running on SVS you can choose between two options, described in the following paragraphs: inspection selection through Graphic User Interface and inspection selection through digital input.

10.1. Inspection selection through Graphic User Interface

When connected to the sensor, from the Menu Sensor select item Change Inspection:



The following SVS Settings dialog window will appear:



In the top view of the window you will see a table showing the current SVS memory slots status. Each slot is represented by a table row, characterized by four columns: from left to right, the first three columns represent the Slot Number, the Name of the Inspection stored in the corresponding Slot and the Slot Status, containing a red led when an Inspection is stored in the corresponding slot or a green led when the slot is empty. The last table column represent the SVS sensor current running Inspection, corresponding to the checked row.

In order to change the current running Inspection you have to select the table row corresponding to the Inspection you want to start running and press the Ok button, on the bottom right view of the dialog window.

Pressing the Close button you will cancel the current action; the current running Inspection will not change.

10.2. Inspection selection through Digital Input

To select the current inspection running on SVS a digital input with a special protocol is used.

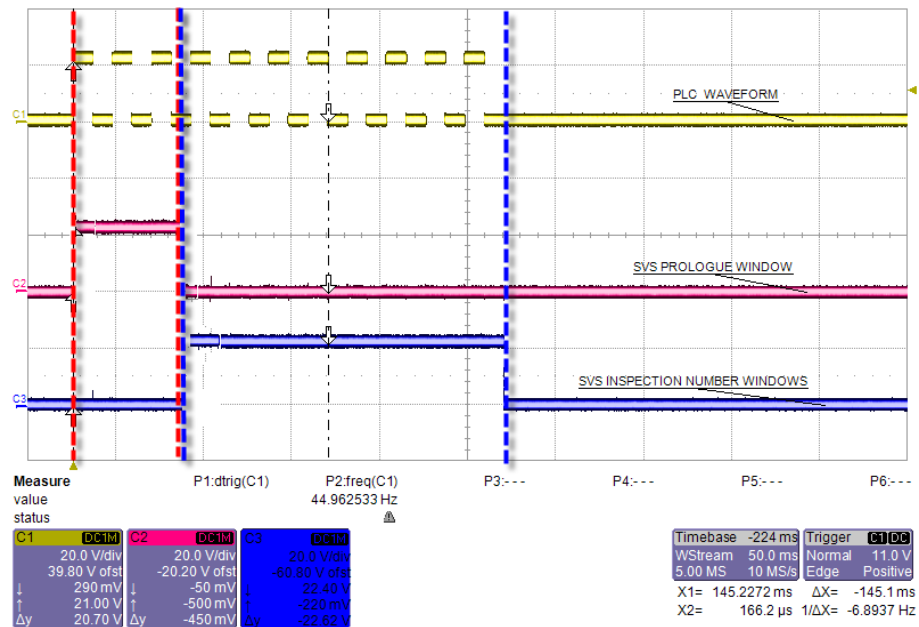
The protocol is composed of a prologue followed by an epilogue.

Basically the prologue is composed of 3 pulses with a width of 10-100 ms and a duty cycle of 50%. The first pulse starts the prologue window that lasts a maximum of $Y=6*X+\text{delta}$ ms (where X is the selected pulse width and delta is a 10 ms margin), during the prologue window 3 pulses are expected to start the inspection selection window, when the prologue window is ended, if 3 and only 3 pulses were counted we proceed to the next step, inspection selection pulse count.

A $Y=16*X+\text{delta}$ ms time window is started and during this period pulses are counted (where X is the selected pulse width and delta is a 10 ms margin).

At the end of the period, the counted pulses means the selected inspection (if the number fits in the available inspections slots, otherwise the request is discarded).

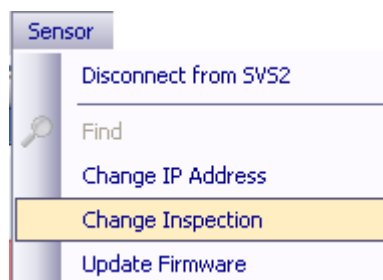
The following image shows an oscilloscope picture that represents the selection of the inspection 8 by the digital input as could be generated by a PLC.



