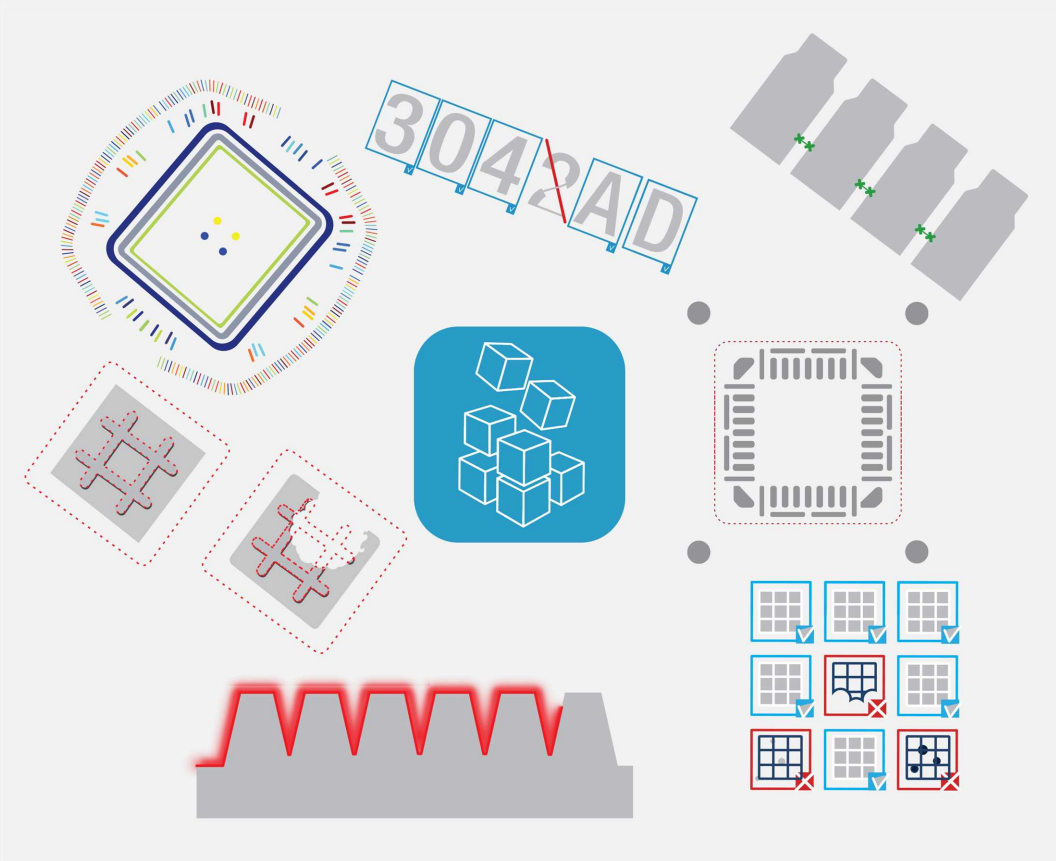


# Open eVision

## Matching and Measurement Tools



This documentation is provided with **Open eVision 24.02.0** (doc build **1198**).  
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# 1. Dealing with Pixel Containers and Files

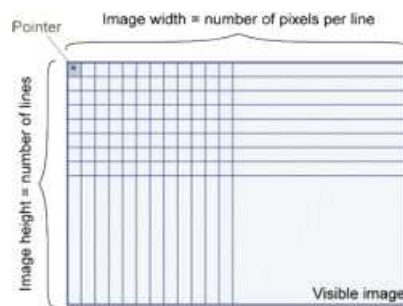
## 1.1. Pixel Container Definition

### Image objects

---

The **Open eVision** image objects contain image data that represents rectangular images.

Each image object has a data buffer, accessible via a pointer, where pixel values are stored contiguously, row by row.



### Image main parameters

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The rectangular array of pixels of an **Open eVision** image object is characterized by the **EBaseROI** parameters:

- The **Width** is the number of pixels per row of the image.
- The **Height** is the number of rows of the image.
- The **Size** contains both the **Width** and the **Height** of the image.

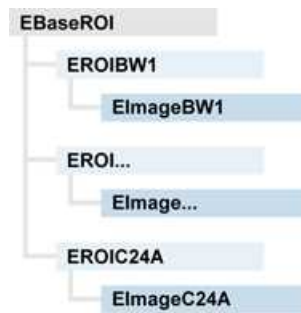
The maximum size for the width and the height is:

- 32,767 ( $2^{15}-1$ ) in **Open eVision** 32-bit
- 2,147,483,647 ( $2^{31}-1$ ) in **Open eVision** 64-bit
- The **Plane** contains the number of color components.
  - For gray-level images: **Plane** = 1
  - For color images: **Plane** = 3

## Classes

---

The image and ROI classes derive from the abstract class `EBaseROI` and inherit all its properties.



## Depth maps

---

A *depth map* represents a 3D object using a 2D grayscale image in which each pixel represents a 3D point.

- The pixel coordinates are the X and Y coordinates of the point.
- The gray value of the pixel is a representation of the Z coordinate of the point.

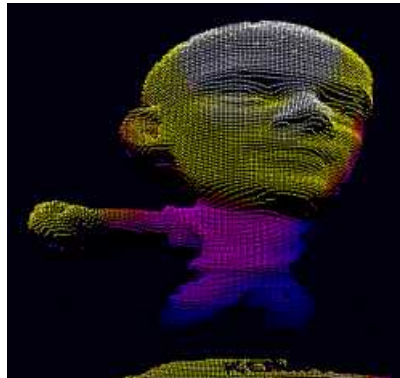


## Point clouds

A *point cloud* is an unstructured set of 3D points representing discrete positions on the surface of an object.

The point clouds are produced by various 3D scanning techniques, such as laser triangulation, time of flight or structured lighting.

 For details, see, for example, [en.wikipedia.org/wiki/Point\\_cloud](https://en.wikipedia.org/wiki/Point_cloud).



## 1.2. Pixel Container Types

 For the enumeration of the available types, see "[EImageType Enum](#)" on page 1.

### Images

Open eVision supports the following image types according to their pixel types.

Open eVision	Genicam PNFC	Definition	Class
<b>BW1</b>	Mono1	1-bit black and white image (8 pixels are stored in 1 byte).	<a href="#">EImageBW1</a>
<b>BW8</b>	Mono8	8-bit grayscale image (each pixel is stored in 1 byte).	<a href="#">EImageBW8</a>
<b>BW16</b>	Mono16	16-bit grayscale image (each pixel is stored in 2 bytes).	<a href="#">EImageBW16</a>
<b>BW32</b>	Mono32	32-bit grayscale image (each pixel is stored in 4 bytes).	<a href="#">EImageBW32</a>
<b>C15</b>	RGB5	15-bit color image (each pixel is stored in 2 bytes). Compatible with Microsoft® Windows RGB15 color images.	<a href="#">EImageC15</a>
<b>C16</b>	RGB565	16-bit color image (each pixel is stored in 2 bytes). Compatible with Microsoft® Windows RGB16 color images.	<a href="#">EImageC16</a>
<b>C24</b>	RGB8	24-bit color image (each pixel is stored in 3 bytes). Compatible with Microsoft® Windows RGB24 color images.	<a href="#">EImageC24</a>
<b>C24A</b>	BGRa8	32-bit color image (each pixel is stored in 4 bytes). Compatible with Microsoft® Windows RGB32 color images.	<a href="#">EImageC24A</a>



#### TIP

[Easy.GetBestMatchingImageType](#) returns the best matching image type for a given file on disk.



## Depth Maps

Open eVision	Genicam PNFC	Definition	Class
EDepth8	Coord3D_C8	8-bit depth map (each pixel is stored in 1 byte as an integer)	EDepthMap8
EDepth16	Coord3D_C16	16-bit depth map (each pixel is stored in 2 bytes as a fixed point)	EDepthMap16
EDepth32f	Coord3D_C32	32-bit depth map (each pixel is stored in 4 bytes as a float)	EDepthMap32f



### TIP

8 and 16-bit depth map values are stored in buffers compatible with the 2D Open eVision images.

## Point Clouds

Open eVision	Genicam PNFC	Definition	Class
Point Cloud	Coord3D_ABC32	Set of points coordinates (each coordinate is stored in 4 bytes as a float)	EPointCloud

# 1.3. Supported Image File Types

 For the enumeration of the available types, see "[EImageFileType Enum](#)" on page 1.

Type	Description
<b>BMP</b>	Uncompressed image data format (Windows Bitmap Format).
<b>JPEG</b>	A lossy data compression standard issued by the <b>Joint Photographic Expert Group</b> registered as ISO/IEC 10918-1. The compression irretrievably loses quality.
<b>JFIF</b>	JPEG File Interchange Format.
<b>JPEG-2000</b>	A data compression standard issued by the <b>Joint Photographic Expert Group</b> registered as ISO/IEC 15444-1 and ISO/IEC 15444-2. <b>Open eVision</b> supports only lossy compression format, file format and code stream variants. - The <i>code stream</i> describes the image samples. - The <i>file format</i> includes meta-information such as the image resolution and color space.
<b>PNG</b>	Lossless data compression method (Portable Network Graphics).
<b>Serialized</b>	The <b>Euresys</b> proprietary image file format obtained from the <b>serialization</b> of <b>Open eVision</b> image objects.
<b>TIFF</b>	The <b>Tag Image File Format</b> is currently controlled by <b>Adobe Systems</b> and uses the LibTIFF third-party library to process images written for the 5.0 or 6.0 TIFF specification. - The file <i>save</i> operations are lossless and save the images without any compression. - The file <i>load</i> operations support all the TIFF variants listed in the LibTIFF specification.

## 1.4. Pixel and File Types Compatibility

For the compatible combinations in the following table, the image integrity is preserved with no data loss (except from JPEG and JPEG2000 with lossy compression).

The other combinations are not supported and an exception occurs if you use them.

Type	BMP	JPEG	JPEG2000	PNG	TIFF	Serialized
BW1	✓	–	–	✓	✓	✓
BW8	✓	✓	✓	✓	✓	✓
BW16	–	–	✓	✓	✓ <sup>2</sup>	✓
BW32	–	–	–	–	✓ <sup>2</sup>	✓
C15	✓	✓ <sup>1</sup>	✓ <sup>1</sup>	✓ <sup>1</sup>	✓ <sup>1</sup>	✓
C16	✓	✓ <sup>1</sup>	✓ <sup>1</sup>	✓ <sup>1</sup>	✓ <sup>1</sup>	✓
C24	✓	✓	✓	✓	✓ <sup>1</sup>	✓
C24A	✓	–	–	✓	–	✓
Depth8	✓	✓	✓	✓	✓	✓
Depth16	–	–	✓	✓	✓ <sup>2</sup>	✓
Depth32f	–	–	–	–	–	✓

- ✓<sup>1</sup>: C15 and C16 formats are automatically converted into C24 during the save operation.
- ✓<sup>2</sup>: BW16 and BW32 are not supported by Baseline TIFF readers.

## 1.5. Color Types

Open eVision supports the following color systems:

EISH	Intensity, Saturation, Hue
ELAB	CIE Lightness, a*, b*
ELCH	Lightness, Chroma, Hue
ELSH	Lightness, Saturation, Hue
ELUV	CIE Lightness, u*, v*
ERGB	NTSC/PAL/SMPTE Red, Green, Blue
EVSH	Value, Saturation, Hue
EXYZ	CIE XYZ
EYIQ	CCIR Luma, Inphase, Quadrature
EYSH	CCIR Luma, Saturation, Hue
EYUV	CCIR Luma, U Chroma, V Chroma

## 2. Conventions

### 2.1. Conventions for Strings

Since **Open eVision** 23.08, the only character encoding used in the **Open eVision** libraries and tools is UTF-8.

- All methods taking `std.string` as argument expect an UTF-8 encoded `std.string`.
- All methods returning a `std.string` always return it as UTF-8 encoded.

#### [Backward compatibility on Windows](#)

On **Windows** (but not on **Linux**), there is also a sanitization process to preserve backward compatibility with older releases that didn't use the UTF-8 encoding.

- The content of each input string is checked to ensure it is UTF-8 encoded.  
If it is not the case:
  - The string is assumed to be encoded using the current Windows Language for Non-Unicode Programs parameter.
  - It is converted to UTF-8.
- The output strings of all libraries and tools are always UTF-8.



#### TIP

Despite the presence of this backward compatibility layer it is recommended to use exclusively UTF-8 to interact with **Open eVision** on all platforms to ensure the best performance and compatibility.

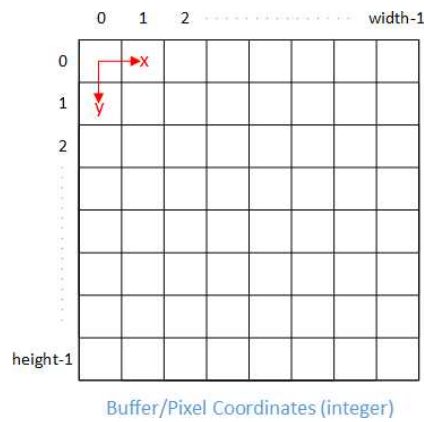
### 2.2. Image Coordinate Systems

The conventions below apply to all **Open eVision** functions and results.

- Pixel coordinates are usually given as integer numbers.
- Some results can use subpixel precision with real (floating point) numbers.
- Some exceptions apply and are documented per library.

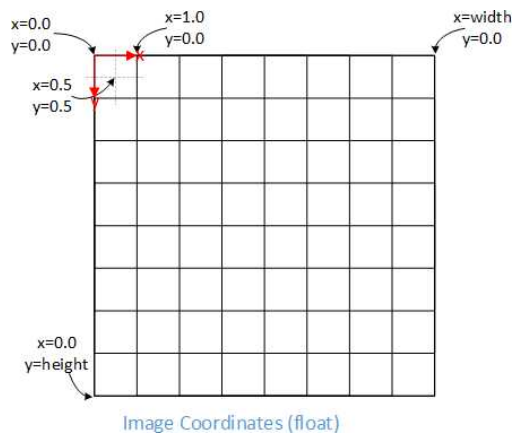
## Integer coordinates

- The origin (0,0) of the coordinate system is the upper left pixel of the image.
- The lower right pixel is (width-1, height-1).



## Real coordinates

- With floating point (x,y) coordinates, the origin is the upper left corner of the upper left pixel.
- The first pixel area ranges in [0,1[ for X and Y axis.
- Coordinates greater or equal than the width or the height are outside the image.

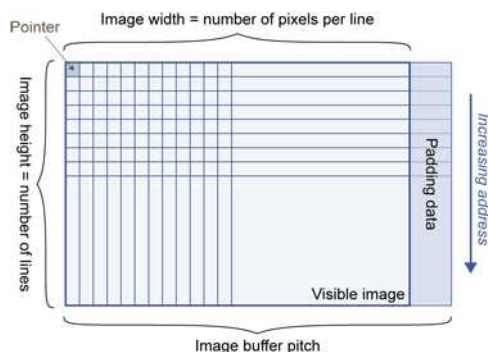


## 2.3. Image and Depth Map Buffer

The pixels of an image and of a depth map are stored contiguously into a buffer, from left to right and from top to bottom, in the Windows bitmap format (top-down DIB -device-independent bitmap-).

The buffer address is a pointer to the address that contains the top left pixel of the image.

- Image buffer pitch
  - The alignment must be a multiple of 4 bytes.
  - The default pitch in **Open eVision** is 32 bytes for performance reasons.



### Memory layout

Image format	Layout	Illustration
EImageBW1	Stores 8 pixels in 1 byte	
EImageBW8 EDepthMap8	Store 1 pixel in 1 byte	
EImageBW16	Stores 1 pixel in 2 bytes	
EImageC15	Stores 1 pixel in 2 bytes - Each color component is coded with 5 bits - The 16th bit is unused	

Image format	Layout	Illustration
<p>EImageC16</p>	<p>Stores 1 pixel in 2 bytes</p> <ul style="list-style-type: none"> <li>- The colors 1 and 3 are coded with 5 bits</li> <li>- The color 2 is coded with 6 bits</li> </ul>	
<p>EDepthMap16</p>	<p>Stores 1 pixel in 2 bytes (fixed point format)</p>	
<p>EImageC24</p>	<p>Stores 1 pixel in 3 bytes</p> <ul style="list-style-type: none"> <li>- Each color component is coded with 8 bits</li> </ul>	
<p>EImageC24A</p>	<p>Stores 1 pixel in 4 bytes.</p> <ul style="list-style-type: none"> <li>- Each color component is coded with 8 bits</li> <li>- The alpha channel is coded with 8 bits</li> </ul>	
<p>EDepthMap32f</p>	<p>Stores 1 pixel in 4 bytes (float format)</p>	

## 3. Basic Operations

### 3.1. Memory Allocation

You can construct an image using an internal or an external memory allocation.

#### Internal memory allocation

The image object dynamically allocates and deallocates a buffer:

- The memory management is transparent.
- When the image size changes, a reallocation occurs.
- When an image object is destroyed, the buffer is deallocated.

To declare an image with an internal memory allocation:

1. Construct an image object, for instance `EImageBW8`, either with width and height arguments or using the `SetSize` function.
2. Access a given pixel using one of the multiple available functions.  
For example, use `GetImagePtr` to retrieve a pointer to the first byte of the pixel at the given coordinates.

#### External memory allocation

Control the buffer allocation or link a third-party image in the memory buffer to an **Open eVision** image.

- You must specify the image size and the buffer address.
- When an image object is destroyed, the buffer is unaffected.

 For details, see "Image and Depth Map Buffer" on page 13 and "Interfacing Third-Party Images" on page 185.

To declare an image with an external memory allocation:

1. Declare an image object, for instance `EImageBW8`.
2. Create a suitably sized and aligned buffer.
3. Assign the buffer to the image with `SetImagePtr`.

**NOTE**

Using the copy constructor of the `EImage` object to copy the externally allocated image does not copy the buffer. The copied image points to the same external buffer as the original image.

**NOTE**

If your buffer rows are not aligned on 4 bytes, use `InitializeFromUnalignedBuffer` instead of `SetImagePtr`. Please note that this allocates the memory internally and copies the external buffer into the internal one instead of using the external one.

## 3.2. Loading a Pixel Container File

### Loading images and depth maps

---

- Use the method `Load` to load image data into an image object.
  - It has only the argument path that includes the path, filename and file name extension.
  - The file type is determined by the file format.
  - The destination image is automatically resized according to the size of the image on disk.
- `Load` throws an exception when:
  - The file type identification fails.
  - The file type is incompatible with the pixel type of the image object.

**NOTE:** When loading a BW16 image (with integer values) in a depth map, the fixed point precision set in the depth map (0 by default) is left unchanged and used.

### Loading point clouds

---

Use the following methods to load a point cloud saved in a specific format:

- `EPointCloud.Load`: **Open eVision** proprietary file format.
- `EPointCloud.LoadCSV`: CSV file.
- `EPointCloud.LoadOBJ`: OBJ file.
- `EPointCloud.LoadPCD`: PCD file (supported in ASCII and binary modes).
- `EPointCloud.LoadPLY`: PLY file (supported only in ASCII mode).
- `EPointCloud.LoadXYZ`: XYZ file.



## 3.3. Saving a Pixel Container File

### Images and depth maps

- Use the method `Save` of an image or the method `SaveImage` of a depth map or a ZMap to save image data of the object into a file.
  - The argument `Path` includes the path, file name and file name extension.
  - The argument `Image File Type` can be omitted. In this case, the file name extension is used.
- `Save` throws an exception when:
  - The requested image file format is incompatible with the pixel type of the image object.
  - The file name extension is not supported while using the Auto file type selection method.

**NOTE:** When saving a 16-bit depth map, the fixed point precision is lost and the pixels are considered as 16-bit integers.



#### TIP

The images with a width or a height larger than 65,536 must be saved in **Open eVision** proprietary format.

### Image File Type arguments

Argument	Image file type
<code>EImageFileType_Auto</code>	(Default) Automatically determined by the file name extension. See below.
<code>EImageFileType_Euresys</code>	<b>Open eVision</b> Serialization
<code>EImageFileType_Bmp</code>	Windows bitmap - BMP
<code>EImageFileType_Jpeg</code>	JPEG File Interchange Format - JFIF
<code>EImageFileType_Jpeg2000</code>	JPEG 2000 File format / Code Stream - JPEG2000
<code>EImageFileType_Png</code>	Portable Network Graphics - PNG
<code>EImageFileType_Tiff</code>	Tagged Image File Format - TIFF

If the argument is `EImageFileType_Auto` or is missing, the assigned image file type is:

File name extension (case-insensitive)	Assigned image file type
BMP	Windows Bitmap format
JPEG or JPG	JPEG File Interchange Format - JFIF
JP2	JPEG 2000 file format
J2K or J2C	JPEG 2000 Code Stream
PNG	Portable Network Graphics
TIFF or TIF	Tagged Image File Format

## Saving JPEG and JPEG2000 lossy compressions

`SaveJpeg` and `SaveJpeg2K` specify the compression quality when `saving` compressed images. They have two arguments:

- Path: a string of characters including the path, filename, and file name extension.
- Compression quality of the image file, an integer value in range [0: 100].  
`SaveJpeg` saves image data using JPEG File Interchange Format – JFIF.  
`SaveJpeg2K` saves image data using JPEG 2000 File format.

### JPEG compression values

JPEG compression	Description
JPEG_DEFAULT_QUALITY (-1)	Default quality (*)
100	Superb image quality, lowest compression factor
75	Good image quality (*)
50	Normal image quality
25	Average image quality
10	Bad Image quality

(\*) The default quality corresponds to the good image quality (75).

### Representative JPEG 2000 compression quality values

JPEG 2000 compression	Description
-1	Default quality (*)
1	Highest image quality, lowest compression factor
16	Good Image Quality (*) (16:1 rate)
512	Lowest image quality, highest compression factor

(\*) The default quality corresponds to the good image quality (16:1 rate).

## Saving point clouds

Use the following methods to save a point cloud in a specific format:

- `EPointCloud::Save`: **Open eVision** proprietary file format.
- `EPointCloud::SaveCSV`: CSV file.
- `EPointCloud::SaveOBJ`: OBJ file.
- `EPointCloud::SavePCD`: PCD file.
- `EPointCloud::SavePLY`: PLY file.
- `EPointCloud::SaveXYZ`: XYZ file.



#### TIP

The PCD format is supported in ASCII and binary modes.

## 3.4. Drawing in Open eVision

### Introduction

---

- Whenever relevant, the **Open eVision** tools provide methods `Draw` to render their contents and/or configuration. This is, for instance, the contents of an `EImage` or the frame of an `EROI`.
- A given tool can have multiple methods `Draw`, usually one for each feature available.
- The **Open eVision** methods `Draw` take an object `DrawAdapter` as their main parameter, and additional parameters for zoom and pan:

```
Tool::Draw(EDrawAdapter* adapter, float zoomX, float zoomY, float panX, float panY);
```

- `zoomX` and `zoomY` are expressed in percentage, 1 is the default value and means no zoom.
- It can be different in the horizontal and vertical directions (which can be useful in the case of non-square pixels for instance).
- If you don't provide a vertical zoom, or set it to 0, it will be set identical to the horizontal one.
- `panX` and `panY` are expressed in pixels, but in image coordinates. It means that the value you pass to `panX` and `panY` are multiplied by the corresponding zoom before being applied.

Example: How to draw an image and a ROI frame on a window under Windows:

```
EImageBW8 image;
EROIBW8 roi;
EWindowsDrawAdapter adapter(windowHdc);
image.Draw(adapter);
roi.DrawFrame(adapter);
```

### Graphical interactions

---

- You can configure some of the **Open eVision** tools graphically and use the provided methods to put your configuration in place.
- Graphical Interaction-enabled tools provide special parameters to some of their methods `Draw` to draw handles on the tool representation.
- To capture the user interactions with those handles, these tools also provide two specialized methods:
  - `HitTest` detects if a handle is under the mouse when providing it with the current cursor coordinates. You typically use this test during a mouse button down event.
  - `Drag` moves the detected handle to the given coordinates. This in turn modifies the tool configuration to match the new handle position. `Drag` is typically associated with the mouse button up event.

**NOTE:** `HitTest` and `Drag` use the same zoom and pan parameters as `Draw`. You must set them the same way (with the same values) to achieve the desired result.

### Draw adapters

---

- The draw adapters are objects that, in addition to representing the context in which to draw, provide methods to draw the selected primitives in that context.
- They are initialized by providing the targeted context to the constructor.

- Some of the drawing methods provided by the draw adapters are (but are not limited to):
  - `EDrawAdapter::Line` / `Lines` draws one or more lines on the context
  - `EDrawAdapter::Rectangle` / `FilledRectangle` draws a rectangle, filled or not, on the context
  - `EDrawAdapter::Ellipse` / `FilledEllipse` draws an ellipse, filled or not, in the context
  - `EDrawAdapter::Text` / `BackedText` renders a text in the context, with or without background
  - `EDrawAdapter::Image` renders an image in the context
- For more information about the drawing primitives provided by the draw adapters, please refer to the reference documentation.
- To set the color of the primitives, provide a pen and/or a brush and use the methods `EDrawAdapter::SetPen` and `EDrawAdapter::SetBrush`.
  - If you do not provide a pen and/or a brush, the default colors are used.
- To set the font of the text, provide a font with the method `EDrawAdapter::SetFont`.

## Standard draw adapters

---

**Open eVision** provides a set of off-the-shelf draw adapters that you can use in different situations:

- `EWindowsDrawAdapter` allows to draw on **Windows** systems. To draw on a window, provide the window's HDC to its constructor, or, to draw in an EImage buffer, provide that EImage.
  - It relies on GDI and GDI+ to provide its services.
  - This is the preferred way to draw on **Windows**.
- `QtDrawAdapter` allows you to draw using **Qt** on a QPainter context. To draw on a QPainter context, provide the QPainter to the constructor, or, to draw on an EImage buffer, provide that EImage.
  - You can use the `QtDrawAdapter` both on **Windows** and **Linux**.
  - This is the preferred way to draw on **Linux**.

**NOTE:** `QtDrawAdapter` is using an external resource (namely **Qt**) and as such is provided as source code in its own header rather than in the global **Open eVision** header. For more information about external and custom draw adapters, see below.
- `EGenericDrawAdapter` is a draw adapter that can only render on an EImage, but it can do it in a consistent manner on all supported OSes.
  - It is available on both **Windows** and **Linux**.

## Drawing in an EImage

---

- As said above, you can draw in an EImage (usually an `EImageBW8` or `EImageC24`) by initializing a draw adapter with that image and using either the **Open eVision** methods `Draw` or the draw adapter drawing primitives:

```
EImageBW8 image;
EMatrixCode code;
EWindowsDrawAdapter adapter(image);
code.DrawPosition(adapter);
```

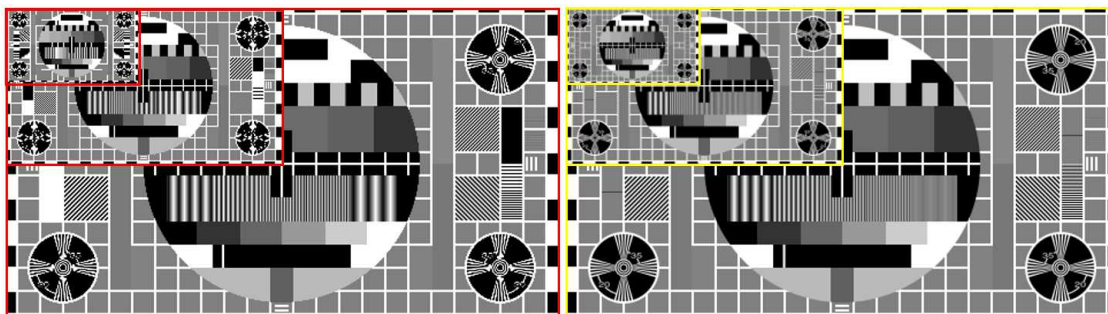
## Custom draw adapters

- If you require a draw adapter to render in a specific, unsupported type of context (for ex. a DirectDraw surface, an OpenGL context...), you can build your own draw adapter by deriving from the interface `EExternalDrawAdapter` provided by **Open eVision** and implementing all the required methods.
- Once this work is done, you will be able to use your new, custom draw adapter in the same way as the off-the-shelf ones, taking advantage of **Open eVision** methods `Draw`.
- The provided `QtDrawAdapter` is a draw adapter built using that mechanism, you can use it as a reference on how to build a custom draw adapter. The sources of the `QtDrawAdapter` are bundled with the Qt Samples.

## Enhanced Image Display

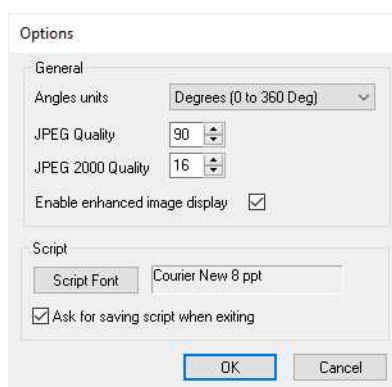
When the enhanced image display mode is enabled, a high-quality interpolation method is used to display the resized images.

- Set `Easy::SetEnableEnhancedImageDisplay(bool)` to `TRUE`, to enable the enhanced image display.
- By default, this option is disabled.
- Enhanced image display has a significant impact on display speed, the drawing can be 4x to 10x slower.
- The drawing of images with `EBW8Vector` or `EC24Vector` used as Look Up Table doesn't support enhanced image display



EnhancedImageDisplay disabled (left) and enabled (right)

- **Open eVision Studio** exposes this option in `View > Option` dialog:



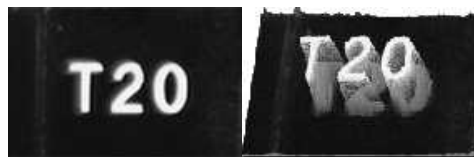
## 3.5. 3D Rendering of 2D Images

These images are viewed by rotating them around the X-axis, then the Y-axis.

### Gray 3D rendering

---

**Easy: :Render3D** prepares a 3-dimensional rendering where gray-level values are altitudes. Magnification factors in the three directions ( $X$  = width,  $Y$  = height and  $Z$  = depth) can be given. The rendered image appears as independent dots whose size can be adjusted to make the surface more or less opaque.



3D rendering

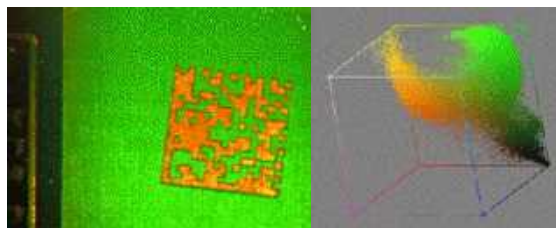
### Color histogram 3D rendering

---

**Easy: :RenderColorHistogram** prepares a 3-dimensional rendering of a color image histogram. The pixels are drawn in the RGB space (not XY-plane) to show clustering and dispersion of RGB values.

This function can process pixels in other color systems (using EasyColor to convert), but the raw RGB image is required to display the pixels in their usual colors.

Magnification factors in all three directions ( $X$  = red,  $Y$  = green and  $Z$  = blue) can be given.

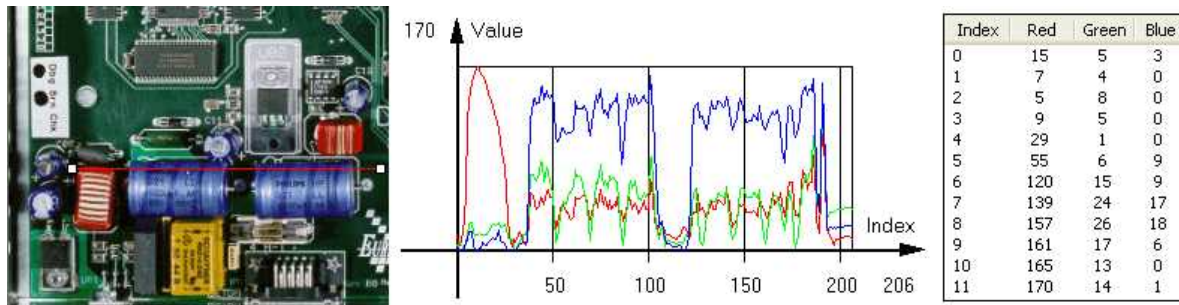


Color histogram rendering

## 3.6. Vector Types and Main Properties

A vector is a one-dimensional array of pixels (taken from an image [profile](#) or contour).

[EVector](#) is the base class for all vectors. It contains all non-type-specific methods, mainly for counting elements and serialization.



Profile in a C24 image, RGB values plot along profile and RGB values array ([EC24Vector](#))

A vector manages an array of elements. Memory allocation is transparent, so vectors can be resized dynamically. Whenever a function uses a vector, the vector type, size and structure are automatically adjusted to suit the function needs.

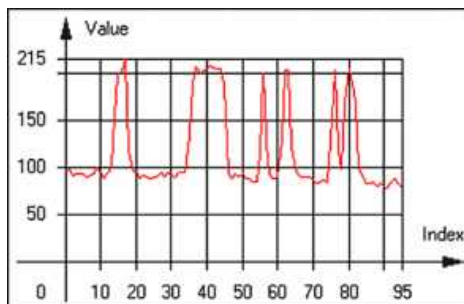
The use of vectors is quite straightforward:

- To create a vector of the appropriate type:
  - Use its constructor and preallocate elements if required.
- To fill a vector with values:
  - Call the [EVector::Empty](#) member to empty it.
  - Call the [EC24Vector::AddElement](#) member to add elements one by one.
  - Use the indexing to access any element.
- To access a vector element, either for reading or writing:
  - Use the brackets operator [EC24Vector::operator\[\]](#).
- To determine the current number of elements:
  - Use the [EVector::NumElements](#) member.
- To draw the vector:
  - A pixel vector is a plot of the element values as a function of the element index, so its graphical appearance depends on its type. You can draw a vector in a window. For legibility, the drawing should appear on a neutral background.
  - Drawing is done in the device context associated to the desired window. By default, curves are drawn in blue and annotations in black. You can define: `graphicContext`, `width`, `height`, `originX`, `originY`, `color0`, `color1` and `color2`.
  - The [EC24Vector](#) has three curves drawn instead of one, each corresponding to a color component. By default the red, blue and green pens are used.



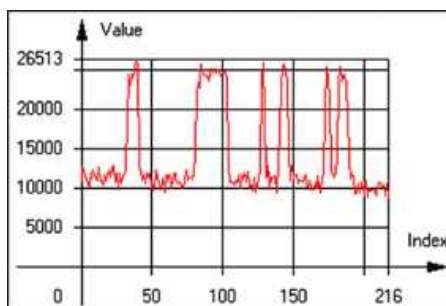
## Vector types

- **EBW8Vector**: a sequence of gray-level pixel values, often extracted from an image profile (used by `EasyImage::Lut`, `EasyImage::SetupEqualize`, `EasyImage::ImageToLineSegment`, `EasyImage::LineSegmentToImage`, `EasyImage::ProfileDerivative...`).



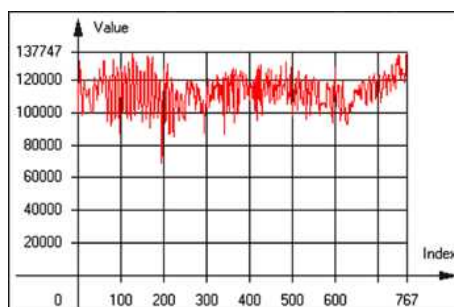
Graphical representation of an **EBW8Vector** (see `Draw` method)

- **EBW16Vector**: a sequence of gray-level pixel values, using an extended range (16 bits), mainly for intermediate computations.



Graphical representation of an **EBW16Vector**

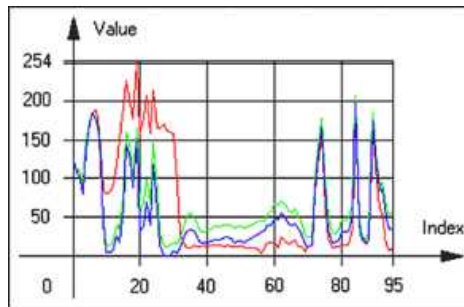
- **EBW32Vector**: a sequence of gray-level pixel values, using an extended range (32 bits), mainly for intermediate computations (used in `EasyImage::ProjectOnARow`, `EasyImage::ProjectOnAColumn`, ...).



Graphical representation of an **EBW32Vector**

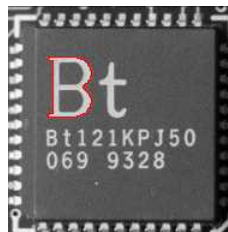


- **EC24Vector**: a sequence of color pixel values, often extracted from an image profile (used by `EasyImage::ImageToLineSegment`, `EasyImage::LineSegmentToImage`, `EasyImage::ProfileDerivative`, ...).



Graphical representation of an **EC24Vector**

- **EBW8PathVector**: a sequence of gray-level pixel values, extracted from an image profile or contour, with corresponding pixel coordinates (used by `EasyImage::ImageToPath`, `EasyImage::PathToImage`, ...).



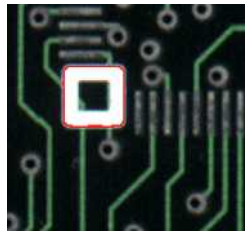
Graphical representation of an **EBW8PathVector** (see `Draw` method)

- **EBW16PathVector**: a sequence of gray-level pixel values, extracted from an image profile or contour, with corresponding pixel coordinates (used by `EasyImage::ImageToPath`, `EasyImage::PathToImage`, ...).



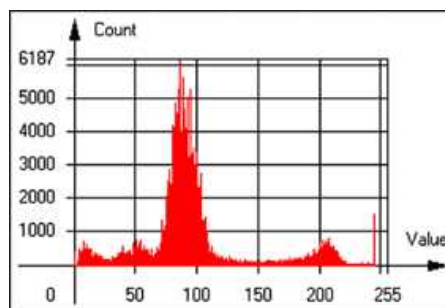
Graphical representation of an **EBW16PathVector** (see `Draw` method)

- **EC24PathVector**: a sequence of color pixel values, extracted from an image profile or contour, with corresponding pixel coordinates (used by `EasyImage::ImageToPath`, `EasyImage::PathToImage`, ...).



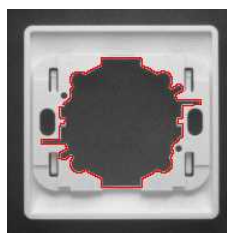
Graphical representation of an `EC24PathVector` (see `Draw` method)

- **EBWHistogramVector**: a sequence of frequency counts of pixels in a BW8 or BW16 image (used by `EasyImage::IsodataThreshold`, `EasyImage::Histogram`, `EasyImage::AnalyseHistogram`, `EasyImage::SetupEqualize`, ...).



Graphical representation of an `EBWHistogramVector` (see `Draw` method)

- **EPathVector**: a sequence of pixel coordinates. The corresponding pixels need not be contiguous (used by `EasyImage::PathToImage` and `EasyImage::Contour`).



Graphical representation of an `EPathVector` (see `Draw` method)

- **EPeakVector**: peaks found in an image profile (used by `EasyImage::GetProfilePeaks`).
- **EColorVector**: a description of colors (used by `EasyColor::ClassAverages` and `EasyColor::ClassVariances`).

## 3.7. ROI Main Properties

ROIs are defined by a [width](#), a [height](#), and **origin x and y coordinates**.

The origins are specified with respect to the top left corner in the parent image or ROI.

The ROI must be wholly contained in its parent image.

The processing/analysis time of a BW1 ROI is faster if [OrgX](#) and [Width](#) are multiples of 8.

### Save and load

---

You can [save](#) or [load](#) an ROI as a separate image, to be used as if it was a full image. The ROIs perform **no memory allocation** at all and never duplicate parts of their parent image, the parent image provides them with access to its image data.

The image size of the new file must match the size of the ROI being loaded into it. The image around the ROI remains unchanged.

### ROI Classes

---

An Open eVision ROI inherits parameters from the abstract class [EBaseROI](#).

There are several ROI types, according to their pixel type. They have the same characteristics as the corresponding [image types](#).

- [EROIBW1](#)
- [EROIBW8](#)
- [EROIBW16](#)
- [EROIBW32](#)
- [EROIC15](#)
- [EROIC16](#)
- [EROIC24](#)
- [EROIC24A](#)

### Attachment

---

An ROI must be [attached](#) to a parent (image/ROI) with parameters that set the parent, position and size, and these links are updated transparently, avoiding dangling pointers.

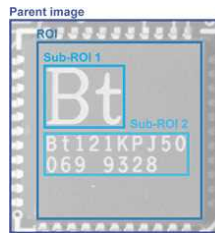
A normal image cannot be attached to another image or ROI.

### Nesting

---

Set and Get functions change or query the width, height and position of the origin of an ROI, with respect to its immediate or topmost parent image.

An image may accommodate an arbitrary number of ROIs, which can be nested in a hierarchical way. Moving the ROI also moves the embedded ROIs accordingly. The image/ROI classes provide several methods to traverse the hierarchy of ROIs associated with an image.



Nested ROIs: Two sub-ROIs attached to an ROI, itself attached to the parent image

## Cropping

`CropToImage` crops an ROI which is partially out of its image. The resized ROI never grows. An exception is thrown if a function attempts to use an ROI that has limits that extend outside of the parents.



### NOTE

*(In Open eVision 1.0.1 and earlier, an ROI was silently resized or repositioned when placed out of its image and sometimes grew. If ROI limits extended outside parents, they were silently resized to remain within parent limits.)*

## Resizing and moving

ROIs can easily be resized and positioned by two functions and dragging handles:

- `EBaseROI.Drag` adjusts the ROI coordinates while the cursor moves.
- `EBaseROI.HitTest` informs if the cursor is placed over a dragging handle.
  - Once the handle is known, the cursor shape can be changed by an `OnSetCursor` MFC event handler. `HitTest` is unpredictable if called while dragging is in progress.
  - `HitTest` can be used in an `OnSetCursor` MFC event handler to change the cursor shape, or before a dragging operation like `OnLButtonDown`, (or `EvSetCursor` and `EvLButtonDown` in Borland/CodeGear's OWL) (or `FormMouseMove` and `FormMouseDown` in Borland/CodeGear's VCL).

## 3.8. Arbitrarily Shaped ROI (ERegion)

**See also:** [example: Inspecting Pads Using Regions](#) / [code snippets: ERegion](#)

### Regions or arbitrarily shaped ROI

---

You define and use regions of interest (ROI) to restrict the area processed with your vision tool and to reduce and optimize the processing time.

In **Open eVision**:

- An **ROI** (`EROIxxx` class) designates a rectangular region of interest.
- A **region** (`ERegion` class) designates an arbitrarily shaped ROI. With regions, you can determine precisely which part of the image, down to a single pixel, is used for your processing.

Currently, only the following **Open eVision** methods support [ERegions](#):

Library	Method
EasyImage	EasyImage::Threshold

Library	Method
	EasyImage::AutoThreshold

Library	Method
	EasyImage: :Copy



Library	Method
	EasyImage::ConvolKernel

Library	Method
	EasyImage::ConvolSymmetricKernel

Library	Method
	EasyImage: :ConvolveLowpass1

Library	Method
	EasyImage: :ConvolveLowpass2

Library	Method
	EasyImage: :ConvolveLowpass3

Library	Method
	EasyImage::ConvolUniform

Library	Method
	EasyImage::ConvolGaussian

Library	Method
	EasyImage: :ConvolHighpass1



Library	Method
	EasyImage: :ConvolHighpass2

Library	Method
	EasyImage::ConvolGradientX

Library	Method
	EasyImage::ConvolGradientY

Library	Method
	EasyImage::ConvolGradient
	EasyImage::ConvolSobelX
	EasyImage::ConvolSobelY
	EasyImage::ConvolSobel
	EasyImage::ConvolPrewittX
	EasyImage::ConvolPrewittY
	EasyImage::ConvolPrewitt
	EasyImage::ConvolRoberts
	EasyImage::ConvolLaplacianX
	EasyImage::ConvolLaplacianY
	EasyImage::ConvolLaplacian8
	EasyImage::DilateBox
	EasyImage::ErodeBox
	EasyImage::OpenBox
	EasyImage::CloseBox
	EasyImage::WhiteTopHatBox
	EasyImage::BlackTopHatBox
	EasyImage::MorphoGradientBox
	EasyImage::ErodeDisk
	EasyImage::DilateDisk
	EasyImage::OpenDisk
	EasyImage::CloseDisk
	EasyImage::WhiteTopHatDisk
	EasyImage::BlackTopHatDisk
	EasyImage::MorphoGradientDisk
	EasyImage::Median
	EasyImage::ScaleRotate
	EasyImage::DoubleThreshold
	EasyImage::Histogram
	EasyImage::Area
	EasyImage::AreaDoubleThreshold
	EasyImage::BinaryMoments
	EasyImage::WeightedMoments
	EasyImage::GravityCenter
	EasyImage::PixelCount
	EasyImage::PixelMax
	EasyImage::PixelMin
	EasyImage::PixelAverage
	EasyImage::PixelStat
	EasyImage::PixelVariance
	EasyImage::PixelStdDev
	EasyImage::PixelCompare
	EasyImage::ImageToLineSegment
	EasyImage::ImageToPath

Library	Method
Easy3D	EDepthMapToMeshConverter::Convert
	EDepthMapToPointCloudConverter::Convert
	EStatistics::ComputePixelStatistics
	EStatistics::ComputeStatistics
	E3DObjectExtractor::Extract
	EZMapToPointCloudConverter::Convert
EasyObject	EImageEncoder::Encode
EasyFind	EPatternFinder::Find
	EPatternFinder::Learn
EasyOCR2	EOCR2::Read
	EOCR2::Detect
EasyGauge	EPointGauge::Measure
	ELineGauge::Measure
	ERectangleGauge::Measure
	ECircleGauge::Measure
	EWedgeGauge::Measure
EasyMatch	EMatcher::LearnPattern
	EMatcher::Match
EasyQRCode	EQRCodeReader::SetSearchField
	EQRCodeReader::Read



## TIP

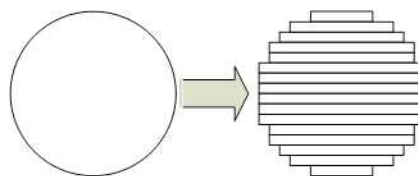
In the future **Open eVision** releases, the support of ERegions will be gradually extended to all operators.

## Creating regions

**Open eVision** offers multiple ways to create regions, depending on the shape you need:

The **ERegion** is the base class for all regions and the most versatile. It encodes a region using a Run-Length Encoded (RLE) representation.

- The RLE representation of a region is made of runs (horizontal, 1-pixel high slices).
- The runs are stored in the form of their ordinate, starting abscissa and length.



Run-Length Encoding of a circle-shaped region

To create a region, either:

- Use one of the geometry-based region classes.
- Use the result of another tool, such as **EasyFind**, **EasyMatch** or **EasyObject**.
- Combine or modify other regions.
- Use a mask image.
- Directly provide the list of runs.

### Geometry-based regions

Geometry based regions are specialized classes of regions that are encompassed in simple geometries. **Open eVision** currently provides classes based on a rectangle, a circle, an ellipse or a polygon.

Use these classes to setup geometric regions and modify them with translation, rotation and scaling. The transformation operators return new regions, leaving the source object unchanged.

- **ERectangleRegion**

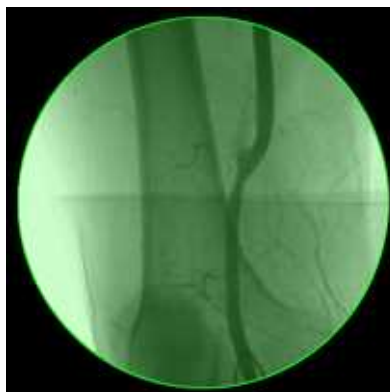
- The contour of an **ERectangleRegion** class is a rectangle.
- Define it using its center, width, height and angle.
- Alternatively, use an **ERectangle** instance, such as one returned by an **ERectangleGauge** instance.



Rectangle region separating a bar code from the background

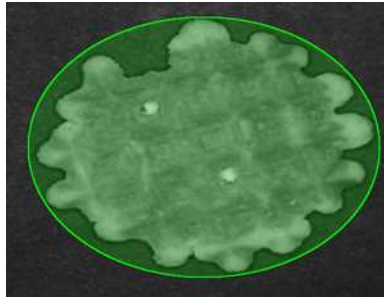
- **ECircleRegion**

- The contour of an **ECircleRegion** class is a circle.
- Define it using its center and radius or 3 non-aligned points.
- Alternatively, use an **ECircle** instance, such as one returned by an **ECircleGauge** instance.



Circle region encompassing the useful part of an X-Ray image

- [EEllipseRegion](#)
  - The contour of an [EEllipseRegion](#) class is an ellipse.
  - Define it using its center, long and short radius and angle.



Ellipse region encompassing a waffle

- [EPolygonRegion](#)
  - The contour of an [EPolygonRegion](#) class is a polygon.
  - It is constructed using the list of its vertices.



Polygon region encompassing a key

### [Using the result of other tools](#)

The [ERegion](#) class provides a set of specialized constructors to create regions from the results of another tool.

In a tool chain, these constructors restrict the processing of a tool to the area issued from the previous tool.



Open eVision provides constructors for the following tools:

- EasyFind: [EFoundPattern](#)
- EasyMatch: [EMatchPosition](#)
- EasyGauge: [ECircle](#) and [ERectangle](#)
- EasyObject: [ECodedElement](#)

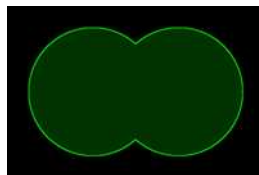
**TIP**

When compatible, **Open eVision** also provides specialized constructors for the geometry-based regions. For instance, [ECircleRegion](#) provides a constructor using an [ECircle](#).

## Combining regions

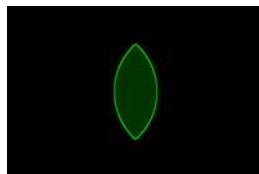
Use the following operations to create a new region by combining existing regions:

- Union
  - The [ERegion::Union\(const ERegion&, const ERegion&\)](#) method returns the region that is the addition of the two regions passed as arguments.



Union of 2 circles

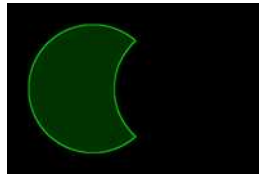
- Intersection
  - The [ERegion::Intersection\(const ERegion&, const ERegion&\)](#) method returns the region that is the intersection of the two regions passed as argument.



Intersection of 2 circles

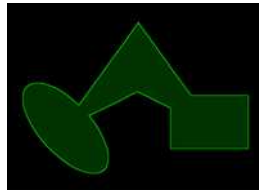


- Subtraction
  - The `ERegion::Subtraction(const ERegion&, const ERegion&)` method returns the first region passed as argument after removing the second one.