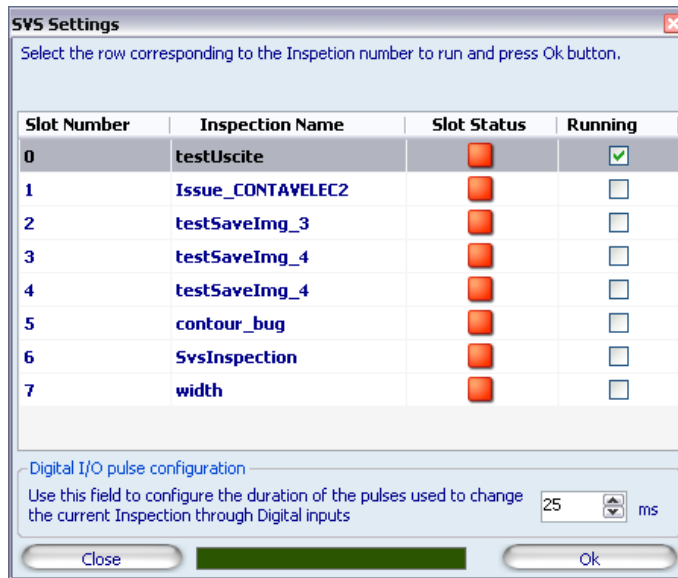
Selection of the inspection number 8

In order to change pulses width accepted by the sensor during Inspection selection through digital input handshake, you have to use the SVS Settings dialog window.

When connected to the sensor, from the Menu Sensor select item Change Inspection:



The following SVS Settings dialog window will appear:



In the bottom view on the dialog window the Digital I/O pulses configuration group box shows a numeric up-down control that can be used to change the current digital Input pulses width: values between 10 ms and 100 ms will be accepted from the SVS sensor.

Once you are confident your configuration is completed, press the Ok button to save the configuration on the sensor. If you press Close button, nothing will change.

Inspection switch timing

Because before the inspection is started some processing has to be done (basically we have to run a sort of inspection on the reference image before we can go in run mode), a unique and definitive timing of the inspection change process is not available because it will depend on the inspection time itself.

If the inspection use very fast tools, for example Position or Width, it will be quite fast (hundred of milliseconds), if the inspection is quite slow, for example a difficult pattern match, the delay will be greater maybe in the 1-2 seconds range.

During the inspection switch process, the sensor stops acquiring new images and enter an idle status. When the switch is complete, the sensor blinks once and then starts the new inspection activity. Anyway it is possible to check the current running inspection using the Graphic User Interface.

11. INSPECTIONS AND PERIODIC MAINTENANCE

Correct system maintenance consists in removing dust or foreign objects from sensor and keeping the configuration software updated to the latest release.

Remove any dust build-up from sensor body using a soft cloth; if needed, dampen cloth slightly with a mild detergent solution.

To clean off dust and fingerprints from the lenses, use an anti-static compressed air can. Use a cloth and a specific lens detergent to remove any residue.

Avoid using:

- alcohol-based detergents or solvents;
- wool or synthetic cloth.

Visit the web site of Datasensor S.p.A. (www.datasensor.com) to check for software updates. To check version and date of the software installed on your system, see Help → About.

11.1. Warranty

The product you purchased is warranted to be free from manufacturing defects for a period of 36 (thirty-six) months from date of manufacture.

Warranty does not cover damage and defects resulting from improper use of the sensor or accidental damage due to shock or in the event the product is dropped.

The sensor contains cutting-edge electronic components that cannot be repaired or replaced by the final user. Do not dismantle the device or make any changes to its components or the warranty will become null and void.

Datasensor S.p.a. may not be held liable for damage to persons or property resulting from failure to comply with the provisions reported herein.

In the event of problems, contact the after sales /repair service of DATASENSOR S.p.A.

After Sales Service

Tel.: +39 051 6765611

Fax: +39 051 6759324

e-mail: service@datasensor.com

12. SPECIFICATIONS

SVS2:

| | |
|----------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Supply voltage: | 24 VDC \pm 10% |
| Ripple voltage: | 1 Vpp max with illuminator 2 Vpp max without illuminator |
| Current draw: <i>(excluding output current and illuminator)</i> | 100 mA at 24 VDC |
| Current draw with illuminator: <i>(depends on how long illuminator stays on)</i> | < 200 mA at 24 VDC |
| Outputs: | 2 PNP outputs (short circuit protection) |
| Network interface: | M12 4-pole – 10/100 Mbps Ethernet |
| Interface for external illuminator: | Strobe signal (TTL) |
| Output current: | 100 mA max |
| Output saturation voltage: | < 2 V |
| Optics: | Integrated |
| Resolution: | 640 \times 480 (VGA) |
| Indicators: | 4 LEDs |
| Setup: | 1 Teach-In key |
| Data retention: | Non-volatile FLASH memory |
| Operating temperature: | -10 $^{\circ}$ C ... +55 $^{\circ}$ C |
| Storage temperature: | -25 $^{\circ}$ C ... +75 $^{\circ}$ C |
| Vibration: | 0.5 mm amplitude, 10 ... 55 Hz frequency, for every axis (EN60068-2-6) |
| Shock resistance: | 11 ms (30 G) 6 shock for every axis (EN60068-2-27) |
| Housing material: | Aluminium alloy / ABS |
| Mechanical protection: | IP50 |
| Connections: | M12 8-pole A-code, M12 4-pole D-code |
| Weight: | 125 g. |