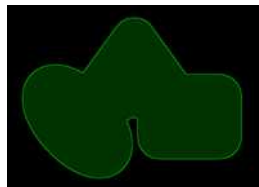
Subtraction of 2 circles

### Morphological operations on regions



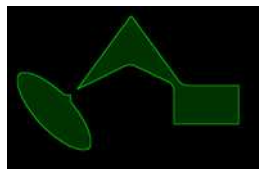
The initial arbitrary region used to illustrate the different morphological operations

- Grow
  - The `ERegion::Grow(int radius)` method returns a region that is the dilation of the region by a disk with a radius equals to the argument.



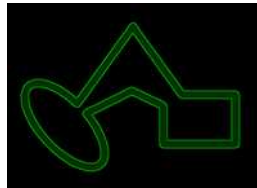
Grow of the arbitrary region

- Shrink
  - The `ERegion::Shrink(int radius)` method returns a region that is the erosion of the region by a disk with a radius equals to the argument.



Shrink of the arbitrary region

- Contour
  - The `ERegion::Contour(int thickness, bool centered = true)` method returns a region that is the contour of the region.



Contour of the arbitrary region

### Free-hand drawing a region

- The `ERegionFreeHandPainter` class provides the methods that allow you to create a region by hand, using the mouse or any other user input method.
- The `RegionFreeHand` sample, available both in C++ and C#, shows how to use this class to draw a region on an image.

### Using regions

The tools supporting regions provide methods that follow one of these conventions:

- `Method(const EImage& source, const ERegion& region)`
- `Method(const EImage& source, const ERegion& region, EImage& destination)`



#### NOTE

The source, the region and the destination must be compatible. It means that the region must at least partly fit in the source, and that source and destination must have the same size.

### Preparing the region

- **Open eVision** automatically prepares the regions when it applies them to an image, but this preparation can take some time.
- If you do not want your first call to a method to take longer than the next ones, you can prepare the region in advance by using the appropriate `Prepare()` method.
- To manually prepare the regions, adapt the internal RLE description to your images.

### Drawing regions

The `ERegion` classes provide several methods to display the regions:

- `ERegion::Draw()` draws the region area, in a semi-transparent way, in the provided device context.
- `ERegion::DrawContour()` draws the region contour in the provided device context.

- `ERegion::ToImage()` renders the region as a mask into the provided destination image.
  - You can configure the foreground and the background colors.
  - If you initialized your image with a width and a height, **Open eVision** renders the region inside those bounds.
  - If not, **Open eVision** resizes the image to contain the whole region.
  - Use `ToImage()` to create masks for the **Open eVision** functions that support them.

## ERegions and EROIs

---

- The older EROI classes of **Open eVision** are compatible with the new regions.
- Some tools allow the usage of regions with source and/or destinations that are ERoi instead of EImage follow one of these conventions:
  - `Method(const ERoi& source, const ERegion& region)`
  - `Method(const ERoi& source, const ERegion& region, ERoi& destination)`



### TIP

In that case, the coordinates used for the region are relative to the reduced ROI space instead of the whole image space .

## ERegion and 3D

---

- The new regions are compatible with the 2.5D representations of Easy3D (`EDepthMap` and `EZMap`).
- You can also reduce the domain of processing when using these classes.

# 3.9. Flexible Masks

## ROIs vs flexible masks

---

ROIs and masks restrict processing to part of an image:

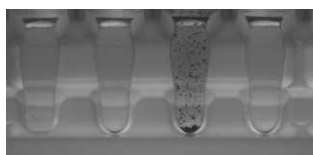
- "ROI Main Properties" on page 27 apply to all Open eVision functions. Using Regions of Interest accelerates processing by reducing the number of pixels. Open eVision supports hierarchically nested rectangular ROIs.
- Flexible Masks are recommended to process disconnected ROIs or non-rectangular shapes. They are supported by some `EasyObject` and `EasyImage` library functions.

## Flexible Masks

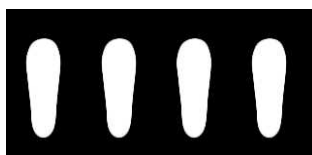
---

A flexible mask is a BW8 image with the same height and width as the source image. It contains shapes of areas that must be processed and ignored areas (that will not be considered during processing):

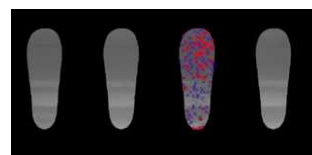
- All pixels of the flexible mask having a value of 0 define the ignored areas.
- All pixels of the flexible mask having any other value than 0 define the areas to be processed.



Source image



Associated mask



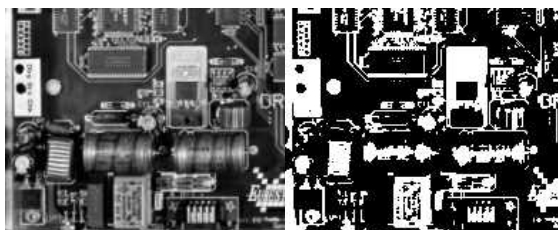
Processed masked image

A flexible mask can be generated by any application that outputs BW8 images and by some [EasyObject](#) and [EasyImage](#) functions.

## Flexible Masks in EasyImage

---

### Code Snippets

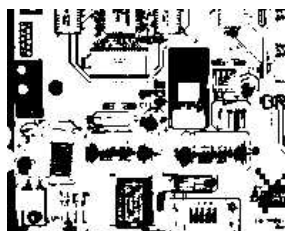


Source image (left) and mask variable (right)

## Simple steps to use flexible masks in Easyimage

---

1. Call the functions from [EasyImage](#) that take an input mask as an argument. For instance, one can evaluate the average value of the pixels in the white layer and after in the black layer.
2. Display the results.



Resulting image

## EasyImage Functions that support flexible masks

---

- `EImageEncoder.Encode` has a flexible mask argument for BW1, BW8, BW16, and C24 source images.
- `AutoThreshold`.
- `Histogram` (function `HistogramThreshold` has no overload with mask argument).
- `RmsNoise`, `SignalNoiseRatio`.
- `Overlay` (no overload with mask argument for BW8 source images).
- `ProjectOnAColumn`, `ProjectOnARow` (Vector projection).
- `ImageToLineSegment`, `ImageToPath` (Vector profile).

## Flexible Masks in EasyObject

---

A flexible mask can be generated by any application that outputs BW8 images or uses the Open eVision image processing functions.

**EasyObject** can use flexible masks to restrict blob analysis to complex or disconnected shaped regions of the image.

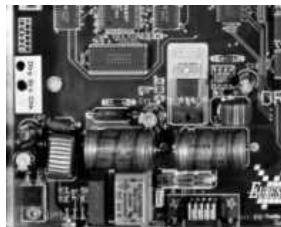
If an object of interest has the same gray level as other regions of the image, you can define "keep" and "ignore" areas using flexible masks and `Encode` functions.

A flexible mask is a BW8 image with the same height and width as the source image.

- A pixel value of 0 in the flexible mask masks the corresponding source image pixel so it doesn't appear in the encoded image.
- Any other pixel value in the flexible mask causes the pixel to be encoded.

## EasyObject functions that create flexible masks

---

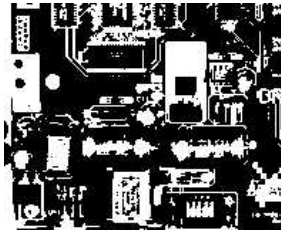


Source image

### 1) `ECodedImage2.RenderMask`: from a layer of an encoded image

1. To encode and extract a flexible mask, first construct a coded image from the source image.
2. Choose a segmentation method (for the image above the default method `GrayscaleSingleThreshold` is suitable).
3. Select the layer(s) of the coded image that should be encoded (i.e. white and black layers using minimum residue thresholding).
4. Make the mask image the desired size using `mask.SetSize(sourceImage.GetWidth(), sourceImage.GetHeight())`.

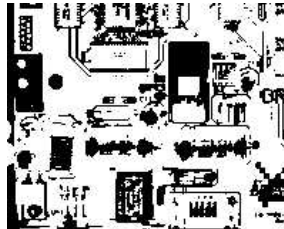
5. Exploit the flexible mask as an argument to `ECodedImage2.RenderMask`.



BW8 resulting image that can be used as a flexible mask

## 2) `ECodedElement.RenderMask`: from a blob or hole

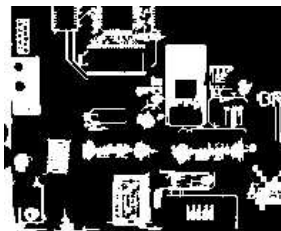
1. Select the coded elements of interest.
2. Create a loop extracting a mask from selected coded elements of the coded image using `ECodedElement.RenderMask`.
3. Optionally, compute the feature value over each of these selected coded elements.



BW8 resulting image that can be used as a flexible mask

## 3) `EObjectSelection.RenderMask`: from a selection of blobs

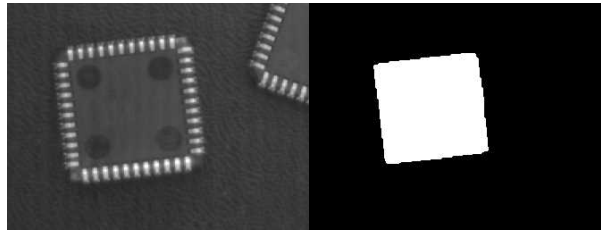
`EObjectSelection.RenderMask` can, for example, discard small objects resulting from noise.



BW8 resulting image that can be used as a flexible mask

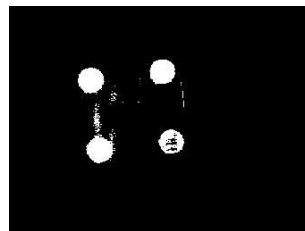
## Example: Restrict the areas encoded by EasyObject

---



Find four circles (left) Flexible mask can isolate the central chip (right)

1. Declare a new `ECodedImage2` object.
2. Setup variables: first declare source image and flexible mask, then load them.
3. Declare an `EImageEncoder` object and, if applicable, select the appropriate segmenter. Setup the segmenter and choose the appropriate layer(s) to encode.
4. Encode the source image. Encoding a layer with just the area in the flexible mask is then pretty straightforward.  
We see that the circles are correctly segmented in the black layer with the `grayscale single threshold segmenter`:



5. Select all objects of the coded image.
6. Select objects of interest by filtering out objects that are too small.
7. Display the blob feature by iterating over the selected objects to display the chosen feature.

## 3.10. Profile

### Code Snippets

#### Profile Sampling

---

A **profile** is a series of pixel values sampled along a line/path/contour in an image.

- `EasyImage.ImageToLineSegment` copies the pixel values along a given line segment (arbitrarily oriented and wholly contained within the image) to a vector. The vector length is adjusted automatically. This function supports flexible masks.
- A **path** is a series of `pixel coordinates` stored in a vector.  
`EasyImage.ImageToPath` copies the corresponding pixel values to the vector. This function supports flexible masks.

- A **contour** is a closed or not (connected) path, forming the boundary of an object. [EasyImage.Contour](#) follows the contour of an object, and stores its constituent pixels values inside a profile vector.

## Profile Analysis

---

The profile can be processed to find peaks or transitions:

- A transition corresponds to an object edge (black to white or white to black). It can be detected by taking the first **derivative** of the signal (which transforms transitions (edges) into peaks) and looking for peaks in it. [EasyImage.ProfileDerivative](#) computes the first derivative of a profile extracted from a gray-level image. The [EBW8](#) data type only handles unsigned values, so the derivative is shifted up by 128. Values under [above] 128 correspond to negative [positive] derivative (decreasing [increasing] slope).
- A **peak** is the portion of the signal that is above [or below] a given threshold - the maximum or minimum of the signal. This may correspond to the crossing of a white or black line or thin feature. It is defined by its:
  - **Amplitude**: difference between the threshold value and the max [or min] signal value.
  - **Area**: surface between the signal curve and the horizontal line at the given threshold.

[EasyImage.GetProfilePeaks](#) detects max and min peaks in a gray-level profile. To eliminate false peaks due to noise, two selection criteria are used. The result is stored in a [peaks vector](#).

## Profile Insertion Into an Image

---

[EasyImage.LineSegmentToImage](#) copies the pixel values from a vector or constant to the pixels of a given line segment (arbitrarily oriented and wholly contained within the image).

[EasyImage.PathToImage](#) copies the pixel values from a vector or a constant to the pixels of a given path.

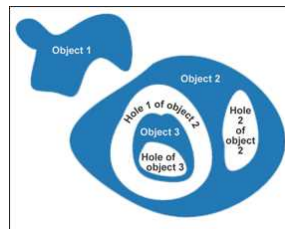


## 4. Matching and Measurement Tools

### 4.1. EasyObject - Analyzing Blobs

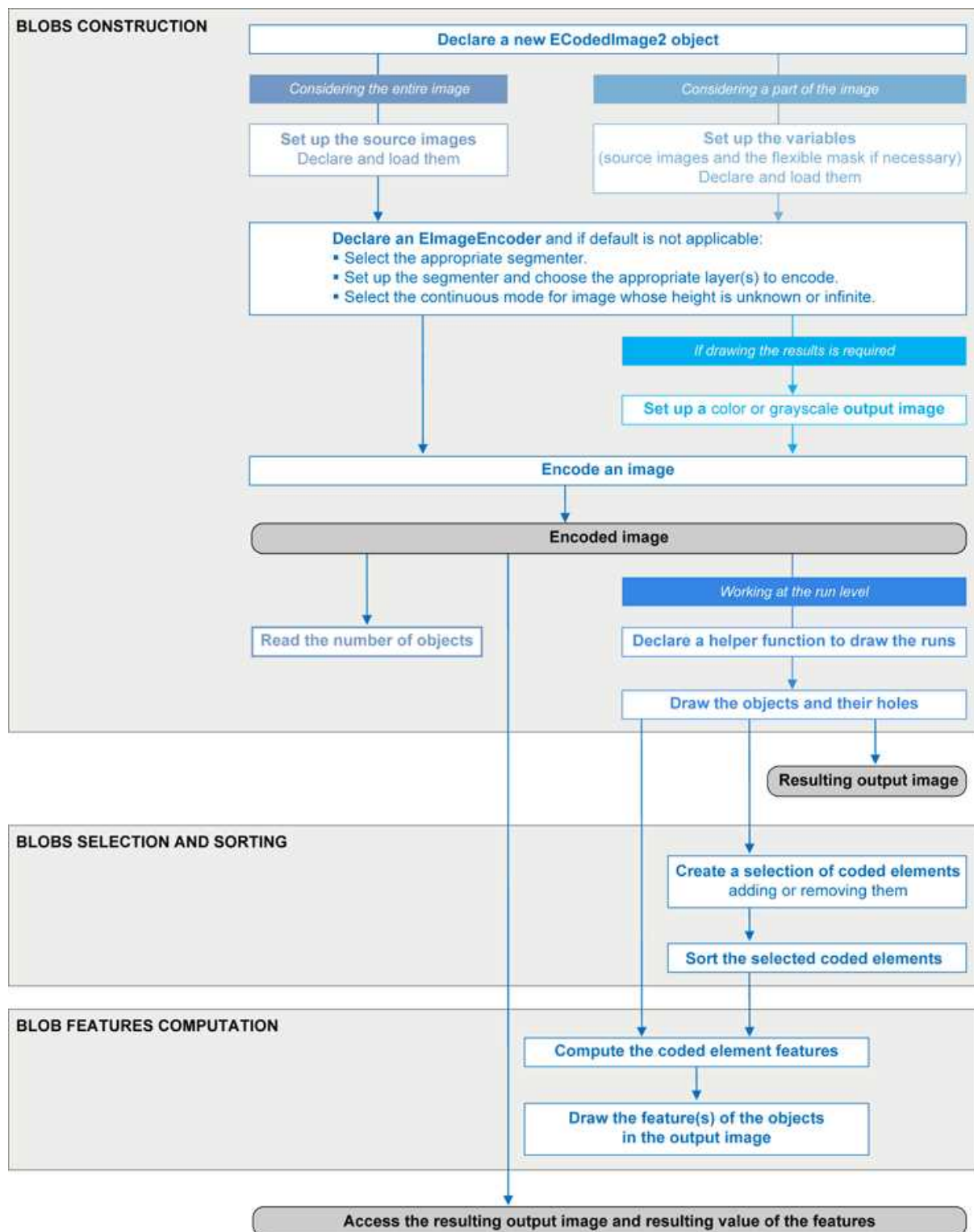
[Reference](#) | [Code Snippets](#)

The [EasyObject](#) library picks out features in an image by creating and processing blobs (objects or holes that have the same gray level range).



This library can be used for BW1, BW8, BW16 and C24 source images and is accessible from the [ECodedImage2 class](#) which has improved execution time, especially for large images with many objects.

## Workflow



## Blob Definition

---

A blob is a grouping of neighboring pixels of the same gray level range. Blobs may be objects or holes in objects. EasyObject functions analyze both objects and holes. When blobs are built, the inclusion relationship between holes and objects is computed.

Even though holes may be the actual objects of interest, it is easier to find an object of interest, then detect its holes (with EasyObject) and measure their characteristics (with EasyGauge or EasyObject).

Blobs are handled as independent entities:

- They can be selected by means of the layer they belong to, their position, a rectangular ROI or their computed features. The selection criteria can be combined (select the small objects; among these, select those close to the right edge...).
- They can be listed and sorted by their geometric characteristics: such as area, width, or ellipse of inertia.

Blob analysis can be restricted to rectangular and nested ROIs, and to complex or disconnected-shape regions using flexible masks.

## Build Blobs

---

EasyObject chooses objects of interest and constructs blobs/holes in two steps:

1. **Segment**: classifies the source image pixels, creates layers, and constructs the runs (a run is a sequence of adjacent pixels in a row, that share the same property).
2. **Encode**: assembles runs, to build blobs for each layer.  
You select which objects or holes are kept.  
[EImageEncoder.Encode](#) analyzes the blobs and stores the result into a coded image which has a set of superimposed, mutually exclusive image layers, where the pixels of each layer have properties in common, such as being above a threshold.  
Flexible masks can restrict encoding to an arbitrary shaped area.

There is no need to build **holes**, they are constructed on-the-fly when required.

## Functions

- Segmentation [GetSegmentationMethod](#) and [SetSegmentationMethod](#)
- Grayscale single threshold [EGrayscaleSingleThresholdSegmenter](#)
- Grayscale double threshold [EGrayscaleDoubleThresholdSegmenter](#)
- Color single threshold [EColorSingleThresholdSegmenter](#)
- Color range threshold [EColorRangeThresholdSegmenter](#)
- Reference image [EReferenceImageSegmenter](#)
- Image range [EImageRangeSegmenter](#)
- Labeled image [ELabeledImageSegmenter](#)
- Binary images [EBinaryImageSegmenter](#)


**Pixel aggregation** (encoder)

- Layer selection
- Object construction: run aggregation into objects
- **Hole construction**: run aggregation into holes

## Extract objects (using geometric parameters)

Once an image has been encoded, the coded elements (objects or holes) are accessible through the abstract class `ECodedElement` which provides a large set of methods applicable to a particular coded element:

Num	Area	Gravity Center X	Gravity Center Y
59	2221	17.67	95.55
37	387	161.69	53.46
47	344	166.43	90.24
32	327	226.23	72.07
40	251	111.45	62.04
50	239	120.41	91.51
4	144	220.98	2.44
68	142	72.05	123.10



Features computation and display

The objects, holes and their features can be efficiently accessed randomly (in an index-based fashion).

## Image Segmenters

### Code Snippets

There are several ways to segment pixels. The method is chosen with `GetSegmentationMethod` and `SetSegmentationMethod`.

### 1. Grayscale Single Threshold (default)

`EGrayscaleSingleThresholdSegmenter` is applicable to BW8 and BW16 grayscale images and produces coded images with two layers:

- The **black layer** (usually Layer 0) contains unmasked pixels with a gray value below the Threshold value.
- The **white layer** (usually Layer 1) contains the remaining unmasked pixels, i.e. unmasked pixels having a gray value greater or equal to the Threshold value.

EasyObject provides 5 thresholding methods:

- **Absolute** (integer value): represents the first gray value of the white layer. Set with `SetAbsoluteThreshold` method and got with `GetAbsoluteThreshold` method.
- **Relative (%)**: represents the fraction of image pixels that belong to the Black layer, it is a user-defined float value in range 0 to 1. Set with `SetRelativeThreshold` method and got with `GetRelativeThreshold` method.
- **Minimum Residue** (default): The threshold is an automatically computed value such that the quadratic difference between the source and thresholded image is minimized.
- **Maximum Entropy**: automatically computed value such that the entropy (i.e. the amount of information) of the resulting thresholded image is maximized.
- **IsoData**: automatically computed value that lies halfway between the average dark gray value (gray levels below the threshold) and average light gray values (gray levels above the threshold).

Grayscale Single Threshold with a minimum residue thresholding method is the default. Only objects whose pixels have a value that is above this threshold are encoded.

## 2. Grayscale Double Threshold

---

[EGrayscaleDoubleThresholdSegmenter](#) is applicable to BW8 and BW16 grayscale images and produces coded images with three layers:

- The **black layer** (usually Layer 0) contains unmasked pixels having a gray value below the Low Threshold value.
- The **white layer** (usually Layer 2) contains unmasked pixels having a gray value above or equal the High Threshold value.
- The **neutral layer** (usually Layer 1) contains the remaining unmasked pixels.

The **Low Threshold** and **High Threshold** are user-defined integer values, set with [SetLowThreshold](#) and [SetHighThreshold](#) methods, and got with [GetLowThreshold](#) and [GetHighThreshold](#) methods.

## 3. Color Single Threshold

---

[EColorSingleThresholdSegmenter](#) is applicable to C24 color images; it produces coded images with two layers:

- The **white layer** (usually Layer 1) contains unmasked pixels that belong to the cube of the color space defined by the threshold point and the white point (255,255,255).
- The **black layer** (usually Layer 0) contains the remaining unmasked pixels.

The **Color Threshold** is a set of three **user-defined** integer values designating a color in the color space, set with [SetThreshold](#) method and got with [GetThreshold](#) method.

## 4. Color Range Threshold

---

[EColorRangeThresholdSegmenter](#) is applicable to C24 color images; it produces coded images with two layers:

- The **white layer** (usually Layer 1) contains unmasked pixels that belong to the cube of the color space defined by the Low Threshold point and the High Threshold point.
- The **black layer** (usually Layer 0) contains the remaining unmasked pixels.

The Low Threshold and High Threshold are each a set of three user-defined integer values designating a color in the color space, set with [SetLowThreshold](#) and [SetHighThreshold](#) methods and got with [GetLowThreshold](#) and [GetHighThreshold](#) methods.

## 5. Image Range

---

The following cases need a segmentation using **pixel-by-pixel thresholding** which gives an allowed range of values for each pixel:

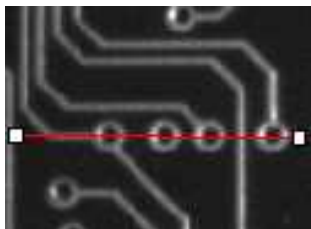
- when the background is not uniform enough,
- when the illumination is not uniform across the image,
- when only differences between the image and a reference image (ideal) are to be enhanced,

The allowed range for each pixel is specified using two images: a low reference image with the minimum values allowed for each pixel, a high reference image with the maximum values. The reference images are thus the source image minus (or plus) a fixed value all over the image (assuming noise distribution is uniform and additive).

The difficulty is preparing suitable high and low reference images.

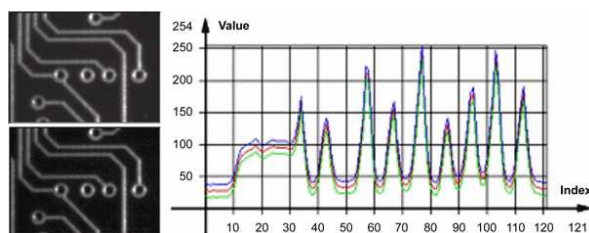
## Preparing high and low reference images

You can start from an image of the scene without defects and add security margins before comparison.



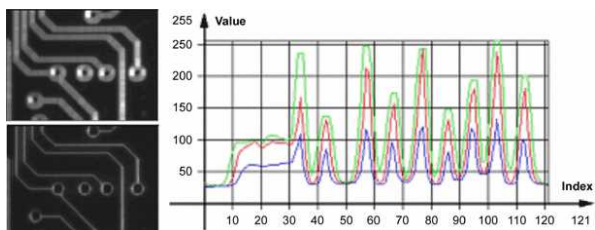
Source image

Gray-level tolerance must be provided for noise and illumination variations.



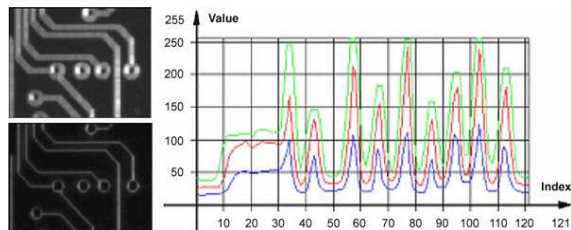
Gray-level tolerance margins

The image may have a slight shift in some direction which can be corrected by enlarging the light and dark areas using dilate and erode morphological operations. This geometric tolerance margin is roughly as large as the morphological filter size.



Geometric tolerance margins

Combining both kinds of tolerance margins gives the best results.



Combined margins

## Image Segmenter

[EImageRangeSegmenter](#) and [EReferenceImageSegmenter](#) are applicable to BW8, BW16, and C24 images; and produce coded images with two layers.

The low threshold and the high threshold are defined for each pixel individually by means of two reference images of the same type as the source image: the Low Image and the High Image. The Reference Image defines the reference threshold of each pixel individually.

- For **grayscale** images, the **white layer** (usually Layer 1) contains unmasked pixels having a gray value in a range defined by the gray value of the corresponding unmasked pixels in the Low, High or Reference Image.
- For **color** images, the **white layer** (usually Layer 1) contains unmasked pixels having a color inside the cube of the color space defined by the colors of the corresponding unmasked pixels in the Low, High or Reference Image.
- The **black layer** (usually Layer 0) contains the remaining unmasked pixels.

Pointers to the **Low Image** can be set or got using the functions associated with the type of the source image:

- BW8: [SetLowImageBW8](#) [GetLowImageBW8](#)
- BW16: [SetLowImageBW16](#) [GetLowImageBW16](#)
- C24: [SetLowImageC24](#) [GetLowImageC24](#)

Pointers to the **High Image** can be set or got using the functions associated with the type of the source image:

- BW8: [SetHighImageBW8](#) [GetHighImageBW8](#)
- BW16: [SetHighImageBW16](#) [GetHighImageBW16](#)
- C24: [SetHighImageC24](#) [GetHighImageC24](#)

Pointers to the **Reference Image** can be set or got using the functions associated with the type of the source image:

- BW8: [SetReferenceImageBW8](#), [GetReferenceImageBW8](#)
- BW16: [SetReferenceImageBW16](#), [GetReferenceImageBW16](#)
- C24: [SetReferenceImageC24](#) , [GetReferenceImageC24](#)

## 6. Labeled Image

---

[ELabeledImageSegmenter](#) is applicable to is applicable to BW8 and BW16 grayscale images; it produces coded images with a number of layers equal to the maximum number of gray values: 256 for BW8 images or 65536 for BW16 images. The layer n contains all the unmasked pixels having a gray value equal to n.

By default, all layers are encoded. However, it is possible to restrict the encoding to a single range of layers with [SetMinLayer](#) and [SetMaxLayer](#) functions which return the lowest and the highest values of the index range respectively.

## 7. Binary Image

---

[EBinaryImageSegmenter](#) is applicable to BW1 binary images; it produces coded images with two layers:

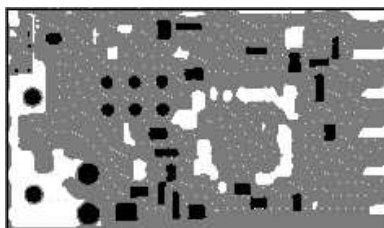
- Black layer (usually index 0) contains unmasked pixels with a binary value equal to zero.
- White layer (usually index 1) contains the remaining unmasked pixels, i.e. unmasked pixels with a binary value equal to one.

# Image Encoder

[Reference](#) | [Code Snippets](#)



The class representing the objects ([EObject](#)) derives from an abstract class [ECodedElement](#).



Object building

## Selecting the Layers to Encode

The segmentation methods (see [Image Segmenters](#)) determine which layer(s) to encode by default, and do not encode pixels from the other layers.

Function `GetMaxLayerIndex` returns the highest Layer Index value. It is available for all segmenters.

### [Enabling/disabling layer encoding for each layer individually](#)

The following tables list, for each layer, the Set/Get function and the default enable/disable value.

Two-layer segmenters

Layer	Set LayerEncoded function	Get LayerEncoded function	Default value
Black layer	<code>SetBlackLayerEncoded</code>	<code>IsBlackLayerEncoded</code>	FALSE
White layer	<code>SetWhiteLayerEncoded</code>	<code>IsWhiteLayerEncoded</code>	TRUE

Three-layer segmenters

Layer	Set LayerEncoded function name	Get LayerEncoded function name	Default value
Black layer	<code>SetBlackLayerEncoded</code>	<code>IsBlackLayerEncoded</code>	FALSE
White layer	<code>SetWhiteLayerEncoded</code>	<code>IsWhiteLayerEncoded</code>	FALSE
Neutral layer	<code>SetNeutralLayerEncoded</code>	<code>IsNeutralLayerEncoded</code>	TRUE

### [Manually Assigning a Layer Index to Each Layer Individually](#)

The following tables list, for each layer, the Set/Get function and the default value.

Two-layer segmenters



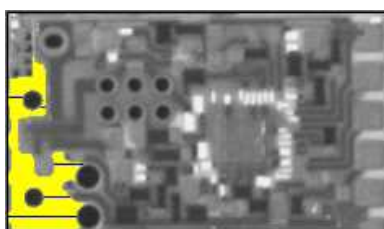
Layer	Set LayerEncoded function name	Get LayerEncoded function name	Default value
Black layer	SetBlackLayerIndex	IsBlackLayerIndex	0
White layer	SetWhiteLayerIndex	IsWhiteLayerIndex	1

Three-layer segmenters

Layer	Set LayerEncoded function name	Get LayerEncoded function name	Default value
Black layer	SetBlackLayerIndex	IsBlackLayerIndex	0
Neutral layer	SetNeutralLayerIndex	IsNeutralLayerIndex	1
White layer	SetWhiteLayerIndex	IsWhiteLayerIndex	2

## Runs

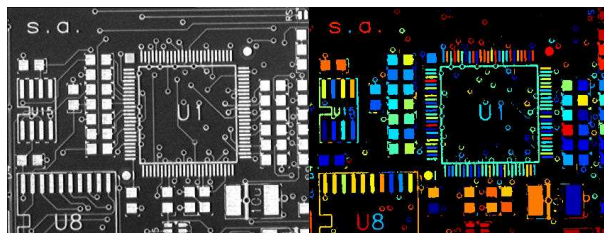
For the sake of computational efficiency, the objects are described as lists of runs. A run is a sequence of adjacent pixels that share homogeneous properties (such as being above a given threshold). These runs are merged in objects by the image encoder.



A single object with five enhanced runs

EasyObject can work at object level, and at run level which allows faster processing in critical cases. This is useful to compute custom features on objects then list all runs belonging to a given object as shown in this example of working at run level, with colored runs in the output image.

1. **Declare a new [ECodedImage2](#) object.**
2. **Declare an [EImageEncoder](#)** and, if applicable, select the appropriate segmenter. Setup the segmenter and choose appropriate layer(s) to encode.
3. **Set up an output image.**
4. **Encode the image.**
5. **Color the runs in the output image.** Iterate over the objects of a specific layer by constructing a loop and then a [RunsIterator](#) object. This iterator allows to browse runs of the considered object. Once the iterator has finished a run of the considered object, the inner loop processes the pixels spanned by this run in the output image.
6. **Select a specific layer.**



Source image (left) with the white layer rendered (right)

## Connexity

Pixels can touch each other along an edge or by a corner. In Four Connexity only pixels touching by an edge are considered neighbors. In Eight Connexity (the default) pixels touching by a corner are also considered neighbors.



4-connexity



8-connexity

Multiple images can be encoded in [continuous mode](#).

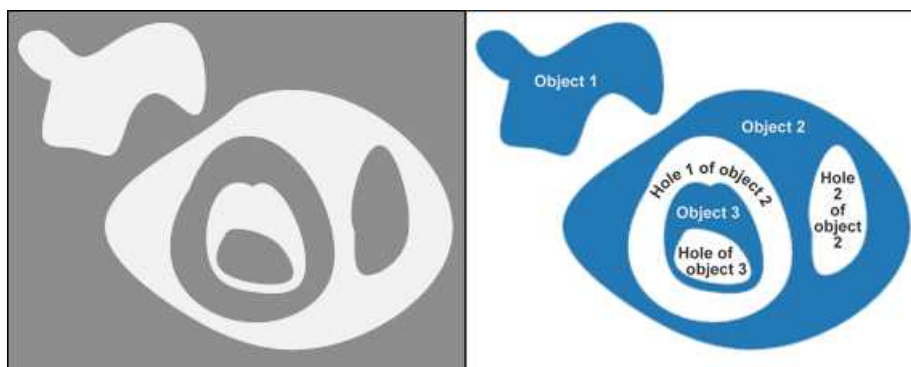
## Holes Construction

### Code Snippets

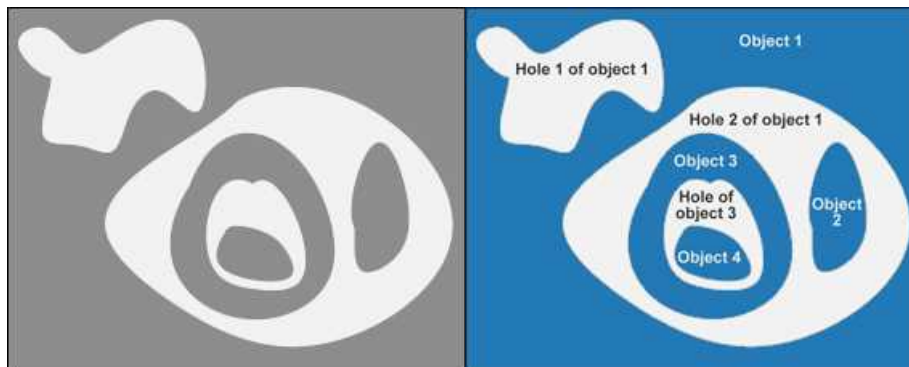
A hole is a set of connected pixels that are entirely surrounded by a parent object (4 or 8 pixels depending on the connexity mode).

A hole has no child. Objects inside a hole are considered as separate objects.

[EObject](#) and [EHole](#) classes both derive from [ECodedElement](#), so objects and holes are managed in the same way and share the same functions.



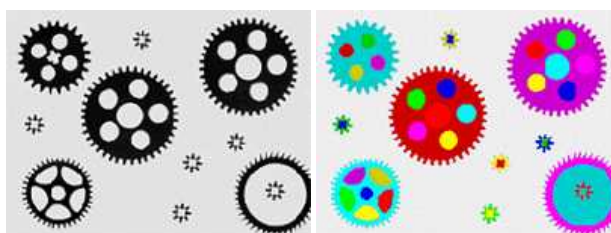
Encoding the white layer (3 objects and 3 holes)



Encoding the black layer (4 objects and 3 holes)

## How to Color holes

1. **Declare a new [ECodedImage2](#) object.**
2. **Declare an [EImageEncoder](#)** and, if applicable, select and setup the appropriate segmenter, and choose the appropriate layer(s) to encode.
3. **Set up an output image.**
4. **Encode the image.**
5. **Declare a helper function to draw the runs.** A helper function (see also section Object Construction/Working at the Run Level) draws the runs in an output image, using, for example, a given color. This function can be shared for objects and holes.
6. **Draw the objects and their holes in the output image.** It is necessary to iterate over the objects of the chosen layer.
  - a. The helper function draws the runs of each object (`DrawRuns`) using a specific color.
  - b. The holes are iterated over the current object, and their runs are drawn.
  - c. Each hole of an object is drawn with a different color computed in the global function (`GetFadedColor`) that returns a color. This color depends upon the hole index, for example a gradation of red to green colors.



Raw image (left) Building of objects and all holes (right)

## Normal vs. Continuous Mode

### Code Snippets

#### [Normal Mode \(default\)](#)

In normal mode, the image encoder does not track blobs across several successive images. EasyObject works with one image, without keeping blobs in memory. All the blobs are returned as objects.

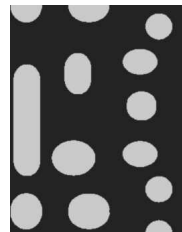
## Continuous Mode

In continuous mode EasyObject can process an image whose height is unknown or infinite (e.g. coming from a line-scan camera). The image is split into several chunks that are fed into an image encoder. Objects that straddle several successive image chunks can be detected.

The image encoder encodes only the objects that contain no run touching the last row of the source image. Objects that touch the inferior border of the image are not written in the coded image because they are expected to continue in subsequent image chunks, but they are kept in memory and are processed when subsequent images are analyzed.

A large image is assumed to be divided into several chunks that are stored in the array `EImageBW8 chunk[x]`.

In this example, we generate a sequence of color images that exhibit objects encoded over successive chunks



Original image



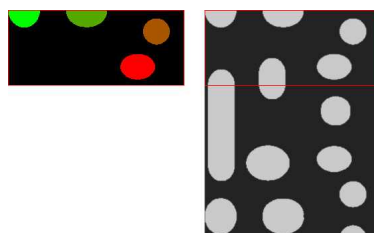
Three chunks of the image

1. **Draw the objects encoded in a layer of a coded image.** This code is essentially the same as in "Browsing Runs" code snippet. The only difference is that an offset can be applied along the Y-axis.
2. **Define a function to draw the objects of a layer.** If a coded image contains objects that were started in a previous image: the runs of this object from the previous image are assigned with a negative Y-coordinate.

The zero Y-coordinate is the first row of the most recently encoded image. The convention is to assign the lowest Y-coordinate to the oldest run in the encoded objects. The method `EImageEncoder.GetStartY` obtains the Y-coordinate of this oldest run. It is necessary to define a function that displays the content of a layer of a coded image. Each object can be displayed with a different color( computed by `GetFadedColor`). This

function closely follows the function `DrawRuns`, but is adapted to continuous mode by taking `GetStartY` into account.

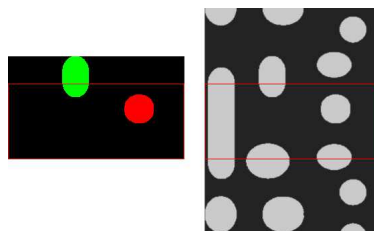
3. **Enable continuous mode** in property `EImageEncoder.SetContinuousModeEnabled`. Additional variables can be declared, for example to store the successive encoded image, or to hold the output images.
4. **Analyze the successive chunks.** To encode successive chunks use `Encode(chunk[count], codedImage)` and then `DrawLayer`. **Note:** The variable `count` spans integers 0, 1 and 2. When an object from a chunk is not complete it is kept in the internal memory of the image encoder.



Content of `layerImage` when `count` equals 0, after the application of `DrawLayer`.

Chunk of the large image that is under consideration.

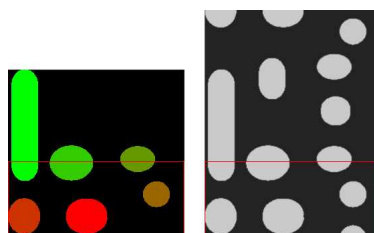
Note that two objects in the lower-left of the image chunk are not encoded, because they touch the border of the chunk.



When `count` reaches 1, one of these two objects becomes completed, which leads to the encoding of the following image.

Two other objects are not encoded yet at this time.

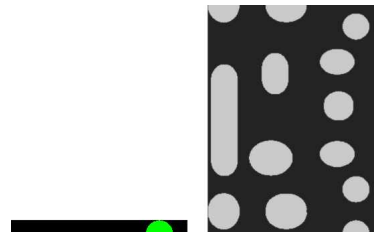
Here is the result of the encoding of the last chunk (`count = 2`).



Three objects from the previous chunks have been closed, and have thus been encoded.

### Flushing Continuous Mode

After encoding the three image chunks, there remains one object to be completed (in the bottom-right corner of the large image). However, as there are no more chunks, it is necessary to explicitly close this object and encode the remaining object using the [flushing of the image encoder](#). The internal memory of the image encoder is then empty.



Result of the flush

## Selecting and Sorting Blobs

### Code Snippets

The object segmentation process considers any blob as an object, including noise pixels which appear as tiny objects. You can select which blobs to keep using the class [EObjectSelection](#).

### Create / modify a selection

---

You can use the methods [Add](#) and [Remove](#) of the class [EObjectSelection](#) to:

- Add or remove a single object, a hole or a whole layer to/from a selection.
- Add or remove objects or holes based on some specified **feature** (see the feature list in [Computing the Coded Element Features](#)).
- Add or remove objects or holes based on their specific **position**, or whether they lie within a specified ROI rectangle.
- Add or remove objects based on their specific position, or whether they lie outside, on or within a specified ROI rectangle or ERegion ([AddObjectsUsingRectangle](#) and [AddObjectsUsingRegion](#)).

These actions can be cascaded and combined at will in a single selection.

### Clear a selection

---

You can clear a previous selection using [EObjectSelection.Clear](#).

### Sort a selection

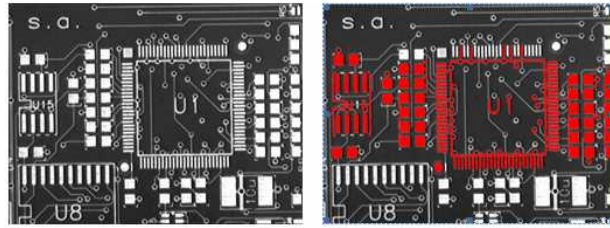
---

You can sort the elements of a selection according to any of their features.

### Example

---

In this example, we select objects in the middle band of an image, with a surface >100 pixels.

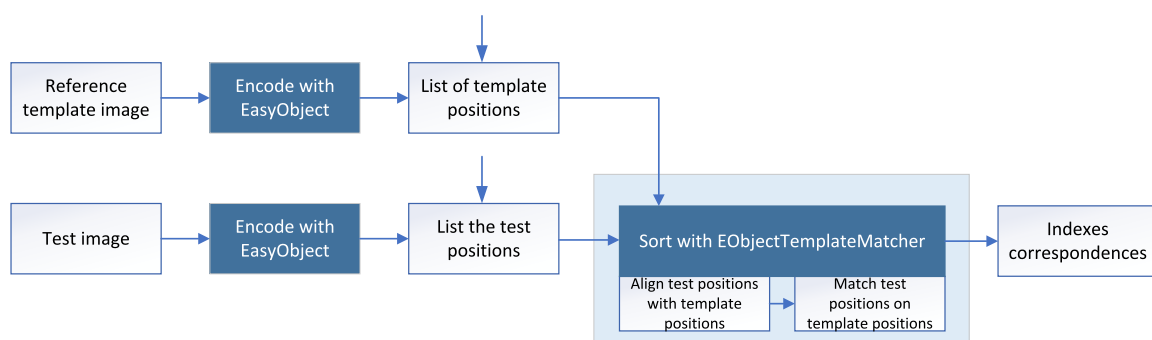


Source image, and selection of objects

1. Declare a new `ECodedImage2` object.
2. Declare an `EImageEncoder` object and, if applicable, select and setup the appropriate segmenter and choose the appropriate layer(s) to encode.
3. Encode the source image.
4. Create a selection of objects. Create an instance of the `EObjectSelection` class and add objects to this selection, for instance through `EObjectSelection.AddObjects`.
5. Remove objects based on the value of one feature at a time. The objects in a selection can be unselected by calling one of the `EObjectSelection.Remove` methods.
6. Remove the objects based on their position using `EObjectSelection.RemoveUsingFloatFeature`. For details, see also "Working at the Run Level".
7. Sort the selected objects using `EObjectSelection.Sort`.
8. Access the selected objects.

## Object Template Matcher

The class `EObjectTemplateMatcher` is a tool designed to align and match the output of **EasyObject** to a reference template. It is designed and developed to handle efficiently thousand of objects.

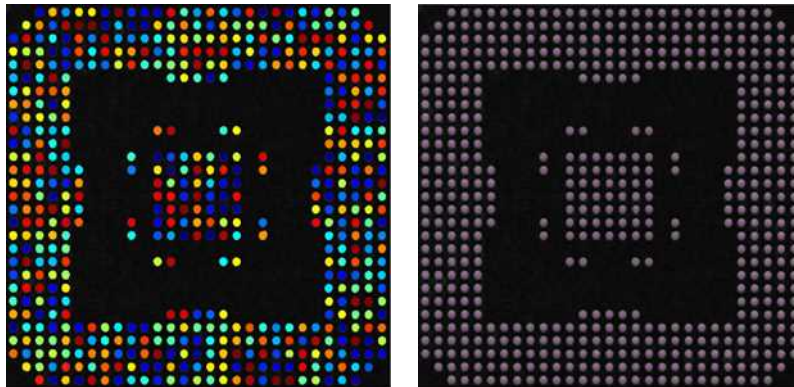




## Creating the reference template

Use the method `BuildTemplate` to create the reference template, with one of the following parameters:

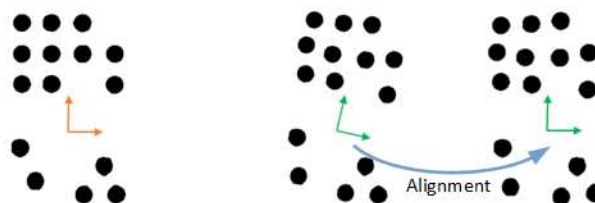
- An `ECodedImage2`, result of the method `EImageEncoder::Encode`.
- An `EObjectSelection`, a selection (subset) of `ECodedImage2` objects.
- A list of positions, given by a vector of points (`std::vector<EPoint>`).



An encoding of the reference image for use as the template.  
And the center positions of each object for use in the matching process.

## Sorting the objects

- To perform the matching after setting up the template:
  - Use the method `SortSelection` with an `EObjectSelection` as parameter.
  - Or use the more generic method `SortPositions` with a `std::vector<EPoint>` as parameter.
- When you pass the objects in a selection as the sort method parameter, the bounding box center of the objects is the position used for the matching with the template.
- Before the sorting, `EObjectTemplateMatcher` performs an optional global rigid alignment of the submitted positions with the defined template.
  - This alignment only applies the translation and rotation transformations.
  - Use the method `SetEnableAlignment` to enable the alignment process.



Left: the template.  
Right: the alignment of the submitted selection.



- After the optional alignment, [EObjectTemplateMatcher](#) matches the submitted positions with the reference template.
  - It uses the shortest distance criterion to pair these positions with the template.
  - You can set the maximum distance to constraint the search. This can speed up the processing.

## Retrieving the Sorting Results

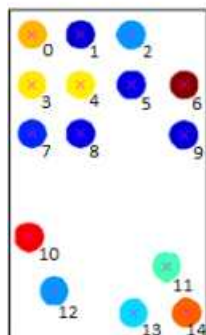
---

- Use one of these methods to retrieve the sorting results:
  - [GetSelectionIndexes](#) returns, for each position in the template, the paired index in the selection. The value -1 is used if the object in the template has no correspondence in the selection.
  - [GetTemplateIndexes](#) returns, for each position in the selection, the paired index in the template. The value -1 is used if the object in the selection has no correspondence in the template.
  - [GetUnpairedObjects](#) returns the positions in the template and in the selection that have not been paired.
- Use the method [GetNumberOfPairedObjects](#) to get the total number of paired objects.
- Use the methods [Save](#) and [Load](#) to store and retrieve the configuration of an [EObjectTemplateMatcher](#) object, including the template.

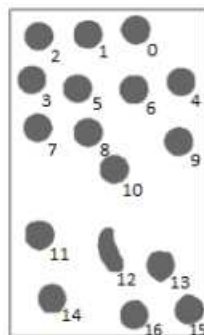


```
NumberOfPairedObjects = 15
SelectionIndexes =
2, 1, 0, 3, 5, 6, 4, 7, 8, 9, 10, 11, 12, 14, 13
TemplateIndexes =
2, 1, 0, 3, 6, 4, 5, 7, 8, 9, 10, 11, 12, 14, 13
UnpairedObjects =
  onlyInTemplate = <>
  onlyInSelection = <>
```

Selection with moved objects

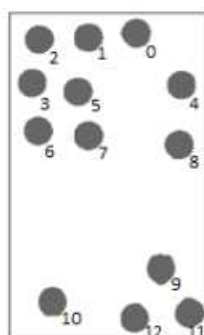


Template with object indexes



```
NumberOfPairedObjects = 15
SelectionIndexes =
2, 1, 0, 3, 5, 6, 4, 7, 8, 9, 11, 13, 14, 16, 15
TemplateIndexes =
2, 1, 0, 3, 6, 4, 5, 7, 8, 9, -1, 10, -1, 11, 13, 14, 13
UnpairedObjects =
  onlyInTemplate = <>
  onlyInSelection = 10, 12
```

Selection with extra objects



```
NumberOfPairedObjects = 13
SelectionIndexes =
2, 1, 0, 3, 5, -1, 4, 6, 7, 8, -1, 9, 10, 12, 11
TemplateIndexes =
2, 1, 0, 3, 6, 4, 7, 8, 9, 11, 12, 14, 13
UnpairedObjects =
  onlyInTemplate = 5, 10
  onlyInSelection = <>
```

Selection with missing objects

## Advanced Features

### Computable Features

Methods prefixed with **Get** indicate a lazy evaluation: the result is computed on the first invocation of the method and cached.

Methods prefixed with **Compute** indicate that the function is reevaluated at every invocation and the result is never cached.

## Position

---

Limit (top, bottom, left, right)	<a href="#">ECodedElement.GetTopLimit</a> <a href="#">ECodedElement.GetBottomLimit</a> <a href="#">ECodedElement.GetLeftLimit</a> <a href="#">ECodedElement.GetRightLimit</a>
Gravity center (X and Y)	<a href="#">ECodedElement.GetGravityCenter</a> <a href="#">ECodedElement.GetGravityCenterX</a> <a href="#">ECodedElement.GetGravityCenterY</a>
Weight gravity center (X and Y)	<a href="#">ECodedElement.ComputeWeightedGravityCenter</a>

## Gravity center and weight gravity center

---



The **gravity center** returns the abscissa of the gravity center of the coded element.

The **weight gravity center** computes the gravity center of a given image over a coded element.