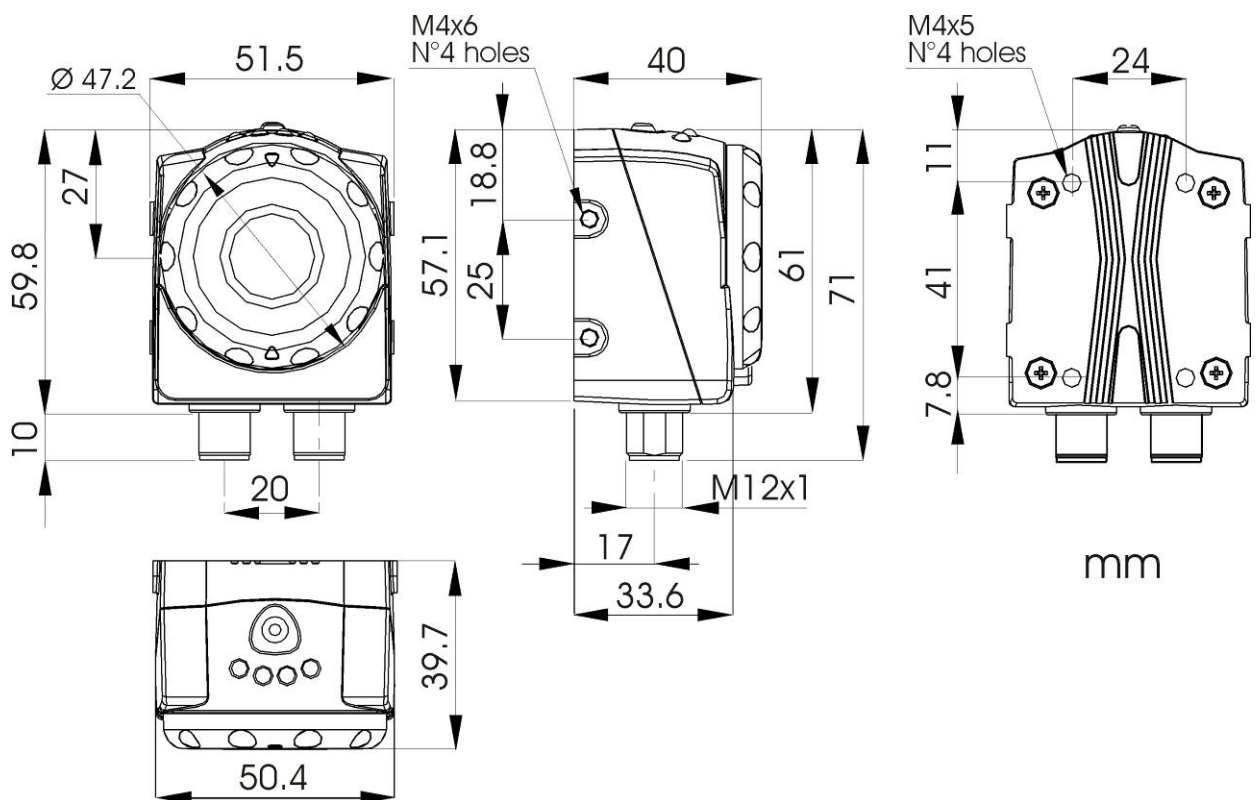
IMAGE SENSOR:

| | |
|---------------------|---------------------------|
| Technology: | CMOS |
| Supply voltage: | 3.3 V |
| Size: | $\frac{1}{3}$ -inch |
| Pixel matrix: | 752 x 480 |
| Pixel size: | 6.0 μ m x 6.0 μ m |
| Maximum frame rate: | 60 fps |
| SNR: | 55 dB |
| Responsivity: | 4.8 V / lux-sec |

13. LIST OF AVAILABLE MODELS

| MODEL | DESCRIPTION |
|----------------|---------------------------|
| SVS2-06-DE-OBJ | 6mm, ETHERNET CONN., OBJ |
| SVS2-08-DE-OBJ | 8mm, ETHERNET CONN., OBJ |
| SVS2-12-DE-OBJ | 12mm, ETHERNET CONN., OBJ |