## Extents

---

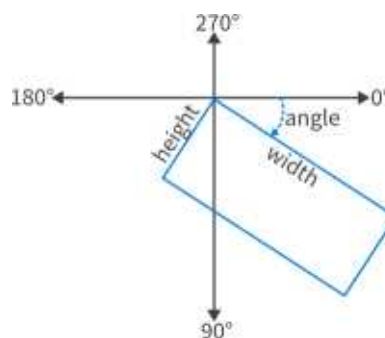
Area (pixel count)	<a href="#">ECodedElement.Area</a>
Feret box (center X and Y, height, width with distinct orientation angles at 22, 45, 68 degrees)	<a href="#">ECodedElement.ComputeFeretBox</a> <a href="#">ECodedElement.GetFeretBox22Box</a> <a href="#">ECodedElement.GetFeretBox22Center</a> <a href="#">ECodedElement.GetFeretBox22CenterX</a> <a href="#">ECodedElement.GetFeretBox22CenterY</a> <a href="#">ECodedElement.GetFeretBox22Height</a> <a href="#">ECodedElement.GetFeretBox22Width</a> <a href="#">ECodedElement.GetFeretBox45Box</a> <a href="#">ECodedElement.GetFeretBox45Center</a> <a href="#">ECodedElement.GetFeretBox45CenterX</a> <a href="#">ECodedElement.GetFeretBox45CenterY</a> <a href="#">ECodedElement.GetFeretBox45Height</a> <a href="#">ECodedElement.GetFeretBox45Width</a> <a href="#">ECodedElement.GetFeretBox68Box</a> <a href="#">ECodedElement.GetFeretBox68Center</a> <a href="#">ECodedElement.GetFeretBox68CenterX</a> <a href="#">ECodedElement.GetFeretBox68CenterY</a> <a href="#">ECodedElement.GetFeretBox68Height</a> <a href="#">ECodedElement.GetFeretBox68Width</a>

Bounding box (center X and Y, height, width)	<a href="#">ECodedElement.GetBoundingBox</a> <a href="#">ECodedElement.GetBoundingBoxCenter</a> <a href="#">ECodedElement.GetBoundingBoxCenterX</a> <a href="#">ECodedElement.GetBoundingBoxCenterY</a> <a href="#">ECodedElement.GetBoundingBoxHeight</a> <a href="#">ECodedElement.GetBoundingBoxWidth</a>
Min. enclosing rectangle (angle, center X and Y, height, width)	<a href="#">ECodedElement.MinimumEnclosingRectangle</a> <a href="#">ECodedElement.MinimumEnclosingRectangleAngle</a> <a href="#">ECodedElement.MinimumEnclosingRectangleCenter</a> <a href="#">ECodedElement.MinimumEnclosingRectangleCenterX</a> <a href="#">ECodedElement.MinimumEnclosingRectangleCenterY</a> <a href="#">ECodedElement.MinimumEnclosingRectangleHeight</a> <a href="#">ECodedElement.MinimumEnclosingRectangleWidth</a>

## Feret box

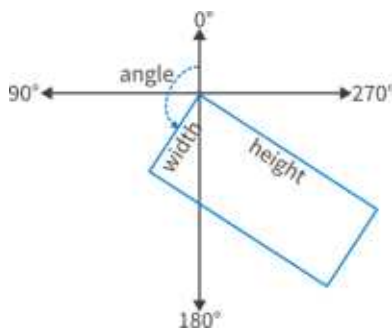
A Feret box is a rectangle with the minimum surface rotated at a specified angle that contains all the pixels center points of an object.

- **Bounding box** is the Feret box at 0°.
- **Minimum enclosing rectangle** is the Feret box with the minimum surface across all the possible angles.
- **Width** of a **FeretBox rectangle** is the length of the rectangle side that exhibits the smallest angle with the X-axis. This is NOT necessarily the smallest side!
- The **height** of a Feret box rectangle is the length of the other side of the rectangle.
- Use [ECodedElement.ComputeFeretBox](#) to compute a Feret box with an arbitrary angle.
  - The angle is measured clockwise from the X axis to the width side of the rectangle as shown in the image below:



- In the legacy **EasyObject** library, the class [ECodedImage](#) does not follow the same conventions. The main differences are:
  - The minimum enclosing rectangle corresponds to the Feret box of the legacy **EasyObject** library ( features [ELegacyFeature\\_Feret\\*](#)).
  - The method [ECodedElement.ComputeFeretBox](#) corresponds to the [ECodedImage.LimitAngle](#) in the legacy **EasyObject** library.

- The angle, width and height in the legacy **EasyObject** library are defined as shown in the image below:



## Miscellaneous

Starting point of the object contour (X and Y)	<code>ECodedElement.GetContour</code> <code>ECodedElement.GetContourX</code> <code>ECodedElement.GetContourY</code>
Path of the object contour	<code>ECodedElement.GetContourPath</code>
Largest run	<code>ECodedElement.GetLargestRun</code>
Run count	<code>ECodedElement.GetRunCount</code>
Object number (index)	<code>ECodedElement.GetLayerIndex</code> <code>ECodedElement.GetElementIndex</code>
Pixel gray-level value (average, deviation, variance)	<code>ECodedElement.ComputePixelGrayAverage</code> <code>ECodedElement.ComputePixelGrayDeviation</code> <code>ECodedElement.ComputePixelGrayVariance</code>
Pixel gray-level value (min and max)	<code>ECodedElement.ComputePixelMax</code> <code>ECodedElement.ComputePixelMin</code>

## Ellipse of inertia



Eccentricity of the ellipse of inertia	<code>ECodedElement.Eccentricity</code>
Moment	<code>ECodedElement.GetCentralMoment</code> <code>ECodedElement.GetMoment</code> <code>ECodedElement.GetNormalizedCentralMoment</code>

Ellipse (angle, height, width)	<a href="#">ECodedElement.GetEllipseAngle</a> <a href="#">ECodedElement.GetEllipseHeight</a> <a href="#">ECodedElement.GetEllipseWidth</a>
Second order geometric moments (Sigma: X, XX, XY, Y, YY)	<a href="#">ECodedElement.GetSigmaX</a> <a href="#">ECodedElement.GetSigmaXX</a> <a href="#">ECodedElement.GetSigmaXY</a> <a href="#">ECodedElement.GetSigmaY</a> <a href="#">ECodedElement.GetSigmaYY</a>

**NOTE**

The object perimeter can be measured indirectly by tracing the object contour with contouring methods and counting the pixels.

From the standard geometric features, others can be derived. For instance, object elongation is computed as the ratio of large to short ellipse axis or max height over max width. Object circularity is defined as the ratio of the squared perimeter divided by four times pi multiplied by the object area.

**NOTE**

**Note.** Formulas (N = area):

$$\sigma_x = I_x = \frac{1}{N} \sum (x_i - \bar{x})^2$$

$$\sigma_y = I_y = \frac{1}{N} \sum (y_i - \bar{y})^2$$

$$\sigma_{xx} = I_x = \frac{I_x + I_y}{2} + \sqrt{\left(\frac{I_x + I_y}{2}\right)^2 + I_x I_y + I_{xy}^2}$$

$$\sigma_{yy} = I_y = \frac{1}{N} \sum (x_i - \bar{x})(y_i - \bar{y})$$

$$\sigma_{xy} = I_{xy} = \frac{I_x + I_y}{2} - \sqrt{\left(\frac{I_x + I_y}{2}\right)^2 + I_x I_y + I_{xy}^2}$$

$$\text{WIDTH} = 4\sqrt{I_x}$$

$$\text{HEIGHT} = 4\sqrt{I_y}$$

$$\text{ANGLE} = \arccot\left(\frac{I_x - I_y}{I_{xy}}\right)$$

## Convex Hull

The convex hull of a shape is the convex polygon of minimum area that completely surrounds an object. The convex hull can be used to characterize the object footprint, as well as to observe concavities. Given that the number of vertices of the convex hull is variable, they are stored in a [EPathVector](#) container.

The corresponding function is [ECodedElement.ComputeConvexHull](#).



## Graphic Representation

The objects can be drawn onto the source image by means of [ECodedImage2.Draw](#). The following features also have a graphical representation that can be drawn by the means of [ECodedImage2.DrawFeature](#).

Objects	Graphic	Objects	Graphic
Bounding box		Feret box with an angle of 45°	
Contour		Feret box with an angle of 68°	
Convex hull		Gravity center	
Ellipse		Minimum enclosing rectangle	
Feret box		Weighted gravity center	
Feret box with an angle of 22°			

## Coordinate System and Conventions

### Coordinate system

EasyObject uses a pixel coordinate system where the origin is conventionally at the top left corner of the top left pixel of an image. Consequently, the fractional part of the coordinates of the center of a pixel is ".5". This convention is best suited for the representation of sub-pixel coordinates.

## Angles

According to the mathematical conventions, the angles are now counted inversely: A positive angle brings the X axis on the Y axis.

## Evaluating the features

There is one property per feature, removing the need to access the feature through an **enum**.

## Draw Coded Elements

Once an image has been encoded, the coded elements (object or hole) are accessible through the abstract class `ECodedElement` and a large set of methods:

### To draw coded elements

---

1. **Declare a new `ECodedImage2` object.**
2. **Declare an `EImageEncoder` object** and, if applicable, select and setup the appropriate segmenter and choose the appropriate layer(s) to encode.
3. **Create an output image:** copy, pixel by pixel, the (grayscale) source image into a (color) output image if the drawing of the resulting features has to be colored.
4. **Encode the source image.**
5. **Draw the features for each object in a layer.**
6. Read the result, which can be rounded down. A specific drawing can be created to mark the feature (for example, draw a target for a gravity center).

To render flexible masks use `ECodedElement.RenderMask`.

The objects, holes and their features can be efficiently accessed randomly (in an index-based fashion).

## Flexible Masks in EasyObject

**See also:** [using Code Snippets : Creating Code Snippets](#)

A flexible mask can be generated by any application that outputs BW8 images or uses the Open eVision image processing functions.

EasyObject can use flexible masks to restrict blob analysis to complex or disconnected shaped regions of the image.

If an object of interest has the same gray level as other regions of the image, you can define "keep" and "ignore" areas using flexible masks and `Encode` functions.

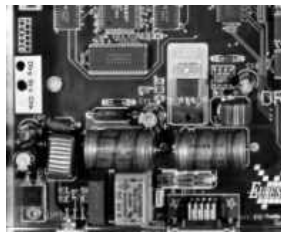
A flexible mask is a BW8 image with the same height and width as the source image.

- A pixel value of 0 in the flexible mask masks the corresponding source image pixel so it doesn't appear in the encoded image.
- Any other pixel value in the flexible mask causes the pixel to be encoded.



## EasyObject functions that create flexible masks

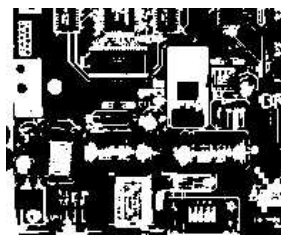
---



Source image

### 1. `ECodedImage2.RenderMask`: from a layer of an encoded image

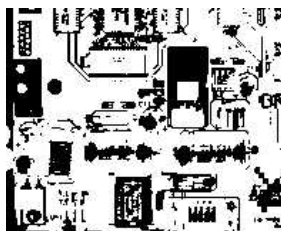
1. To encode and extract a flexible mask, first construct a coded image from the source image.
2. Choose a segmentation method (for the image above the default method `GrayscaleSingleThreshold` is suitable).
3. Select the layer(s) of the coded image that should be encoded (i.e. white and black layers using minimum residue thresholding).
4. Make the mask image the desired size using `mask.SetSize(sourceImage.GetWidth(), sourceImage.GetHeight())`.
5. Exploit the flexible mask as an argument to `ECodedImage2.RenderMask`.



BW8 resulting image that can be used as a flexible mask

### 2. `ECodedElement.RenderMask`: from a blob or hole

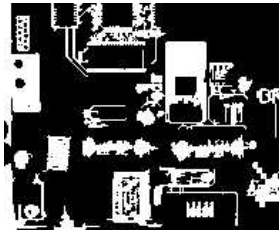
1. Select the coded elements of interest.
2. Create a loop extracting a mask from selected coded elements of the coded image using `ECodedElement.RenderMask`.
3. Optionally, compute the feature value over each of these selected coded elements.



BW8 resulting image that can be used as a flexible mask

### 3. EObjectSelection.RenderMask: from a selection of blobs

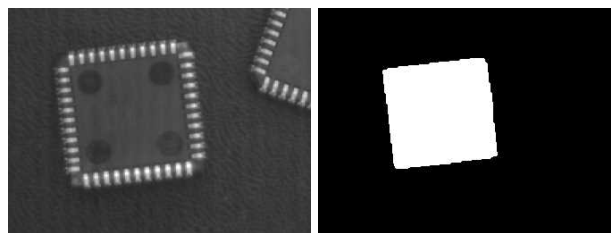
EObjectSelection.RenderMask can, for example, discard small objects resulting from noise.



BW8 resulting image that can be used as a flexible mask

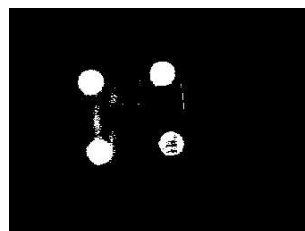
#### Example: Restrict the areas encoded by EasyObject

---



Find four circles (left) Flexible mask can isolate the central chip (right)

1. Declare a new [ECodedImage2](#) object.
2. Setup variables: first declare source image and flexible mask, then load them.
3. Declare an [EImageEncoder](#) object and, if applicable, select the appropriate segmenter. Setup the segmenter and choose the appropriate layer(s) to encode.
4. Encode the source image. Encoding a layer with just the area in the flexible mask is then pretty straightforward.  
We see that the circles are correctly segmented in the black layer with the [grayscale single threshold segmenter](#):



5. Select all objects of the coded image.
6. Select objects of interest by filtering out objects that are too small.
7. Display the blob feature by iterating over the selected objects to display the chosen feature.

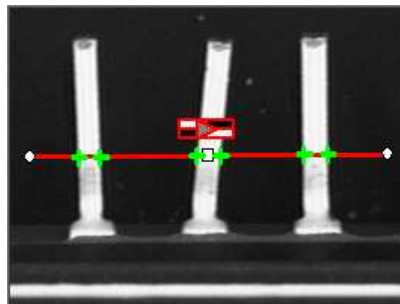
## 4.2. EasyGauge - Measuring down to Sub-Pixel

### Workflow

#### EasyGauge

---

**EasyGauge** library controls dimensions. It accurately determines position, orientation, curvature and size of parts. It can interact graphically to place and size gauges, combine them in grouped hierarchies, and store and retrieve them with all their parameters.



#### TIP

The theoretical best-case precision is 1/64th pixel for all **EasyGauge** operators. In practice, you can assume a precision of 1/10th pixel.

#### Workflow

---

The gauge model can be built programmatically or in a graphical editor, then "played" in the final application.

Choose the workflow that matches the complexity of your model and the accuracy required: uncalibrated, calibrated or grouped.

#### [Uncalibrated Gauging: for a simple model](#)

**EasyGauge** basic use is straightforward.

- a. Create a gauge object that corresponds to the required measurement.
- b. Change the parameters whose default values are not appropriate.
- c. Invoke the desired measurement function.
- d. Read the resulting position parameters.

**Uncalibrated gauging** is easy to implement but has several drawbacks:

- Measurements are performed in pixels, not millimeters.
- Measurement models are not portable: gauge positions and sizes must be reworked if viewing conditions change.
- Optical distortion or perspective causes inaccurate measurements.

## Calibrated gauging: for one or two simple measurement sites

Calibrated gauging is more accurate, and measures the inspected parts independently of the viewing conditions.

All measurements are taken in the calibrated units, with any distortion implicitly compensated. Refer to Calibration to learn how to master field-of-view calibration.

- a. Create a calibrator object.
- b. Place it on the inspected scene.
- c. Adjust calibration parameters.
- d. Attach a gauge.

## Complex Gauging

Gauges can be grouped (see Gauge Manipulation Processes) and attached to another item:

- *Attaching gauges to an EFrameShape* object moves the gauges with the frame (translation and/or rotation), the application program must adjust the frame position to track the inspected part.
- *Attaching gauges to another gauge* moves them according to the measured position of the supporting gauge. For example, if gauges are attached to a common rectangle gauge that is detecting the outline of a part, all gauges automatically track the part when the rectangle outline is fitted.

If using several measurement sites, you can save the complete model, with calibration modes, coefficients, and attached gauges, in a single file.



### NOTE

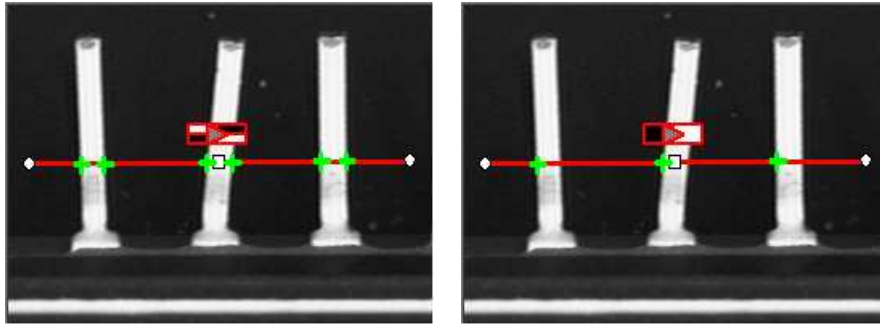
Unlike the rest of **Open eVision**, **EasyGauge** uses a pixel center origin (see "[Image Coordinate Systems](#)" on page 11). The subpixel coordinate (0, 0) is the center of the upper left pixel of the image.

## Gauge Definitions

### Point gauge

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You can select the most relevant transition points along a line segment probe that crosses one or several objects edges. Crosswise and lengthwise filtering can be activated for noise reduction.



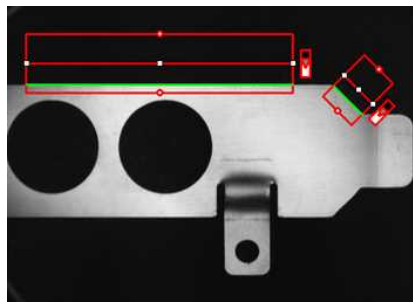
Point location. Contrast-based selection

## Usage

- Define and position the gauge, then fit the points with [Measure](#).
- Use the methods [EPointGauge.GetNumMeasuredPoint](#) and [EPointGauge.GetMeasuredPoint](#) to access the results.

## Line gauge

The placement of a [line gauge](#) is defined by its [center coordinates](#), its [length](#) and its [angle](#) with respect to the X-axis. To constrain the line slope value, set [Angle](#) and [KnownAngle](#).



Line fitting

## Usage

- Define and position the gauge, then use [Measure](#) to fit the lines.
  - The method [ELineGauge.GetFound](#) returns TRUE if a suitable line is found.
  - To obtain the [line properties](#), set the [ActualShape](#) property to TRUE to return the fitted line (TRUE value) (instead of the nominal line position FALSE value, default).
- Alternatively, [MeasuredLine](#) provides the results as an [ELine](#) object.

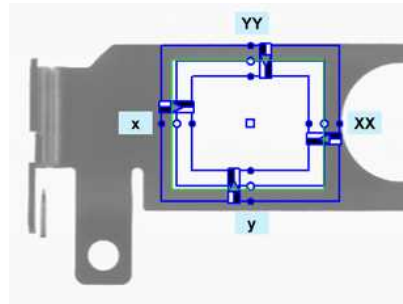
## Rectangle Gauge

The placement of a [rectangle gauge](#) is defined by its nominal position (given by the coordinates of its [center](#)), its [nominal size](#) and its [rotation angle](#).

Each side of a rectangle can have its own transition detection parameters, and can be set to active or inactive with the [ActiveEdges](#) property. When a side is active:

- setting the value of a parameter only applies to the currently active sides<sup>1</sup>.
- getting the value of a parameter yields a result only when the value of this property is the same for all active sides.
- only active sides are used for measurement and model fitting.

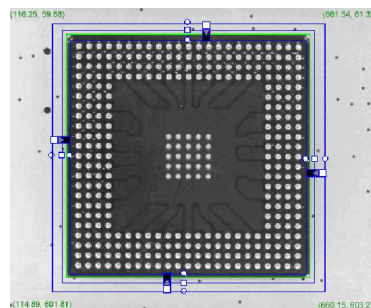
These rules allow to set different parameters for different sides, and measure parallel sides or a corner point instead of the whole rectangle. The four sides are denoted by letters "x", "y", "XX" and "YY" respectively.



Naming conventions for the sides of a rectangle gauge

## Usage

- Define and position the gauge, then use [Measure](#) to fit the lines.
  - The method [ERectangleGauge.GetFound](#) returns TRUE if a suitable rectangle is found.
  - To obtain the [rectangle properties](#), set [ActualShape](#) to TRUE to return the fitted line (TRUE value) (default is FALSE).
- Alternatively, [MeasuredRectangle](#) provides the results as an [ERectangle](#) object.
- For instance, you can accurately locate the four corners (landmarks) of a rectangle using a rectangle fitting gauge.



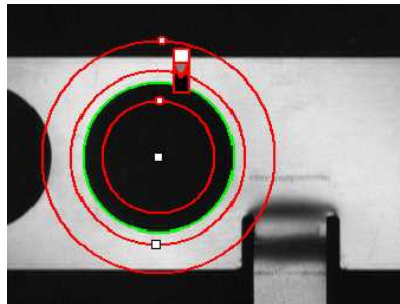
Locating a rectangle's corners

## Circle gauge

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The placement of a [circle gauge](#) is defined by its nominal position (given by the coordinates of its [center](#)), its nominal [diameter](#) (or [radius](#)), the angular position from where it extends and its angular [amplitude](#).

The Set member can distinguish between a full circle and an arc (the arc amplitude must be specified).



Circle fitting

## Usage

- Once the gauge has been defined and positioned, use [Measure](#) to trigger the circle fitting operation.
  - The method [ECircleGauge.GetFound](#) returns TRUE if a suitable rectangle is found.
  - To obtain the measurement results, set the [ActualShape](#) mode to TRUE. The [ActualShape](#) mode determines whether an inquiry returns the fitted circle (TRUE value) or the nominal circle position (FALSE value, default).
  - The requested information is then retrieved by means of the [circle properties](#).
- Alternatively, [MeasuredCircle](#) provides the results as an [ECircle](#) object.

## Wedge gauge

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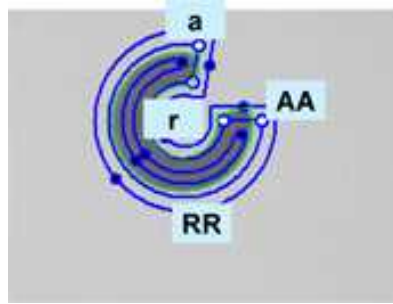
The placement of a [wedge gauge](#) is defined by its nominal position (given by the coordinates of its [center](#)), its nominal [inner](#) and [outer radius](#) ([inner](#) and [outer diameter](#)), its [breadth](#) (difference between radii), the [angular position](#) from where it extends and its [angular amplitude](#).

The Set member can distinguish between a full ring, a sector of a ring and a disk.

Each side of a wedge can have its own transition detection parameters and can be set to active or inactive with the [ActiveEdges](#) property. When a side is active, this means that:

- setting the value of a parameter only applies to the currently active sides;
- getting the value of a parameter yields a result only when the value of this parameter is the same for all active sides;
- only active sides are used for measurement and model fitting.

So different sides can have different parameters, and you can measure parallel arcs or oblique sides, or a corner point, instead of the whole wedge. The four sides are denoted by letters "a", "r", "AA" and "RR" respectively.



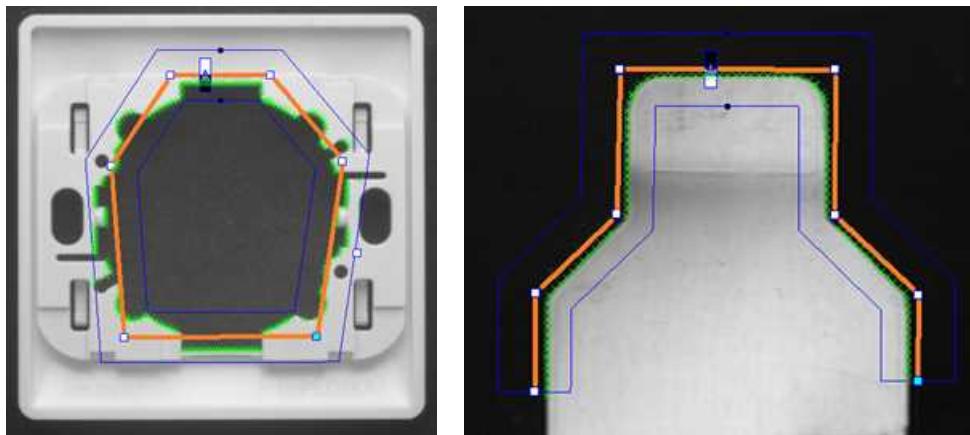
Naming conventions for the sides of a wedge gauge

## Usage

- Define and position the gauge, then use [Measure](#) to fit the lines.
  - The method [EWedgeGauge.GetFound](#) returns TRUE if a suitable rectangle is found.
  - To obtain the [wedge properties](#), set the [ActualShape](#) property to TRUE to return the fitted line (instead of the nominal line position FALSE, default).
- Alternatively, [MeasuredWedge](#) provides the results as an [EWedge](#) object.