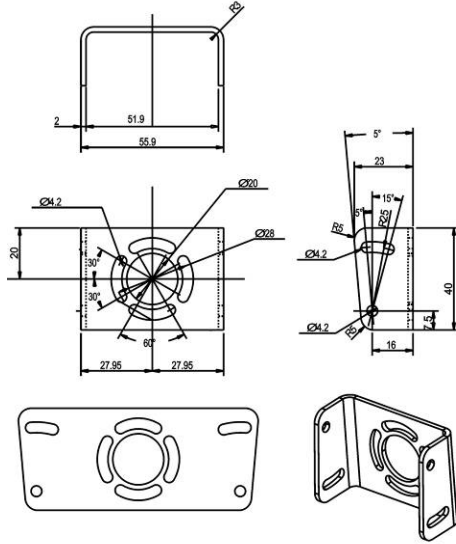
14. OVERALL DIMENSIONS



15. ACCESSORIES

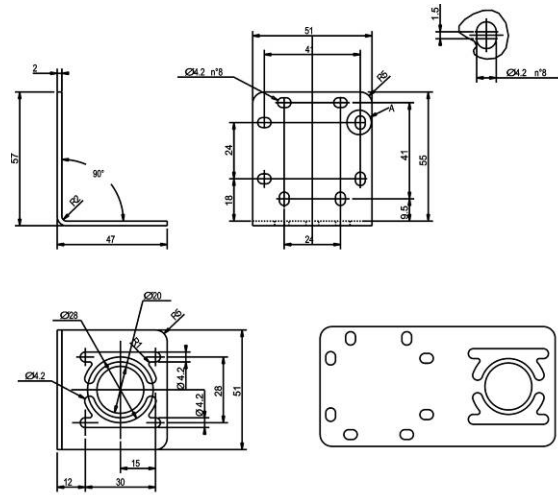
ST-5066

U-shaped fixing bracket for angle adjustment

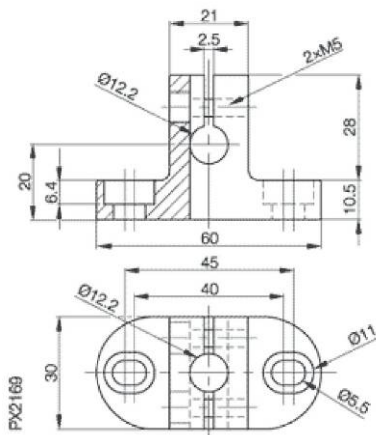


ST-5068

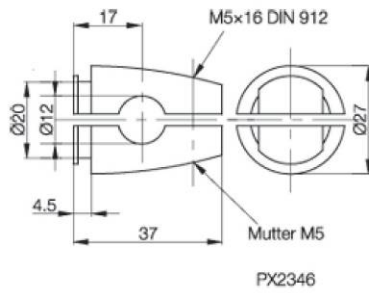
L-shaped fixing bracket for 90° mounting



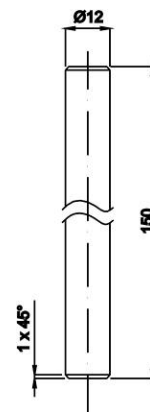
Base



MOUNTING KIT
Pin



Arm





| MODELLO | DESCRIZIONE | N° ORDINE |
|------------------------|----------------------------------------------|-----------|
| SVS-ST-5068 | U-shaped fixing bracket for angle adjustment | 95A901320 |
| SVS-ST-5066 | L-shaped fixing bracket for 90° mounting | 95A901330 |
| SVS-CV-RJ45C-03 | 3 m crossed Ethernet cable | 95A901340 |
| SVS-CV-RJ45D-03 | 3 m direct Ethernet cable | 95A901350 |
| SVS-MK-01 | Mounting Kit | 95A901380 |

| MODEL | DESCRIPTION | ORDER N° |
|------------------------|---------------------------------------------------|-----------|
| SVS-ST-5068 | L-shaped fixing bracket for 90° mounting | 95A901320 |
| SVS-ST-5066 | U-shaped fixing bracket for angle adjustment | 95A901330 |
| SVS-CV-RJ45C-03 | 3 m crossed Ethernet cable | 95A901340 |
| SVS-CV-RJ45D-03 | 3 m direct Ethernet cable | 95A901350 |
| SVS-MK-01 | Mounting Kit | 95A901380 |
| CS-A1-06-B-03 | 3 m M12 8 pole connector with not shielded cable | 95ACC2230 |
| CS-A1-06-B-05 | 5 m M12 8 pole connector with not shielded cable | 95ACC2240 |
| CS-A1-06-B-10 | 10 m M12 8 pole connector with not shielded cable | 95ACC2250 |

16. TUTORIAL

16.1. ► Digital image

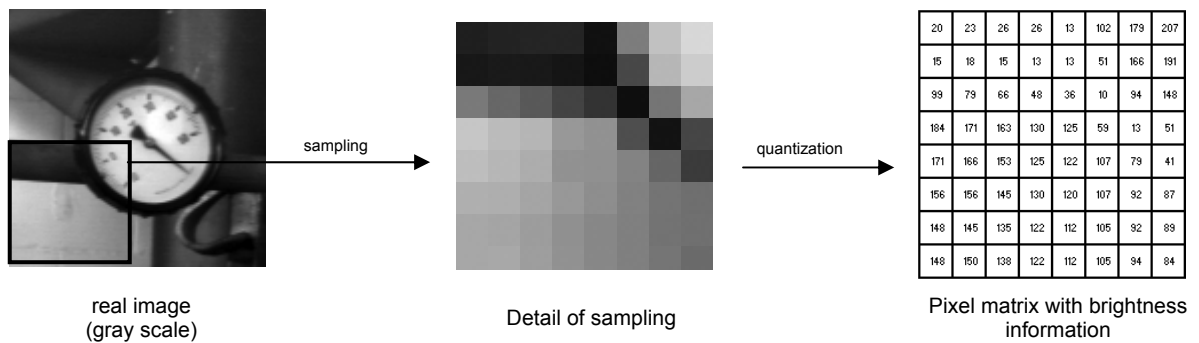
Digitization allows real images acquired by a camera to be treated using a processor.

This is done in two steps:

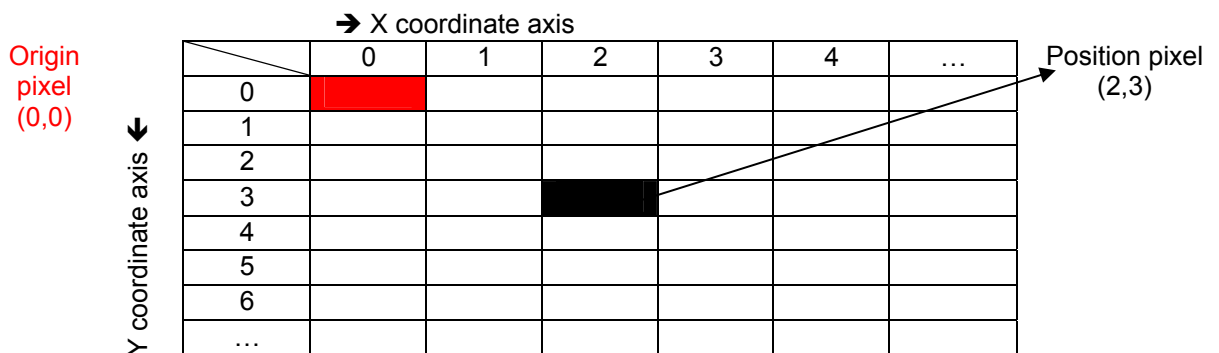
- sampling: image is divided into a dot matrix; dots are termed picture elements (or more commonly pixels);
- quantization: each pixel is associated to a numeric value.

Such information may signify point brightness for gray scale images (0 = black, 255 = white), or three values (Red-Blue-Green, RGB coding) for colour images.

As a result, the real image is converted to a mathematical format (the pixel matrix) which can be processed by a personal computer.



The SVS2 sensor offers a maximum resolution of 640 × 480 pixel, which means that the personal computer will treat acquired images as matrices consisting of 640×480 elements (307200 values). Each element is identified by its location in the matrix, i.e. by specifying column and line and considering the first element in the top left corner as the origin (in the matrix shown above, this would be the pixel with brightness equal to 20).



16.2. ► Machine vision

This is a specific branch of Computer Vision (or "artificial vision").

Computer vision is a generic concept which applies to all processes aimed at extracting information from images. On the other hand, machine vision has a specific purpose, i.e. control the operation of equipment and machinery in industrial applications (such as manufacturing lines or goods handling applications).

In order to perform this task, machine vision equipment features stand-alone processing capabilities, digital inputs and outputs, and dedicated peripherals such as photocells and/or a communication network that allows communication with other similar devices.

In the SVS2 system, sensor vision serves the purpose of inspecting products in order to:

- detect missing or incomplete parts;
- read bar codes or datamatrix information;
- take measurements.

16.3. ► Lighting Conditions Setup

Lighting conditions are a critical aspect in all the machine vision tasks, thus they have to be carefully set and preserved during the whole inspection process.

The goal of this section is to briefly describe some important considerations about lighting conditions, easily suitable in many typical machine vision tasks.

- Keep lighting constant into the scene.

Lighting intensity has to be maintained constant as much as possible, avoiding variations due to ambient light, sunlight or other external light source. External light source may lead to a failure inspection. Suppressing the external light effects can prevent such failures. It is possible that the sensor internal illuminator is not effective enough and an external illuminator have to be used instead. An alternative solution can make use of panels or any physical barrier to mask the inspection area.

- Keep lighting consistent into the scene.

Make sure that the whole scene receives an uniform illumination to avoid very bright spots or shadows. Moreover, make sure that the target-objects are well contrasted in their features and well separated from the background.

- Place the light on the right position.

Adjust the best distance between the light source, the sensor and the target-object. Make sure that the light source has the proper brightness intensity to avoid the saturation of some area of the scene.

- Illumination with reflective surfaces

Experimental tests have demonstrated the inefficacy of the SVS internal illuminator whenever the target-objects have a reflective surface. The reflected light causes the saturation of some area of the scene. In these cases is recommended to use an external source of illumination.