## Polygon gauge

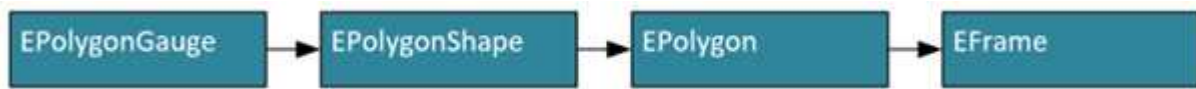
- A polygon is defined as a list of connected vertices, forming a closed or an open shape. [EPolygonGauge](#) computes several transition points along each edge of the polygon, like with a line gauge. Then from these transition points, a measured polygon is computed with a strategy depending on the measurement mode.



In orange, the closed or open polygon gauge and, in green, the measured transition points



- The position of the vertices of the polygon are defined in the local [EFrame](#) of the polygon.
  - An [EFrame](#) is a coordinate system, with a position, an orientation and a scale.
  - The class [EPolygon](#) stores the vertices and other attributes.
  - The class [EPolygonShape](#) handles the hierarchy of the shapes and the drawing methods.
  - The class [EPolygonGauge](#) is the main class for the measurement process.

Class dependency of the class [EPolygonGauge](#)

- To setup the polygon geometry, use the following methods:
  - [EPolygon.SetCenter](#) (derived from [EPoint.SetCenter](#)), [EPolygon.SetAngle](#) (derived from [EFrame.SetAngle](#)) and [EPolygon.SetScale](#) (derived from [EFrame.SetScale](#)) to change the [EFrame](#) reference coordinate system.
  - [EPolygon.SetIsClosed](#) to choose between close or open polygon configuration.
  - [EPolygon.AppendVertex](#) to add a new vertex to the polygon.
  - [EPolygon.SetVertex](#) to change the position (x, y) of a vertex.
  - [EPolygon.InsertVertex](#) to insert a vertex before the given index.
  - [EPolygon.RemoveVertex](#) to remove a vertex at the given index.
  - [EPolygonShape.AddVertexAtDisplayPosition](#) to insert a vertex depending on a display coordinate (typically a mouse click). This is useful for the graphical edition of a polygon.
  - [EPolygonShape.RemoveVertexAtDisplayPosition](#) to remove the closest vertex to a display coordinate.

**TIP**

[EPolygonGauge](#) has 3 measurement modes [EPolygonMeasurementMode](#).

The typical use cases are:

- For [Global](#): the precise positioning of parts.
- For [Edge](#): the verification of specific shapes defined by angles and lengths.
- For [Point](#): the measure of complex object contours.

- Use the method `EPolygonGauge.SetMeasurementMode` to select the measurement mode:
  - **Global**: The position, the orientation and optionally the scale of the polygon (`EFrame`) are adjusted to fit the detected transition points.

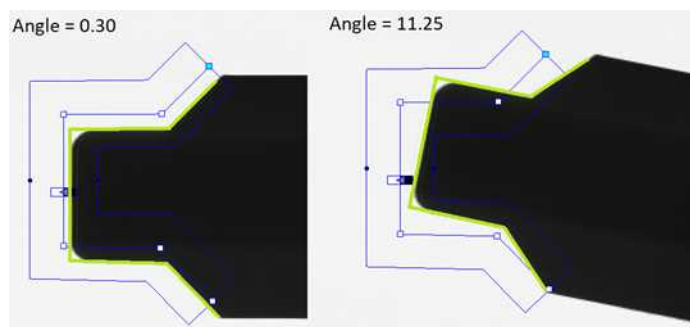
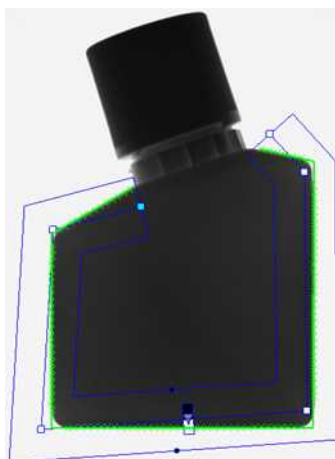


Illustration of the Global measurement mode:  
the measured polygon is a translation and a rotation of the input polygon

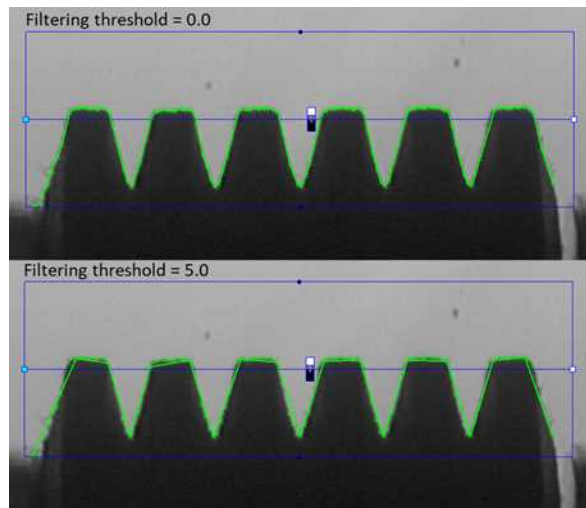
By default, the global transformation is rigid:

- Only the translation and the rotation are optimized to match the contour of the object.
- If scaling is required, you must explicitly enable it with the method `EPolygonGauge.SetEnableScaling`.
- The global measurement doesn't change the polygon vertex positions, it only adjusts the polygon frame.
- **Edge**: Each polygon edge is measured individually.
  - A polygon composed by the union of these fitted edges is generated.
  - The number of edges of the measured polygon is the same as the input polygon.



The input polygon (blue) and the fitted polygon (green)

- **Point**: All transition points on the object contour are used to build a new polygon, with an optimized number of edges.
  - The resulting polygon is simplified using a filtering threshold to reduce the number of edges while keeping the shape of the object.
  - The resulting number of edges depends on the geometry of the contour of the object and on the filtering threshold.
  - Set the filtering threshold with `EPolygonGauge.SetFilteringThreshold`.



A polygon gauge with a single edge produces a measured polygon that follows the contour of the object. Depending on the filtering threshold, the number of vertices is reduced.

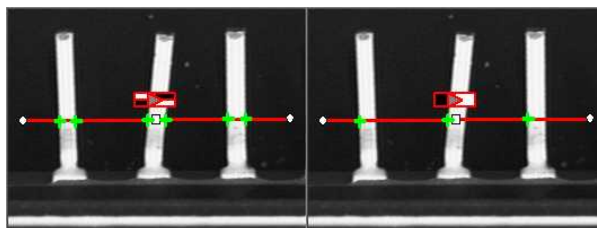
- Other parameters of the class [EPolygonGauge](#).
  - The class [EPolygonGauge](#) inherits other common **EasyGauge** parameters:
    - [EPolygonGauge.SetNumFilteringPasses](#) sets the number of filtering passes, then removes outliers before the line fitting operation. This parameter is only available in Global et Edge measurement modes.
    - [EPolygonGauge.SetMinNumFitSamples](#) sets the minimum number of samples required for the fitting on each edge of the polygon. The measure fails if the minimum is not achieved.
    - [EPolygonGauge.SetTransitionType](#) sets the transition type ([ETransitionType](#)): white to black, black to white or both.
    - [EPolygonGauge.SetTransitionChoice](#) selects which peak is used when there are several transitions.
    - [EPolygonGauge.SetSamplingStep](#) gives the distance, in pixels, between two sample points.

### Usage

- Sets the parameters of the gauge, then use [EPolygonGauge.Measure](#) to fit the polygon.
  - The method [EPolygonGauge.GetFound](#) returns TRUE if a suitable polygon is found.
  - To obtain the polygon geometry, use the method [EPolygonGauge.GetMeasuredPolygon](#).

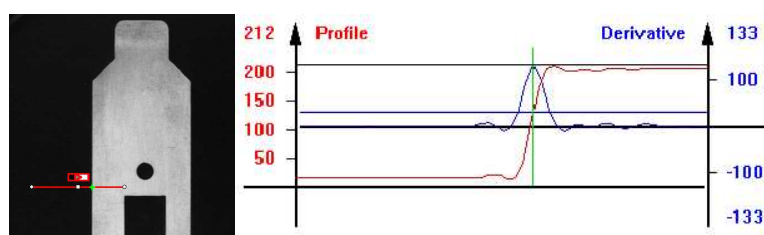
## Find Transition Points Using Peak Analysis

Finds the position of all transition points along a line segment probe that crosses one or several objects edges, and allows selecting the most relevant ones. Crosswise and lengthwise filtering can be activated for noise reduction.



Point location. Contrast-based selection

## Point Location principle



Point location principle (left) and S-shaped curve and its derivative (right)

On a linear profile extracted from an image, an edge appears as a transition from dark to light (or vice versa). When plotting pixel values along the gauge, this transition appears as an S-shaped curve. The first derivative of this curve exhibits a peak around the transition point. The better the contrast, the sharper the transition and the higher the peak.

EasyGauge extracts the pixel values along a profile (red curve) then uses peak analysis to determine the transition location. All the pixel values in the peak [area1](#) are used to compute the transition location.

- Sub-pixel accuracy is only possible if the transition is surrounded by almost uniform regions of at least 2 pixels wide.
- [BWB2](#) transitions have an increasing profile curve and the peak takes positive values. Otherwise, the curve decreases and the peak extends negatively.
- You cannot normally detect peaks using the default threshold value (20) as BWB or WBW transitions base the peak analysis on the gray level profile along the EPointGauge (or sample path) and not its first derivative.

[EPointGauge](#) contains all point measurement parameters, with default values that detect reasonably contrasted edges.

<sup>1</sup>Area between the derivative curve and a horizontal user-defined threshold level

<sup>2</sup>Black / White / Black

## EPointGauge parameters

**Center:** Nominal point position (will normally be different before and after measurement).

**Tolerance:** Tolerance value and gauge orientations.

**TransitionType, TransitionChoice, TransitionIndex:** Peak selection strategies.

**Threshold:** Noise immunity.

**MinAmplitude, MinArea:** Peak strength.

**Thickness, Smoothing:** Local filter widths.

**RectangularSamplingArea** Sets sampling area (rectangular by default) to transverse filtering mode.

**Measure:** Measures the object.

- In single transition mode, **Valid** returns True when an appropriate point was found. To obtain measurement results, set **ActualShape** to True so that **Center** returns the located point. (False default value returns nominal point position ).

- In multiple transition mode, **NumMeasuredPoints** returns the number of points found, **GetMeasuredPoint** returns an **EPoint** object which contains located point information.

An integer index between 0 and **GetNumMeasuredPoints**-1 must be passed.

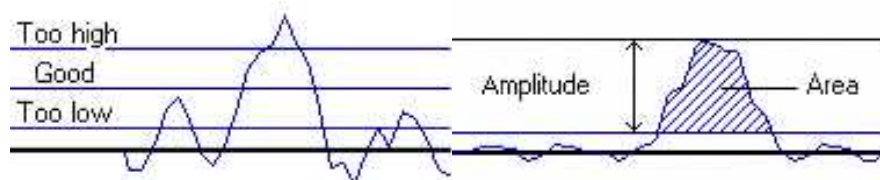
**GetMeasuredPeak:** Returns **EPeak** containing the peak's **Area** and **Amplitude**, and the delimiting coordinates along the probe segment (**Start**, **Length** and **Center** values).

## Select Peaks to improve edge precision

The threshold level is very important:

- Too high can cause significant peaks to be missed, and insufficient pixel values to achieve good precision.
- Too low can cause false peaks because of noise.

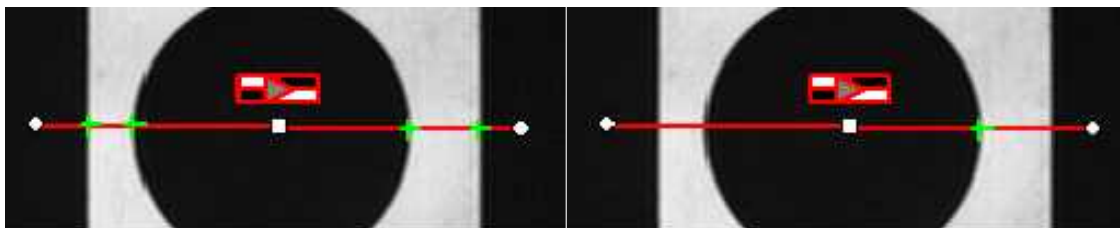
To resolve this dilemma, the EasyGauge peak selection mechanism can reject low contrast or false edges: transition strength is measured by peak *amplitude* and *area*. Every edge measurement determines peak amplitude and area. If either value falls below the **minimum amplitude** or **minimum area**, the peak is disregarded and no point is assumed at that location.



Threshold level selection (left) and Peak amplitude and area (right)

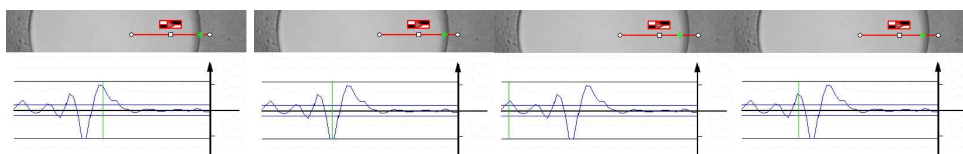
## Multiple versus single transition

EasyGauge can measure several edge points in a single go and retrieve all results afterwards while in *multiple transition mode*.



Multiple transition (left) versus single transition (right)

You can select the single most relevant transition based on 4 criteria: the highest peak, the peak with the largest area, the peak closest to the gauge center, or the N-th peak encountered starting from one tip of the gauge.

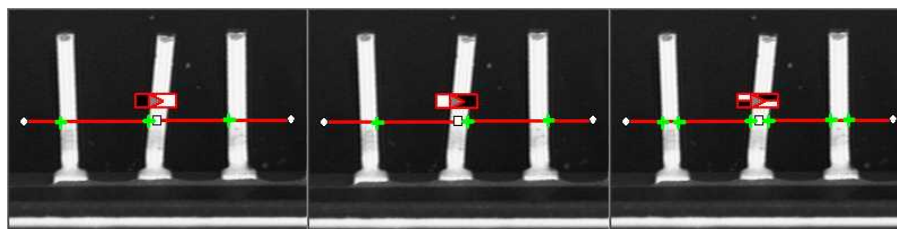


Choice: (1) best area, (2) best amplitude, (3) closest, (4) 3rd from the start

**NOTE:** When several peaks have the same value (same area, same amplitude...), the last peak is selected.

### Positive or negative peak selection

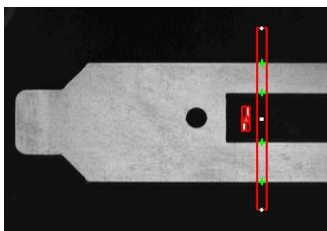
Peak selection can also be refined by choosing the transition polarity: White to Black or Black to White (i.e. positive or negative peak), or indifferent.



Black to white, white to black or indifferent polarities

### Prefiltering

Prefiltering the image locally can reduce noise effects. Transverse (lengthwise) filtering averages several parallel lines when sampling the image. Longitudinal (crosswise) uniform filtering can also be applied to the resulting profile curve.



Thick point gauge for filtering

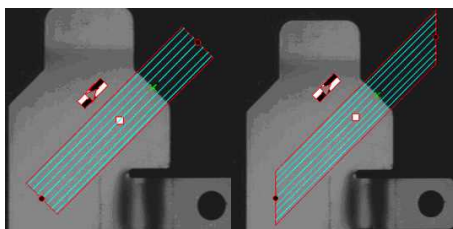
## Transverse Filtering

Transverse filtering places parallel line segments in either a parallelogram or a rectangle (default). This behavior can be toggled.

Parallelogram mode is faster than rectangular if the angle is close to  $0^\circ$  or  $90^\circ$ , or thickness is less than 5. If thickness=1, no difference exists between the two modes.

**thickness** determines the number of parallel lines.

**sampling area** is the smallest region containing all the parallel line segments.



Rectangular sampling area (left) and Parallelogram sampling area (right)

## Point Probe Position

The expected **nominal** position of a point gauge is specified by its **center**, orientation **angle** with respect to the X-axis, and length **tolerance** that the point position can vary.

The results are the coordinates of the located points (the **actual** location) and the strength of the transition (amplitude and area).

Low values indicate a weak edge, possibly corresponding to an unreliable or inaccurate measurement.

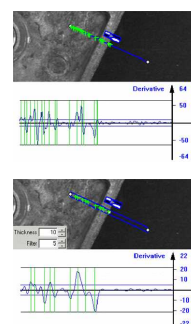
## Tuning Point Measurement Parameters for unclear edges

The EasyGauge default parameters and working modes are good for clear edges. More complex situations may need parameter tuning.

### 1. Set the gauge point location and tolerance.

The center position and orientation are easy to decide based on a sample image or on coordinate considerations. The tolerance depends on the edge position variations. A larger tolerance increases the likelihood of hitting an edge, but it may be a false edge or extraneous feature.

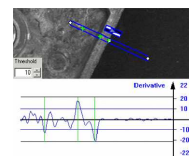
**2. Decide whether noise reduction is required.** Lay the gauge over the desired location and observe the profile curve and its derivative (play with the filtering parameters while looking at the plotted curve). The curve regularity gives an indication of the spread of the gray-level values.



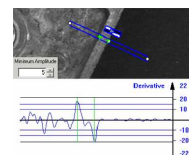


When these coefficients are set, the gray-level profile will not change anymore.

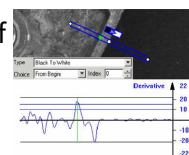
**3. Set the threshold value** to be low enough for useful parts of the peaks to cover enough pixels (to achieve better sub-pixel accuracy), but not lower than the ambient image noise.



**4. Remove weak or false edges** using the list of peak amplitudes and areas. Plotting these values along with good and extraneous peaks can help find appropriate peak rejection limits.



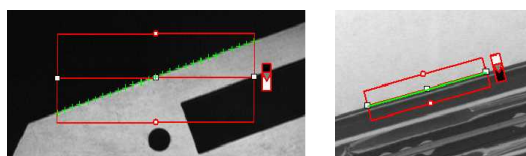
**5. Choose whether all transition points are needed or just the most relevant.** If all are required, they can be queried one after another. Otherwise, a point selection strategy should be chosen based on strength, order or transition polarity (black to white and/or conversely).



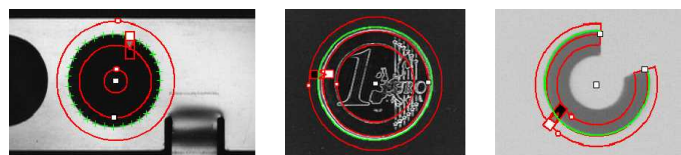
## Find Shapes Using Geometric Models

The predefined geometric models [ELineGauge](#), [ECircleGauge](#), [ERectangleGauge](#), [EWedgeGauge](#) or [EPolygonGauge](#) can be fit over the edges of an object. The targeted edge must be defined, and points sampled along it at regularly spaced point measurement gauges. Model fitting in the least square sense can be applied.

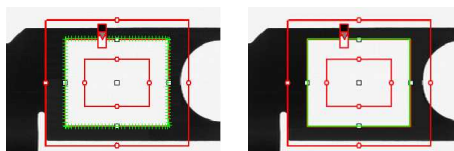
- **Line:** Measures position and orientation of straight edges.



- **Circle:** Measures position and curvature of a circle or arc.

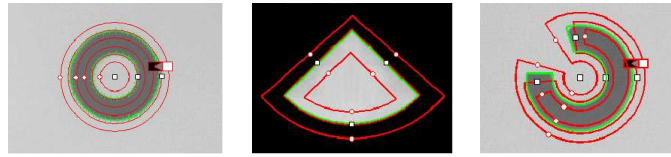


- **Rectangle:** Measures position, orientation and size of a rectangle.

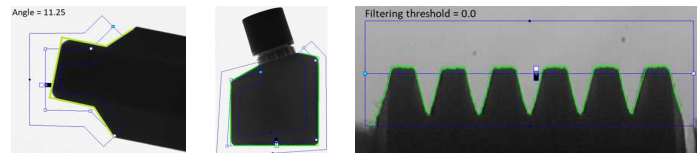




- **Wedge:** Measures position, orientation and size of a ring/ disk sector / curvilinear rectangle.

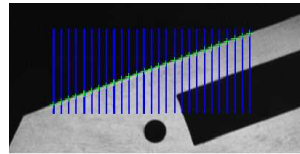


- **Polygon:** Fits a polygon to an object and measures the exact position of the polygon, the relative orientation of the edges or the path of the contour.



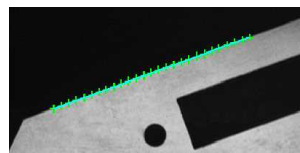
All gauge types share these common features:

- **Point sampling**
  - Point gauges are placed along the edges and point measurement carried out at regularly spaced spots, which can be adjusted differently per side in rectangle and wedge gauges. All point measurement parameters and operating modes are available.
  - **SamplingStep** sets the spacing of point location gauges along the model.
  - **NumSamples** returns the number of points sampled during the model fitting operation.



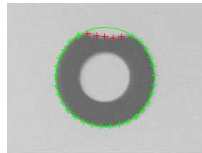
Sampling paths and sampled points

- **Model fitting**
  - The model is adjusted to minimize error residue and provide the best edge parameter estimates. Rectangles and wedges have parallelism and concentricity constraints. Image shows sampled points and fitted line.



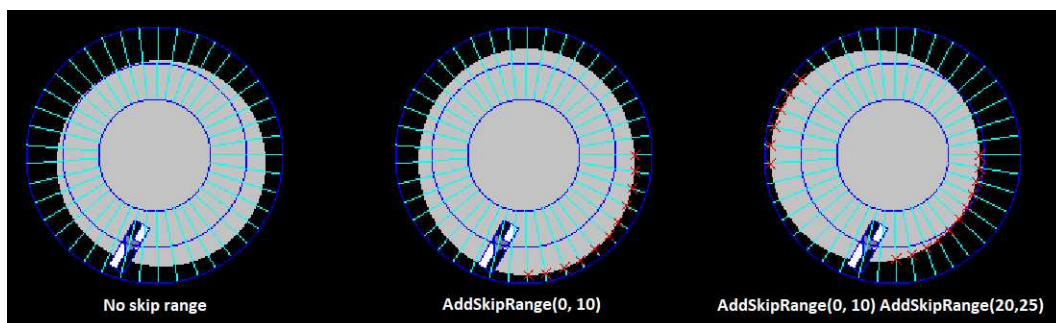
- **Outlier rejection**

- After model fitting, some points will be too far away from the fitted model and may harm location accuracy. EasyGauge can tag them as outliers to be ignored using the [FilteringThreshold](#) property.
- The outlier elimination process can be repeated several times using [NumFilteringPasses](#). The number of valid sample points remaining after a model fitting operation is kept in [NumValidSamples](#). The average distance of these points to the fitted model is returned by [AverageDistance](#).



- **Skip range**

- The skip ranges define exclusion ranges for the paths. The sample point indexes in the skip ranges are not taken into account to fit the model.
- The skip ranges apply to all gauge models: [line](#), [circle](#), [rectangle](#), [wedge](#) and [polygon](#).
- To define several skip ranges, use [AddSkipRange](#).
- To manage the skip ranges, use [RemoveSkipRange](#), [RemoveAllSkipRanges](#) and [GetSkipRange](#).
- You must call the method [Measure](#) to take a skip range into account.
- Use the attribute [EDrawingMode\\_PointsInSkipRange](#) with the method [Draw](#) to display the skipped points.



## Gauge Manipulation: Draw, Drag, Plot, Group

**EasyGauge** provides means to graphically interact with gauges to place and size them, combine them as a hierarchy of grouped items, and store/retrieve them and all working parameters to/from model files.

### Draw

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[Draw](#) gives a graphical representation of a gauge. Drawing is done with the current pen in the device context associated with the desired window. Depending on the operation, handles may be displayed.

## Drag

---

An operator can drag a gauge interactively over an image. Several dragging handles are available.

- HitTest determines when the mouse cursor is over a handle. When it is, the cursor shape should be changed for feedback, and a drag can take place.
- Drag moves the handle and the corresponding gauge accordingly.

In addition, if you are interacting with a polygon gauge, you can:

- Use the method `EPolygonGauge.AddVertexAtDisplayPosition` (derived from `EPolygonShape.AddVertexAtDisplayPosition`) to create a new vertex at a chosen position (typically at a mouse click)
- Use the method `EPolygonGauge.RemoveVertexAtDisplayPosition` (derived from `EPolygonShape.RemoveVertexAtDisplayPosition`) to remove a vertex.

## Plot

---

EasyGauge can Plot gray-level values along the sampled paths and/or its derivative - useful for parameter tuning.

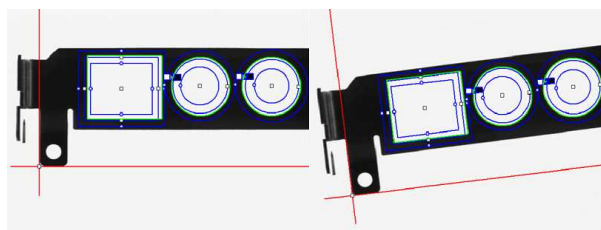
- Point measurement gauges can plot after calling `Measure`.
- Model fitting gauges can plot after calling `MeasureSample` with an index argument that lies between 0 and `GetNumSamples-1` (included).
- To view the corresponding sampling path, use the method `Draw` with mode `EDrawingMode_SampledPath`.