16.4. ► Lighting Options

Ring light

A technique with many application possibilities. The illuminator is mounted directly on the sensor and illuminates any object in front of it. A ring light provides diffused lighting over a small area.

- Advantages: provides correct lighting also for small objects. Reduces shadows on images with protrusions. Centres the light on the image.
- Disadvantages: with large objects, the corners of the image may lose brightness, creating a halo of black pixels along the external image edge. With highly reflective objects, the image may contain a circular glare of reflected light.

Top light

This technique generates even light in a concentrated area. The illuminator is positioned behind the sensor and if oriented correctly can carry-out very precise inspections.

- Advantages: the light beam is outside the axis respect to sensor optics, allowing the highlight of specific target areas and not others.
- Disadvantages: difficulty in lighting evenly the entire object, especially in presence of protruding parts that create unwanted shadows.

Back light

The illuminator is positioned behind the target-object, aimed directly back towards the sensor, and the resulting silhouette can be inspected for dimension and shape control. The brightness is low. Typical applications include object sorting according to shape and dimensions, measurement of spacing between chip leads, inspection of object holes or cracks.

- Advantages: does not supply surface characteristics. Facilitates the diameter measurement of round objects. Shows presence or absence of holes.
- Disadvantages: illuminator positioning behind object may result difficult. Does not analyse object surfaces. The illumination area must be larger than then inspection area.

16.5. ► Blob / Blob analysis

A blob (blob stands for Binary Large Object) is a set of adjacent pixels having the same brightness.

Typically, they are searched and identified in binarized images (►), in an attempt to group all bright pixels and all dark pixels together into connected structures.

There are two key techniques to identify these structures and they focus on two different aspects:

Individual pixel: in this approach, once a (say) dark pixel is identified, all adjacent pixels are analysed recursively and the dark pixels are attached to the blob. This process is applied to each and every image pixel;

Line: the image is scanned line by line to identify dark and bright regions, which are appropriately attached to the previously identified blobs as scanning proceeds.

Obviously enough, the second approach is faster, because the image is only processed once!

To further improve performance, filters may be set for the minimum number of pixels a connected structure must have in order to be correctly recognised as a blob, as is the case (for instance) with groups of pixels due to noise.

Filters may also be set for the maximum number of pixels in a blob: this solves the problems associated with those clusters that touch on the perimeter of the inspection area.

Once the blobs have been identified, certain pieces of information may be obtained:

- area;
- bounding box (rectangle that encompasses the blob, useful for approximating the perimeter);
- moments (to define orientation);
- convex perimeter (provides a more accurate perimeter approximation than bounding box).

Undoubtedly, this analysis technique offers significant advantages, namely processing speed and the ability to accept variations in the orientation and size of the target image.

However, identification proves difficult in the case of:

- clusters having weak contrast to the background;
- stacked objects or objects touching each other;
- objects that closely resemble each other.

16.6. ► Binarization

This is a process that converts any given image to a two-level image (in our instance, black and white). Conversion is based on a threshold that classifies the individual pixels as "level 255" (or "white") or "level 0" (or "black") depending on whether they are above or below set threshold. Let us consider a shot of a dark object on a bright background. Binarization is expressed as follows:

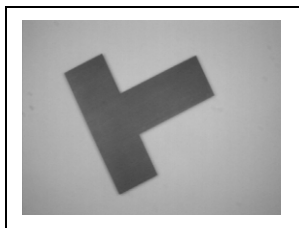
$$B(i, j) = \begin{cases} 0 & \text{if } I(i, j) < S \\ 255 & \text{if } I(i, j) > S \end{cases}$$

In other words, the pixel with coordinates (i,j) of the source image I will be coloured black in the binarized image B if its (brightness) value is found to be below the threshold S, or will be coloured white if its value is above the threshold.

The purpose of this operation is to highlight just the key features of the image to minimise the computational load associated with its analysis.

The critical issue in this process is how to select the threshold S.

Let us consider a histogram of a gray scale image (representing the number of pixels as a function of brightness value)



gray scale image

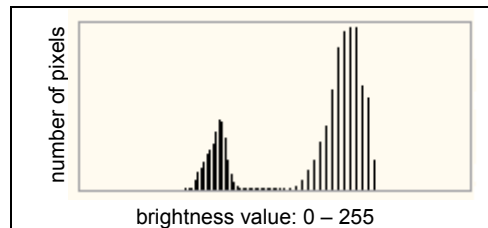


image histogram

As you can see, the brightness values of image pixels are clustered around two values ("bimodal" histogram): a low value that represents dark points (the object) and a high value that represents bright points (the background).

The most effective value is found mid-way between the two (128): this will turn out a binarized image where the object is neatly and accurately represented. With a lower threshold (90), part of the object would be treated as background; a higher threshold (175) would cause part of the background to be classified as object.

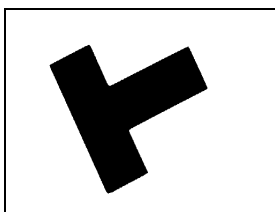


Image binarized with S = 128

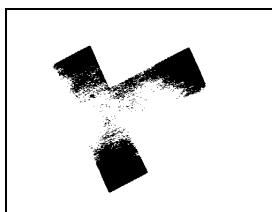


Image binarized with S = 90

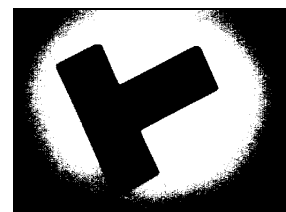


Image binarized with S = 175

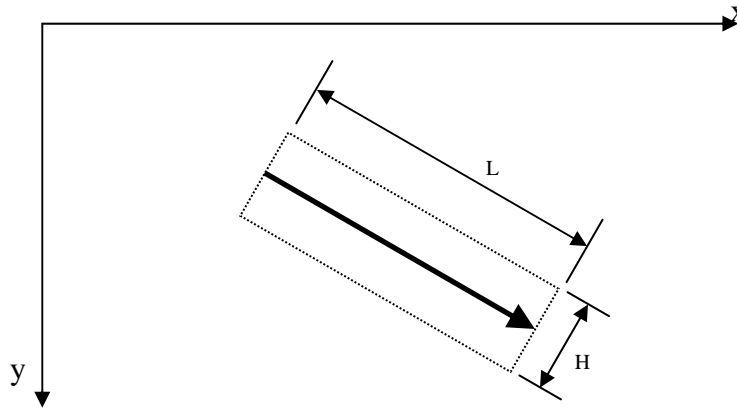
Obviously enough, an image where object and background are not clearly differentiated (similar brightness values) will turn out a histogram with all pixels clustered around one value, and setting the appropriate threshold will prove quite difficult.

16.7. ► Edge / Edge Detection

The term "edge" signifies the contour of the object shown in an image.

From an operational viewpoint, what happens is that the system detects the difference in the brightness of adjacent pixels compared to a certain threshold value.

In the SVS2 system, such variation is detected in one direction:



Let us consider the portion of image inside the rectangle that contains the plotted arrow (length L and height H): this area can be represented by a matrix of values that represent the brightness of the individual pixels

| | | | | | |
|---------------------------------|----|-----|-----|-----|-----|
| | 85 | 98 | 120 | 128 | 135 |
| | 81 | 88 | 102 | 118 | 129 |
| | 87 | 101 | 119 | 128 | 136 |
| total of column divided by 3 | 84 | 96 | 114 | 125 | 133 |

Each average value contains the information relating to a group of pixels and allows more accurate analysis.

At this point, edge identification may rely on threshold value or contrast.

Edge identification based on threshold

This is a simple, fast method that simply involves setting a numeric threshold. The edge is identified when the values associated with adjacent pixels encountered in the direction of the arrow are found to lie on different sides of the threshold (one above and the other below the threshold or vice versa, depending on whether target edges are negative or positive.)

The weakness of this method lies in the fact that effective edge identification requires guaranteed steady lighting.

Identification based on contrast

Edges are not detected directly based on pixel brightness, but rather using the first derivative of brightness trend.

This method is based on the search for maximum and minimum values of the function:

- a maximum value identifies a positive edge;
- a minimum value identifies a negative edge.

This way, detection is not dependant on brightness, because while a variation in brightness does somehow affect the image in terms of pixel brightness, the differences between pixels are virtually unchanged. This method is ideal for those application where steady lighting is not guaranteed.

On the other, it involves greater computational load and longer processing times.

16.8. ► Inspection times

Total inspection duration depends on three factors:

- exposure time (►);
- acquisition time;
- processing time

Exposure time: Time period during which the acquisition device is exposed to light. The longer the exposure time, the greater the quantity of light entering the device. The duration of this time period is determined by:

- speed of parts to be inspected: high speeds require shorter exposure times or images will be blurred;
- inspection pace: this is a constraint on exposure time, which is supposed to be short to allow a large number of objects to be inspected;
- available light: the better the lighting, the fewer the acquisition problems due to low exposure values.

Where reducing exposure time is a must, certain arrangements might help preserving the quality of acquired images:

- increasing the brightness of the inspection area;
- increasing CMOS gain, where gain (output/input ratio) means an increase in brightness, which, on the other hand, may worsen image quality;
- using variable-aperture lenses: the greater the cavity that lets light pass past the lenses, the lower the image depth (please note that focusing an object may prove difficult when object distance from the lenses is variable).