## Group

---

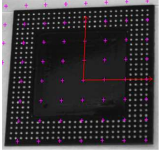
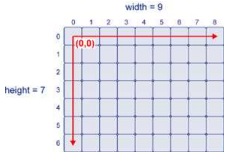
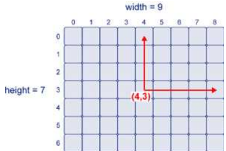
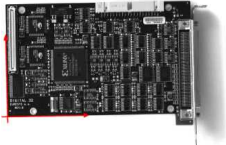
Measurement gauges can be grouped (their relative placement remains fixed) to form a dedicated tool that can be moved (translated and rotated) to follow the movement of inspected items / probes before computing measurements.

- `Attach` associates a gauge to a mother gauge or `EFrameShape` object.
- `NumDaughters`, `GetDaughter`, or `Mother` retrieves information relative to attached daughters or mother.
- `Detach`, `DetachDaughters` dissociates the gauge or daughters from the mother.



# Calibration and Transformation

## Field-of-view calibration

<p>Calibration establishes the relationship between real-world point coordinates and image pixels. A simple calibration model computes faster, a repeatable part position is easier to locate.</p>	
<p><b>The Raw sensor</b> coordinate system starts from upper left and extends rightwards and downwards. The range of abscissas is 0 to width-1 and the range of ordinates is 0 to height-1 where integer coordinate values correspond to pixel centers.</p>	
<p><b>The Centered sensor</b> coordinate system starts at the center (<math>([width-1]/2, [height-1]/2</math> in the Raw system) and extends rightwards and upwards.</p>	
<p>The real world 3D coordinates are defined in a 2D reference frame tied to a reference plane. The origin and direction of the axis are normally aligned with major features of the inspected parts.</p>	

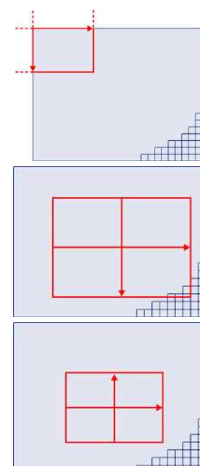
## Before World-to-Sensor Transform

Before converting from world to sensor coordinates, sources of distortion should be eliminated:

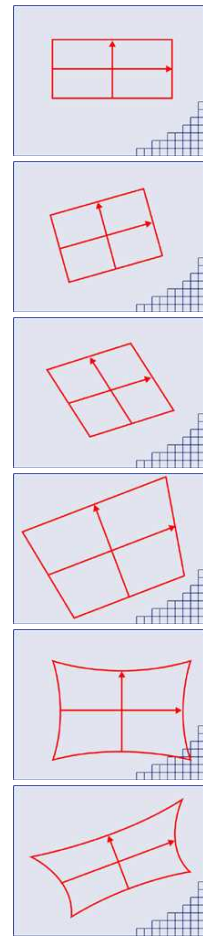
- adjust sweep frequency or scanning speed to avoid non-square pixels.
- adjust optical alignment to minimize perspective effect. The field of view should be parallel to the sensor plane.
- use long focal distances and good quality lenses to minimize Optical distortion.
- use appropriate scale factor based on lens magnification, observation distance and focusing.
- minimize skew and translation effects by secure fixtures, and part-movement / acquisition-triggering synchronization.

## Effects of World-to-Sensor Transform

- **No calibration.** World and sensor coordinates are identical.
- **Translated calibration:** The coordinate origin can be moved. World coordinates correspond to pixel units.
- **Isotropic scaling** (square pixels). A scale factor converts pixel values to physical measurements.



- **Anisotropic scaling** (non-square pixels). Uses two scale factors with pixel aspect ratio ( $X/Y$ ) in the range  $[-4/3, -3/4]$  (or  $[3/4, 4/3]$ ). Pixels are always displayed as square, so the image appears stretched.
- **Scaled and skewed** (square pixels). Real-world axis aligns with rotated inspected part using translation, rotation and scaling.
- **Scaled and skewed** (non-square pixels). Distortion is apparent. Occurs when camera scan speed does not match pixel spacing.
- **Perspective distortion** causes further away objects to look smaller; lines remain straight but angles are not preserved.
- **Optical distortion** causes cushion or barrel appearance of rectangles.
- **Combined distortions** result in a complex, non linear, transform from real-world to sensor spaces.



## Calibration Using EWorldShape

The EWorldShape object can calibrate the whole field of view (in given imaging conditions with fixed camera placement and lens magnification), if the optical setup is modified.

EWorldShape computes appropriate calibration coefficients and transforms measurement gauges that are tied to it.

It can set world-to-sensor transform parameters, perform conversions from and to either coordinate system, determine unknown calibration parameters, and save the parameters of a given transform for later reuse.

After calibration EWorldShape can perform coordinate transform for arbitrary points using SensorToWorld and WorldToSensor to:

- measure non-square pixels and rotated coordinate axis.
- correct perspective and optical distortion, with no performance loss.

There are several ways to obtain the calibration coefficients:

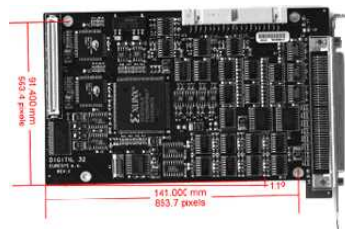
## Estimate (feasible if no distortion correction is required and accuracy requirements are low)

To estimate the calibration coefficients either locate the limits of the field of view and divide the image resolution by the field of view size, or use the following procedure:

1. Take a picture of the part to be inspected or a calibration target (e.g. rectangle).
2. Locate feature points such as corners in the image (by the eye) and determine their coordinates in pixel units —let  $(i, j)$ .
3. Use the euclidean distance formula to derive the calibration coefficient:  $C = \frac{\sqrt{(i_1 - i_0)^2 + (j_1 - j_0)^2}}{D}$  where C is a calibration coefficient, in pixels per unit, and D is the world distance between the corresponding points, in units.
4. For non-square pixels repeat this operation for pairs of horizontal and vertical points.

To estimate a skew angle, apply this formula to two points on the X-axis in the world system:

$$\theta = \arctan \frac{j_1 - j_0}{i_1 - i_0}$$



Estimating scale factors and skew angle

When the calibration coefficients are available, use `SetSensor` to adjust them and set the calibration mode, or set them individually using: `SetSensorSize`, `SetFieldSize`, `SetResolution`, `SetCenter`, `SetAngle`.

## Pass a set of reference points (landmarks) to a calibration function

Locate at least 4 landmarks and obtain their coordinates in sensor (using image processing) and world coordinate systems (actual measurements). More landmarks give more accurate calibration.

The resulting pixels aspect ratio (X resolution / Y resolution) must be in the range  $[-4/3, -3/4]$  (or  $[3/4, 4/3]$ ).

Use the method `EWorldShape::AddLandmark` to add reference points, then use `EWorldShape::AutoCalibrateLandmarks` to calculate the calibration.

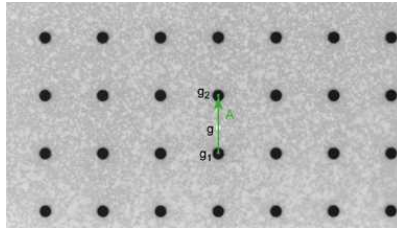
## Analyze a Calibration target

A calibration target can be automatically analyzed to get an appropriate set of landmarks. It is an easy way to achieve automatic calibration, provided an appropriate procedure is available to extract the desired landmark point coordinates.

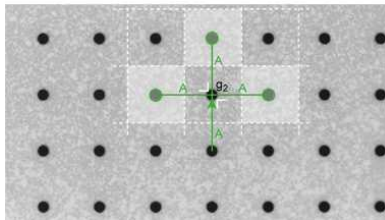
Open eVision relies on the use of a specific target holding a rectangular grid of symmetrical dots (of any shape) with no other object on the grid.

### Dot Grid based calibration example

1. Grab an image of the calibration target in such a way that it covers the whole field of view (or restricts the image of view to an ROI where only dots are visible).
2. Apply blob analysis to extract the coordinates of the centers of the dots, as can be done by [EasyObject](#).
3. Pass all points detected to [AddPoint](#) (sensor coordinates only).
4. Call [RebuildGrid](#) to reconstruct a grid to calibrate a field of view using an iterative algorithm which computes the world coordinates of each dot.
  - a. The grid points nearest to the gravity center ( $g$ ) of grid points are selected ( $g_1$  and  $g_2$ ) to form the first reference oriented segment, of length  $A$ .



- b. Starting from the extremity of the reference segment ( $g_2$ ), the algorithm determines 3 tolerance areas (white squares in the figure), in perpendicular directions. The tolerance areas are centered at a distance  $A$  (length of the reference segment) from ( $g_2$ ). They are square, with a side-length of  $A$ .  
The algorithm searches for 1 neighboring point, in each of the 3 tolerance areas.  
The grid will be correctly calibrated if each tolerance area contains a neighboring point.

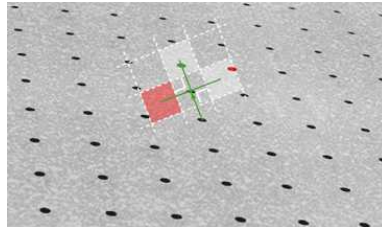


- c. The 3 perpendicular segments are the references of the next iterative searches. The algorithm goes back to step 2.
5. Call Calibrate.



If the grid exhibits too much distortion, grid reconstruction does not work as expected. The following errors could happen:

1. A tolerance area does not contain a neighboring point (red square in the figure).
2. A tolerance area contains more than one neighboring point.
3. The point in the tolerance area is not the correct one. For instance, the point might be diagonally connected (red point in the figure).



#### TIP

Use the method `EWorldShape::AutoCalibrateDotGrid` to automatically perform the process above.

## Advanced Features

The field-of-view calibration model can be tuned using these parameters:

### Sensor width and height

---

The [sensor width](#) and [sensor height](#) give the logical image size, in pixels (always integers).

### Field-of-view width and height

---

The [field-of-view \(f-o-v\) width](#) and [height](#) give the actual image size, in length units, i.e. the size of the rectangle corresponding to the image edges in the world space. These values are related to the pixel resolution by the following equations:

$$\begin{aligned} f\text{-}o\text{-}v \text{ width} &= \text{pixel width} * \text{sensor width} \\ f\text{-}o\text{-}v \text{ height} &= \text{pixel height} * \text{sensor height} \end{aligned}$$

or

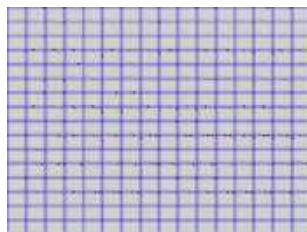
$$\begin{aligned} \text{sensor width} &= f\text{-}o\text{-}v \text{ width} * \text{horizontal resolution} \\ \text{sensor height} &= f\text{-}o\text{-}v \text{ height} * \text{vertical resolution} \end{aligned}$$

By default pixel height is not specified, the pixels are assumed to be square (pixel width = pixel height).



## Ratio

---



Anisotropic aspect ratio

## Center abscissa and ordinate

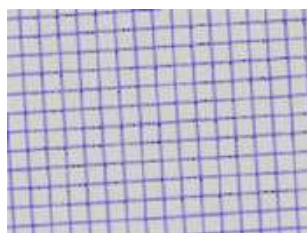
---

The **center abscissa** (x) and **ordinate** (y) indicate the image origin point (world coordinates (0,0)). Default is the image center.

## Skew angle

---

The **skew angle** is the angle formed by the real-world reference frame (X-axis) and the image edge (horizontal). The default is no skew.



Skew angle



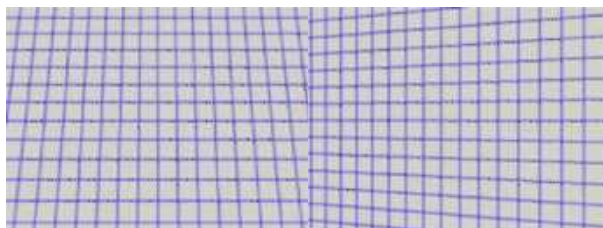
### NOTE

When the pixels are not square, the [EWorldShape](#) object can convert the angle between the world and sensor spaces.

## X and Y tilt angles

---

The **X** and **Y** tilt angles describe the viewing plane direction. They correspond to the required rotations around X and Y axis that bring the Z axis parallel to the optical axis.

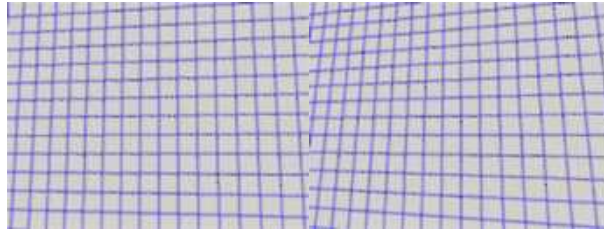


Tilt X and tilt Y angles

## Perspective strength

---

The **perspective strength** gives a relative measure of the perspective effect. The shorter the focal length, the larger the value.

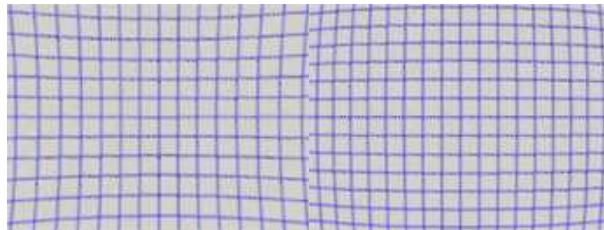


Weak and strong perspective

## Distortion strength

---

**Distortion strength** gives a relative measure of radial distortion in the image corners, that is the ratio of image diagonal length with and without distortion.

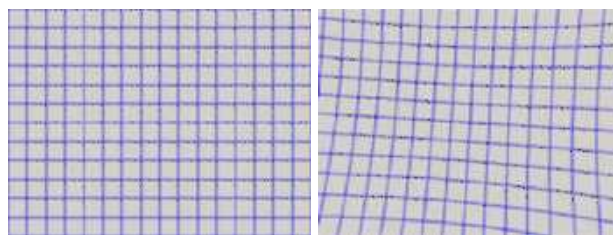


Positive and negative distortion

**Calibration mode**, expressed as a combination of options, can be accessed via [CalibrationModes](#).

## Effect of the Calibration Coefficients

---



No calibration coefficient: All coefficients combined.

## Unwarp an Image

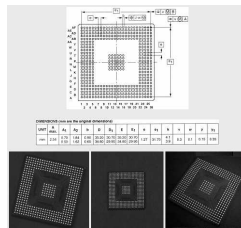
An **EWorldShape** object manages a field-of-view calibration context. Such an object is able to represent the relationship between world coordinates (physical units) and sensor coordinates (pixels), and account for the distortions inherent in the image formation process.

Image calibration is an important process in quantitative measurement applications. It establishes the relation between the location of points in an image (pixel indices) and the actual positions of those points in the real world, on the inspected item.

Calibration can be setup by providing explicit calibration parameters of the calibration model, or a set of known points (landmarks), or a calibration target.

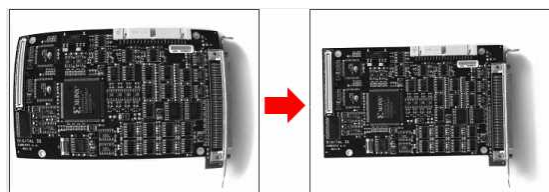
The goal of calibration is twofold:

- To gain independence with respect to the viewing conditions (part placement in the field of view, lens magnification, sensor resolution, ...), letting you describe the inspected item once for all using absolute measurements.



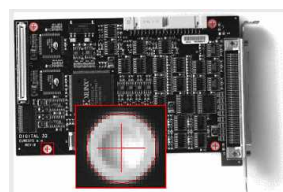
Single model versus multiple viewing conditions

- To correct some distortion related to the imaging process (perspective effect, optical aberrations, ...).



Removal of image distortion

The pixel indices in an image are usually integer numbers, but fractional values can occur when using sub-pixel methods. They are normally obtained by processing an image and locating known feature points. These values are called sensor coordinates.

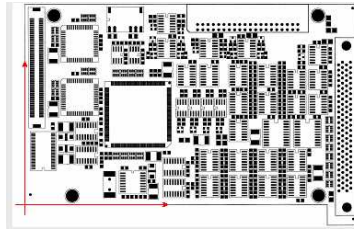


Feature point in sensor space

The world coordinates describe the location of points on the inspected item are expressed in an appropriate length measurement unit.

The world coordinates are actual dimensions, usually gathered from design drawings or by mechanical measurements.

They require a reference frame to be defined.

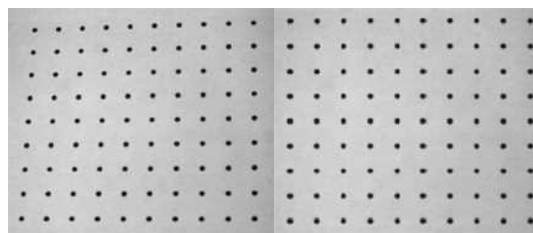


Reference frame in world space

## Unwarp

---

**Unwarp an image** using [Unwarp](#), [SetupUnwarp](#) and [UnwarpAfterSetup](#). Using a lookup table before unwarping may speed up the process.



Distorted vs. Unwarped image

## 4.3. EasyFind - Matching Geometric Patterns

### Introduction

### Purpose and Principles

#### Purpose

---

Based on an innovative feature-point technology, **EasyFind** is a matching tool designed to rapidly locate one or more instances of a reference model in an image. With an adjustable accuracy up to sub-pixel level, it reports very precise information about the instances found, such as their location, rotation angle, scale and matching score.

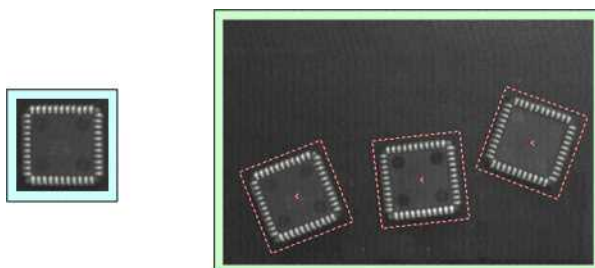
- **EasyFind** supports “don't-care” areas, a feature that allows the creation of complex pattern shapes.
- Fast Processing and Improved Robustness:

**EasyFind** is based on a new feature-point technology. Instead of comparing the reference model to the sample image pixel-wise, it carefully selects relevant feature points in the model. This method allows **EasyFind** to match only the areas that convey valuable information, resulting in faster processing and much improved robustness.

- Training on vector patterns:

In this mode, the learning is done on collections of 2D geometrical shapes rather than on rasterized patterns. The learning model is constructed using the new class `EVectorModel` either by loading it from a DXF file or, programmatically, by using **Open eVision** `EShape` objects.

This extension is well- suited to find objects with a known geometry.



Example of a model (left) and 3 found instances (right)



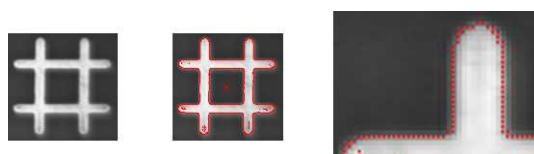
**TIP**

Compared to **EasyMatch**, **EasyFind** is computationally fast, robust against noise, occlusion, blurring, missing parts and illumination variations.

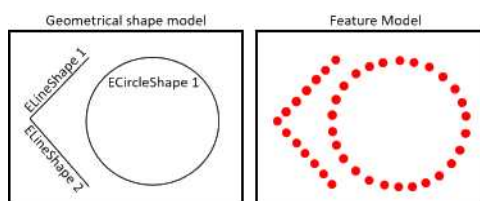
### Edge feature points

- **EasyFind** uses edge feature points to find instances in a search field:
  - An **edge feature point** is an abrupt change of gray level between two regions.
  - It indicates that there is an edge at this location in the search field.
- To start the finding function, **EasyFind** needs either a model image on which it computes the edge feature points or directly a geometrically-defined feature model.

**NOTE:** The optimal model depends on the type of pattern that you are searching.

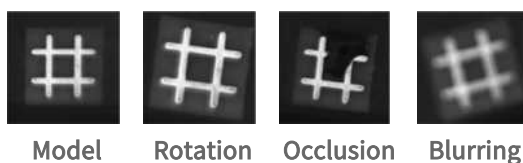


An image model and the computed edge feature points



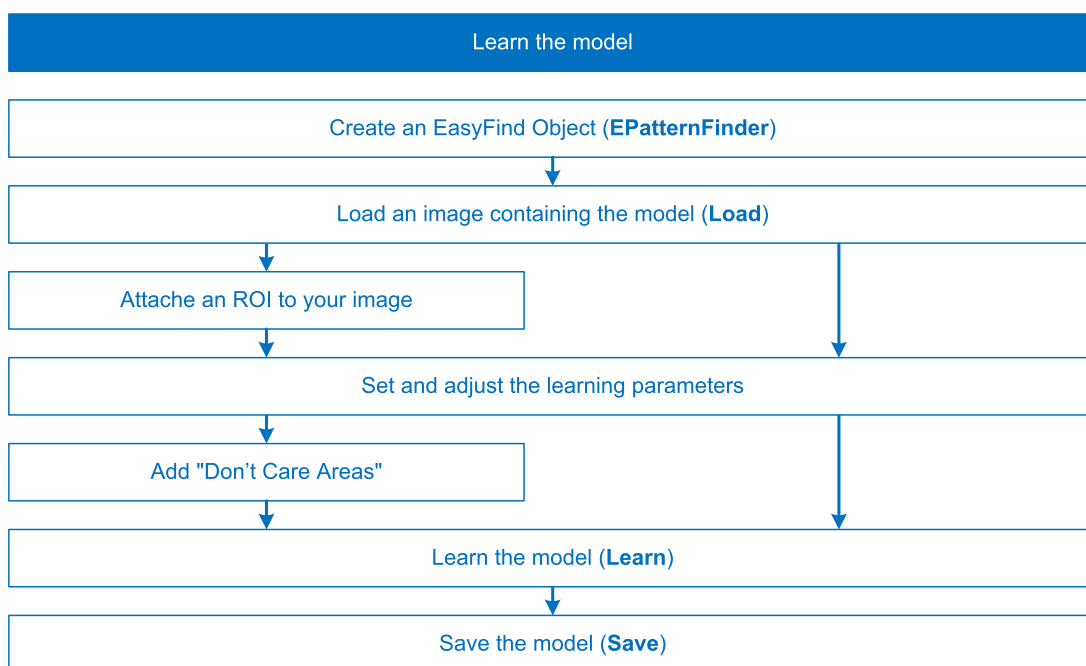
A vector model and the computed edge feature points

- The point-by-point scores improve the robustness and the computation time of the finding phase.
- To use this tool:
  - The models must be well contrasted with sharp edges.
  - They should be substantially different from the rest of the expected search fields.
  - They can be scaled or rotated.
- **EasyFind** is very robust regarding:
  - Blurring
  - Noise
  - Occlusion
  - Illumination variation

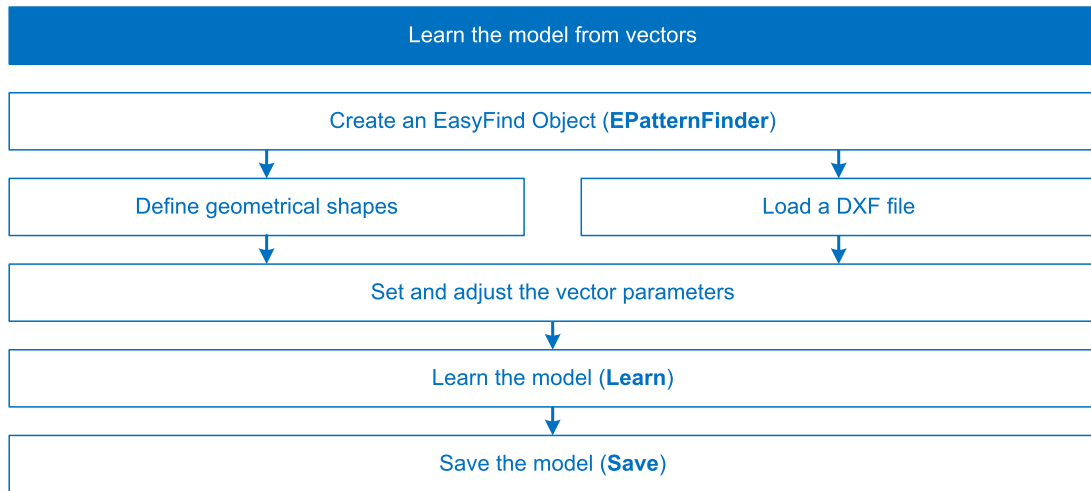


## Workflow

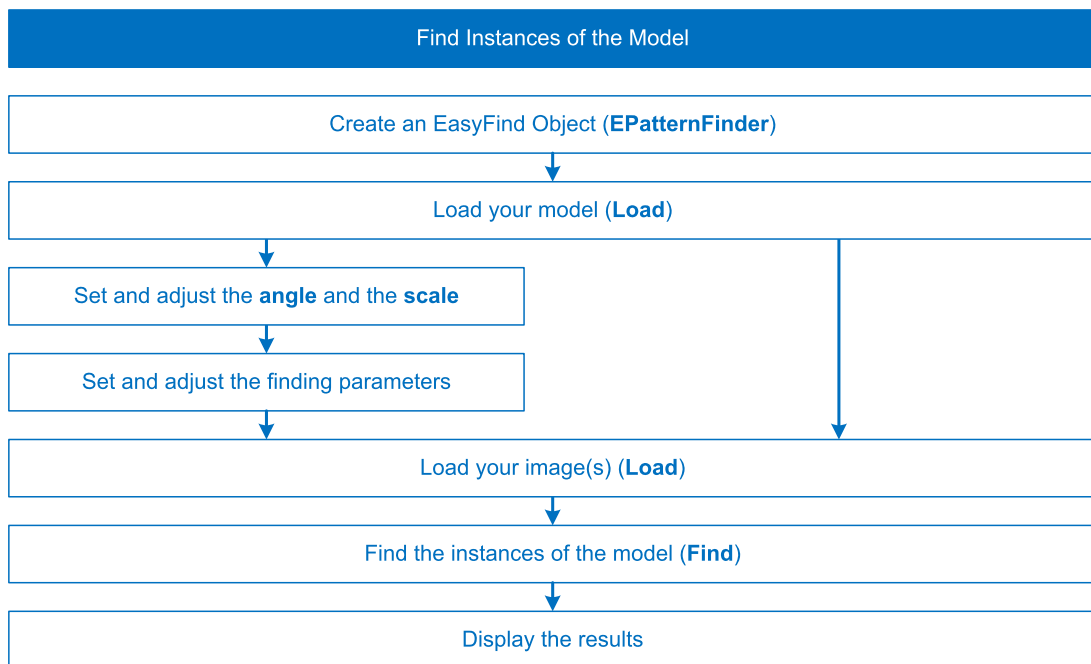
### Learn the model from images



## Learn the model from vectors



## Find instances of the model



# Using EasyFind

## Learn the Model from Images

### Learning

---

**EasyFind** detects in images the instances of a reference model.

- The reference model is a set of all the feature points that **EasyFind** computes during the learning process:
  - **EasyFind** can extract these points from a bitmap representation of the pattern as described below.
  - Or it can use the feature points that are directly given by geometrical shapes (see "[Learn the Model from Vectors](#)" on page 115).