Acquisition time: Time taken by the sensor to capture an image. After the CMOS has been exposed to light/image during the exposure time, the image must be transferred to device memory. It takes about 30 ms to transfer a complete image. This time is significantly reduced if only a part of the total image is acquired.

Processing time: Time taken to process the acquired image. It depends on the operations and tools used for the inspection.

16.9. ► Contour match

In this analysis method, objects are recognized by comparing their contour. Binarized images are analysed to identify those among the so-called BIS (Binary Image Set) that are made up of black pixels only. The contour (which is not part of the BIS) is considered as a closed line along the border of the binary image.

The contour match process is capable of identifying both internal and external contours.

To achieve recognition, first create a database of master images supplemented with certain data (such as position, number of pixels, size) which will be used for the comparison.

During the inspection, the acquired image undergoes the same process and the results are compared to those stored in the database.

Match score is determined and expressed as the difference between sample value and detected target values: each element of the target image is matched to the closest database element.

The contour match method offers such benefits as an interesting processing speed and the ability to handle objects at different orientations.

While providing greater accuracy than blob analysis, the contour match method has the same drawback: less than ideal differentiation of object from the background, inability to recognise stacked objects or objects touching each other.

16.10. ► Pattern match

In the pattern match method, a sample object is recognised by searching for the matching brightness matrix in the target image.

The system stores a "pattern" of the master image and tries to find that pattern in all inspected target images. During the search process, the pattern is made to slide over the image while brightness differences are calculated pixel by pixel. An object is recognized when the total calculated difference is below a preset threshold.

16.11. ► Exposure

Exposure time determines how long the image acquisition device must remain exposed to light.

Image quality depends on this parameter, that is determined based on:

- Lens aperture;
- Exposure time.

The term Lens aperture denotes the ratio of lens length to lens width. A longer lens (where light travels a longer distance) will have a higher ratio and will provide less strength. Conversely, a shorter lens features a lower ratio (fast lens).

The term exposure time is also known as "shutter opening time" and is directly proportional to the quantity of light hitting the sensor: the greater the shutter opening time, the greater the quantity of light, hence the brighter the acquired image.

A fast lens allows for shorter shutter opening time.

This is because exposure is a combination of aperture and opening time. As these are inversely proportional, doubling aperture allows for halved opening time.

This determines *correct exposure*, which is the right quantity of light needed for details to be visible both in the dark and bright areas of the image.

Underexposure will result in crushed blacks, i.e. loss of detail.

Overexposure will produce blown-out areas (bright, pale and flat).

17. GLOSSARY

- Algorithm : set of instructions that accomplish a task in a finite number of steps;
- CMOS : Image acquisition device. It consists of a set of photo-sensitive elements (→ pixels) arranged in a matrix that are exposed to light through a glass window on chip surface;
- Cross cable : special network cable where the transmit wires and the receive wires are crossed.
- Focal length : Distance between the rear nodal point of lens (position at which light rays depart from the rear end of the lens) and the sensor;
- FOV : Stands for Field Of View, field of vision of the sensor;
- Gray scale : Scale of values associated with the brightness of an image's pixels. For an 8-bit image, possible values are 256 (0 – 255, where '0' denotes black and '255' denotes white);
- Hub : Node in a computer network that performs routing tasks;
- Inspection : Process through which sensor performs check and measures certain features of the target image and returns a result;
- Inspection area : shot area or part of the shot area that undergoes processing;
- Inspection result : Possible results are
 - "PASS", if the inspection (all controls/measurements) gave a positive outcome,
 - "FAIL", if the inspection (at least one control/measurement) gave a negative outcome, or if the inspection could not be completed because one control/measurement was found to be impossible to perform;
- IP address : Unique address that identifies any one network device. It operates much like a telephone number. Just as you need a person's phone number to call that person, you cannot communicate with the sensor unless you know its IP address. The IP address is made up of four numbers separated by dots. Example: 172.27.101.175.
- LAN : Short for "Local Area Network" or "local network", identifies a computer network confined in a small area (office or building) never farther apart than a few kilometres; it includes interconnections and shared peripherals;
- LED : Refers to Light Emitting Diode, a semiconductor device that produces photons from the recombination of electrons-electron holes;
- Locator : Device that focuses processing on a definite portion of the inspection area;
- Master image : see *Reference image*;
- Noise : Non-significant data that alter the source of information to be processed;
- Operating distance : Distance between the back of the lens and target object;
- Reference image : Stored image that provides a reference for processing;
- ROI : Refers to Rectangle (or Region) of Interest; area of acquired image that undergoes control/measurement;
- Status : Result of the inspection referred to individual control/measurement (status may be "PASS" or "FAIL");
- Target image : Image captured by sensor, subject to processing/inspection;
- Task : Operation. Refers to each individual action that - as part of a set of operations - leads to the solution of a problem.