### Process

---

To learn a model in an image with **EasyFind**:

1. Create an EPatternFinder instance for the model and an EFoundPattern vector for the results.

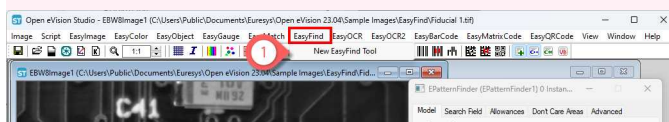
#### Code

```
EPatternFinder finder;  
vector<EFoundPattern> foundPattern;
```

#### Studio

In the main menu:

1. **EasyFind** > **New EasyFind Tool** > name your tool.





## 2. Load the image with your model.

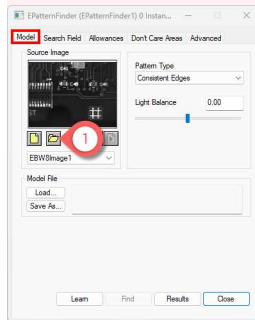
### Code

```
EImageBW8 image;
image.Load("Fiducial 1.tif");
```

### Studio

In the tool window, in the **Model** tab:

1. Open your **Source Image**.
2. Select your image in the browse dialog (Fiducial 1.tif).



## 3. Attach an ROI to your image.

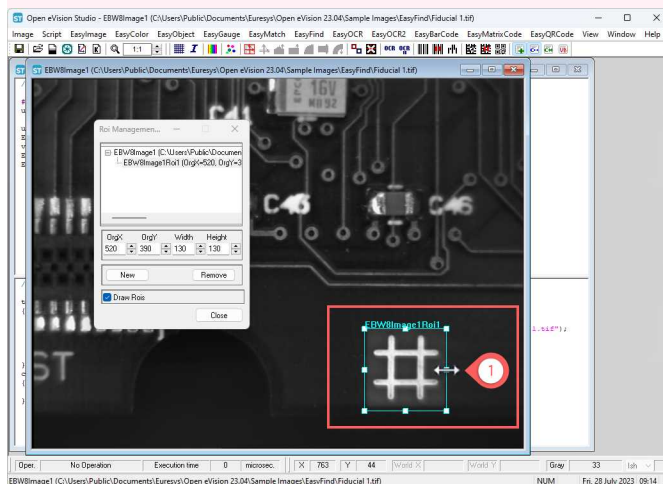
### Code

```
EROIBW8 pattern;
pattern.Attach(&image, 520, 390, 130, 120);
```

### Studio

In the image window:

1. Right-click > **New ROI** > move and resize in the image > **Close**.



4. According to your application and needs, adjust the **"Learning Parameters"** on page 123.
5. To adjust the model shape and to improve your find results, you can add **"Don't Care Areas"**.

 See **"Use "Don't Care Areas" in the Model"** on page 121.

6. Select the source image and learn the model.

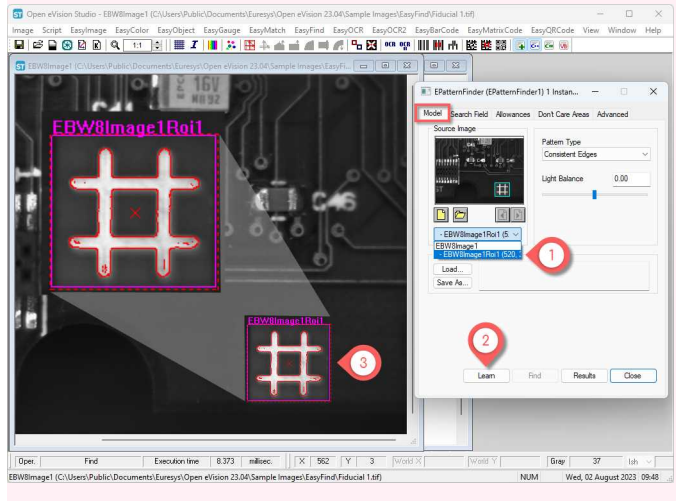
Code

```
finder.Learn(&pattern);
```

Studio

In the tool window, in the **Model** tab:

1. Select the ROI as your **Source Image**.
2. **Learn**
3. The result is displayed on the image.



7. If you want to reuse it later, save the new model (. fnd file).

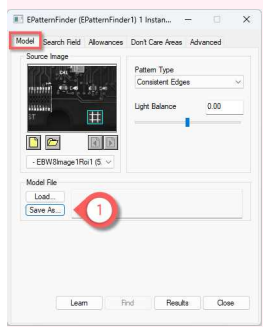
Code

```
finder.Save("myModel.fnd");
```

Studio

In the tool window, in the **Model** tab:

1. In the **Model File** area > **Save As...**



► **EasyFind** creates and save your model.

Use this model to perform:

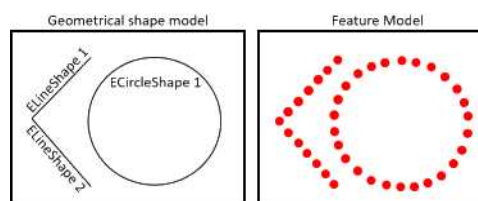
- ["Find Instances of the Model" on page 117](#)

# Learn the Model from Vectors

## Learning

**EasyFind** detects in images the instances of a reference model.

- The reference model is a set of all the feature points that **EasyFind** computes during the learning process:
  - **EasyFind** can extract these points from a bitmap representation of the pattern (see "[Learn the Model from Images](#)" on page 112).
  - Or it can use the feature points that are directly given by geometrical shapes as described below.
- To learn a model from geometrical shapes:
  - Use the class `EVectorModel` to hold a collection of shapes as a vector model.
  - Load the `EVectorModel` from an external DXF file or use the **Open eVision** API to define it.



## Process using an EPolygonShape



### NOTE

- This feature is not available in **Open eVision Studio**.
- You can also use the sample program [EasyFindVectorLearn](#).

To learn a model from geometrical shapes with **EasyFind**:

1. Create an `EPatternFinder` instance for the model.

#### Code

```
// EPatternFinder constructor
EPatternFinder finder;
```

2. Create your vector model and get its root shape.

#### Code

```
// EVectorModel constructor
EVectorModel myModel;
// Get the root EFrameShape of the model
EFrameShape& shapeMother = myModel.GetRoot();
```

### 3. Create your polygon.

#### Code

```
// EPolygonShape constructor
EPolygonShape polygon;
// Define the vertices of a polygon
std::vector<EPoint> vertices = { {0.f, 0.f}, {1.f, 0.f}, {1.f, 1.f}, {0.f, 1.f} };
// Define the EPolygonShape
polygon.SetPolygon(EPolygon(vertices, true));
```

### 4. Attach the polygon to the root shape and adjust its parameters according to your application and needs.

 See ["Vector Model Parameters" on page 136](#).

#### Code

```
// Attach the EPolygonShape to the root EFrameShape
polygon.Attach(&shapeMother);
// Sets the polarity of the EPolygonShape
polygon.SetProperty("polarity", "direct");
```

### 5. Learn the model.

#### Code

```
finder.Learn(&pattern);
```

### 6. If you want to reuse it later, save the new model (.fnd file).

#### Code

```
finder.Save("myModel.fnd");
```

#### ► EasyFind creates and save your model.

Use this model to perform:

- ["Find Instances of the Model" on page 117](#)

## Process using a DXF file



#### NOTE

This feature is not available in **Open eVision Studio**.

- Alternatively to define the geometrical shapes of your model, you can load an [EVectorModel](#) from an external DXF file.

Once loaded, the [EVectorModel](#):

- Holds a collection of shapes.
- Holds a center position depending on the method used for the definition of the DXF.

### 1. Create an EPatternFinder instance for the model.

#### Code

```
// EPatternFinder constructor
EPatternFinder finder;
```

## 2. Create your vector model.

Code

```
// EVectorModel constructor
EVectorModel myModel;
```

## 3. Load the model from the DXF file.

Code

```
// Load the model from a dxf file
myModel.LoadDXF("myModel.dxf");
```

## 4. The scale and polarity attributes are not part of the DXF file. If necessary, add them to the `EVectorModel`.

 See "[Vector Model Parameters](#)" on page 136.

## 5. Learn the model.

Code

```
finder.Learn(&pattern);
```

## 6. If you want to reuse it later, save the new model (.fnd file).

Code

```
finder.Save("myModel.fnd");
```

### ► **EasyFind** creates and save your model.

Use this model to perform:

- "[Find Instances of the Model](#)" on page 117

# Find Instances of the Model

## Finding

---

**EasyFind** detects the instances of your reference model in your images.

These instances can be highly-degraded due to noise, blur, occlusion, missing parts or unstable illumination conditions. To optimize the finding process, adjust the search parameters and check what **EasyFind** has found in the result information.



### TIP

To speed up the search process, you can also use [multicore processing](#). This is especially interesting when you use **EasyFind** with angle and scale tolerances.

## Process

📄 Create your model as described in "Learn the Model from Images" on page 112 or "Learn the Model from Vectors" on page 115.

- In **Open eVision Studio**, if you just created a model following "Learn the Model from Images" on page 112, go directly to **step 3**.

1. Create an EPatternFinder instance for the model and an EFoundPattern vector for the results.

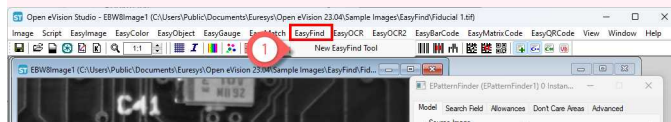
### Code

```
EPatternFinder finder;
std::vector<EFoundPattern> foundPattern;
```

### Studio

In the main menu:

1. **EasyFind** > **New EasyFind Tool** > name your tool.



2. Open an existing model saved in a .fnd file:

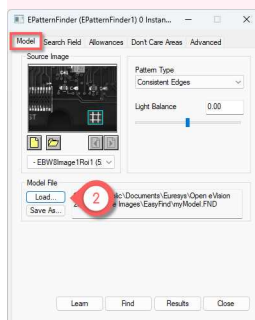
### Code

```
finder.Load("myModel.fnd");
```

### Studio

In the tool window, in the **Model** tab:

1. In the **Model File** area > **Load...**



3. According to your application and needs, adjust the following parameters:
- **SetAngleBias** and **SetAngleTolerance**: search for instances in this angle range.
  - **SetScaleBias** and **SetScaleTolerance**: search for instances in this scale range.

 see "Finding Parameters" on page 128 for more details.

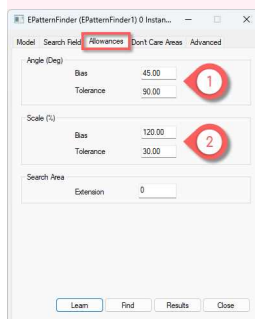
#### Code

```
finder.SetAngleBias(45.00f);
finder.SetAngleTolerance(90.00f);
finder.SetScaleBias(1.20f);
finder.SetScaleTolerance(0.30f);
```

#### Studio

In the **Allowances** tab:

1. In the **Angle (Deg)** area, set the **Bias** and the **Tolerance** on the angle.
2. In the **Scale (%)** area, set the **Bias** and the **Tolerance** on the scale.



4. Load your image(s).

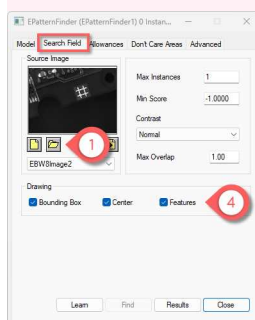
#### Code

```
EImageBW8 srcImage;
srcImage.Load("...\\Sample Images\\EasyFind\\Fiducial 2 (Skewed).tif");
```

#### Studio

In the tool window, in the **Search Field** tab:

1. Open your **Source Image**.
2. Select one or several images in the browse dialog (Fiducial 2->8 xxx.tif).
3. Name your image set.
4. In the **Drawing** area, check all settings to display them on the found instances.



5. Find the instances in your image set.

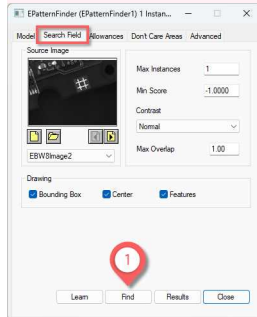
Code

```
foundPattern = finder.Find(&srcImage);
```

Studio

In the Search Field tab:

1. Find



6. Display the results.

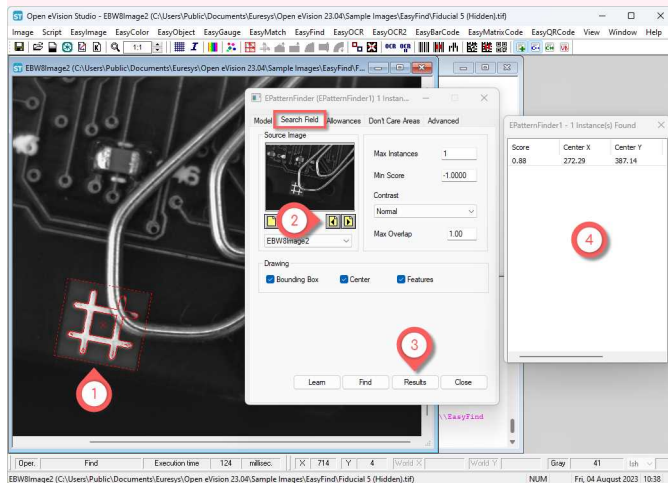
Code

```
float score= foundPattern[0].Score;
float centerX= foundPattern[0].Center.X;
float centerY= foundPattern[0].Center.Y;
```

Studio

In the tool window, in the Search Field tab:

1. The instance location and feature points are highlighted in the current source image.
2. Use the Load Previous File and Load Next File to browse the images of your set.
3. Click on Results to open the result windows.
4. The result windows displays the score and the center coordinates of the found instance(s).





## Open eVision Studio Tools

### Use "Don't Care Areas" in the Model



#### NOTE

The "don't care areas" are deprecated:

- Instead, use an ERegion (see "[Arbitrarily Shaped ROI \(ERegion\)](#)" on page 29).

- As ERegions are not supported in **Open eVision Studio**, you can still use "don't care areas" as described below to improve the finding results.

#### Don't care areas

---

- Use "don't care areas" in geometric pattern matching to define in the image the meaningful features only.
- Create a "don't care areas" mask image to remove from the search process the areas that may change from image to image, such as text and numbers:
  - "0" values indicate ignored areas.
  - "255" values indicate areas taken into account.

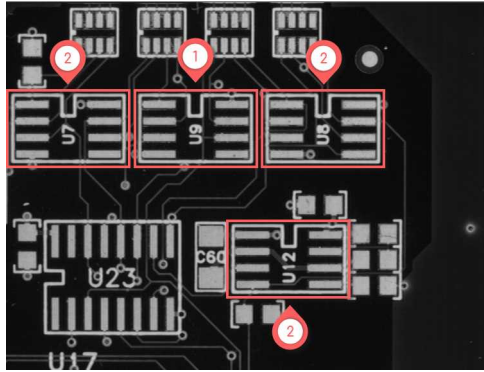
 For more details about the mask, see "[Flexible Masks](#)" on page 51.

## Process

 Create your model as described in "Learn the Model from Images" on page 112.

This example is based on the file Solder Pad 1.tif with:

- An ROI positioned at (200, 130, 190, 130)
- `Max Instances` = 4



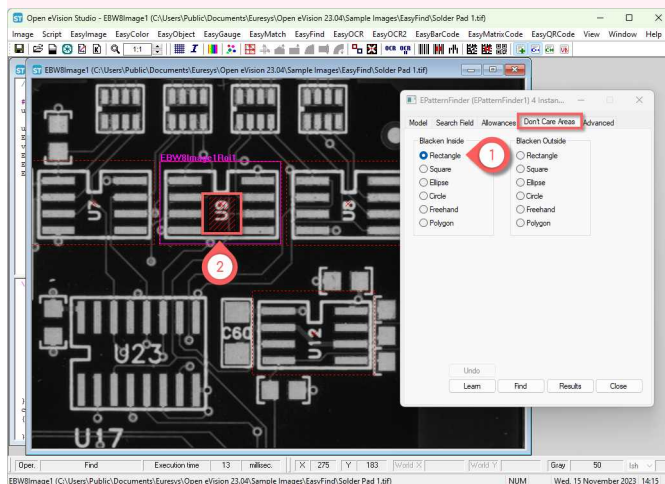
(1) Model - (2) Instances

### 1. Add a Don't Care Area to improve your model.

#### Studio

In the tool window, in the `Don't Care Areas` tab:

1. `Blacken Inside` > `Rectangle`.
2. Draw a rectangle over the central number to remove this part from the model.

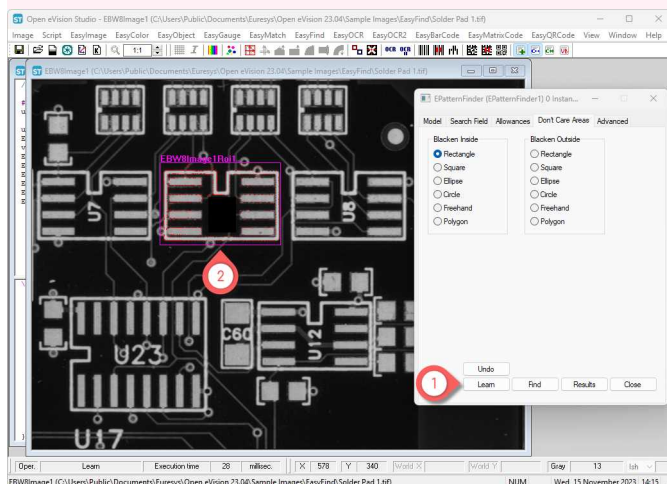


## 2. Learn the model.

### Studio

In the tool window, in any tab:

1. **Learn**
2. The result is displayed on the image.



► In the example, the find results are better with the don't care area than without as follows:

Score	Center X	Center Y	Angle (Deg)	Scale(%)
1.00	295.00	195.00	0.00	100.00
0.95	493.51	195.28	0.00	100.00
0.94	96.84	194.84	0.00	100.00
0.92	440.32	397.89	0.00	100.00

Score	Center X	Center Y	Angle (Deg)	Scale(%)
1.00	295.00	195.00	0.00	100.00
0.96	96.89	194.83	0.00	100.00
0.96	493.53	195.30	0.00	100.00
0.95	440.25	397.89	0.00	100.00

Results without (left) and with (right) don't care areas

► **EasyFind** creates your model.

Use this model to perform:

- ["Find Instances of the Model" on page 117](#)

## Setting the Parameters

## Learning Parameters

📖 The following parameters are set and used in the process: ["Learn the Model from Images" on page 112.](#)



### TIP

These parameter settings are saved together with your model in the model file.

## Pattern type

---

- Use the parameter `SetPatternType` to set the pattern type as consistent edges (default) or thin structures.

**EasyFind** supports 2 pattern types:

- Use Consistent edges when:
  - Your model is well contrasted with sharp edges.
  - Your model is substantially different from the rest of the expected search fields.
- Use Thin structures when:
  - The edges of your model are consistent between thin elements and regions.
  - The contrast is the same for each thin element.



Examples of thin structures

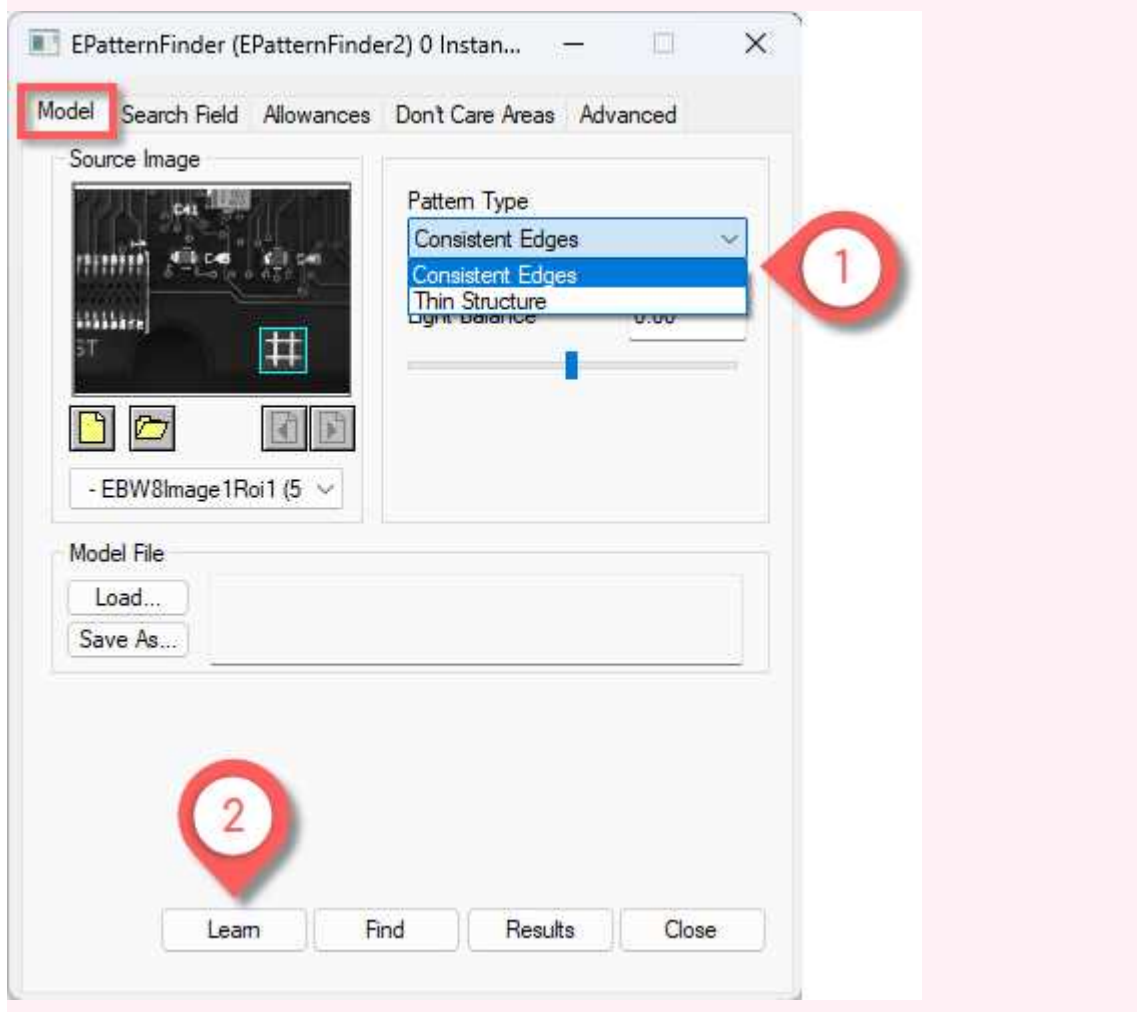
### Code

```
finder.SetPatternType(PatternType_ConsistentEdges);
```

Studio

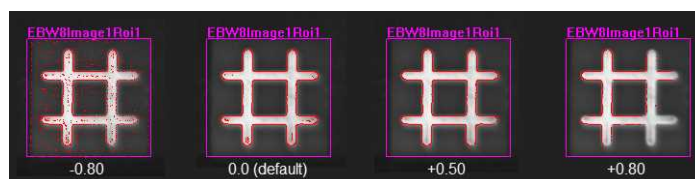
In the Model tab:

1. Select the Pattern Type.
2. Learn



### Light Balance

- Use the parameter `SetLightBalance` to adjust the gray-level threshold of the model so that it fits the useful parts of the pattern.
  - In **Open eVision Studio**, the preview of the model is automatically updated when you adjust the light balance.
  - Once you have the correct light balance, learn your model again.
- ▶ Example of the computed feature points for different light balance values:



## Code

```
finder.SetLightBalance(0.50f);
```

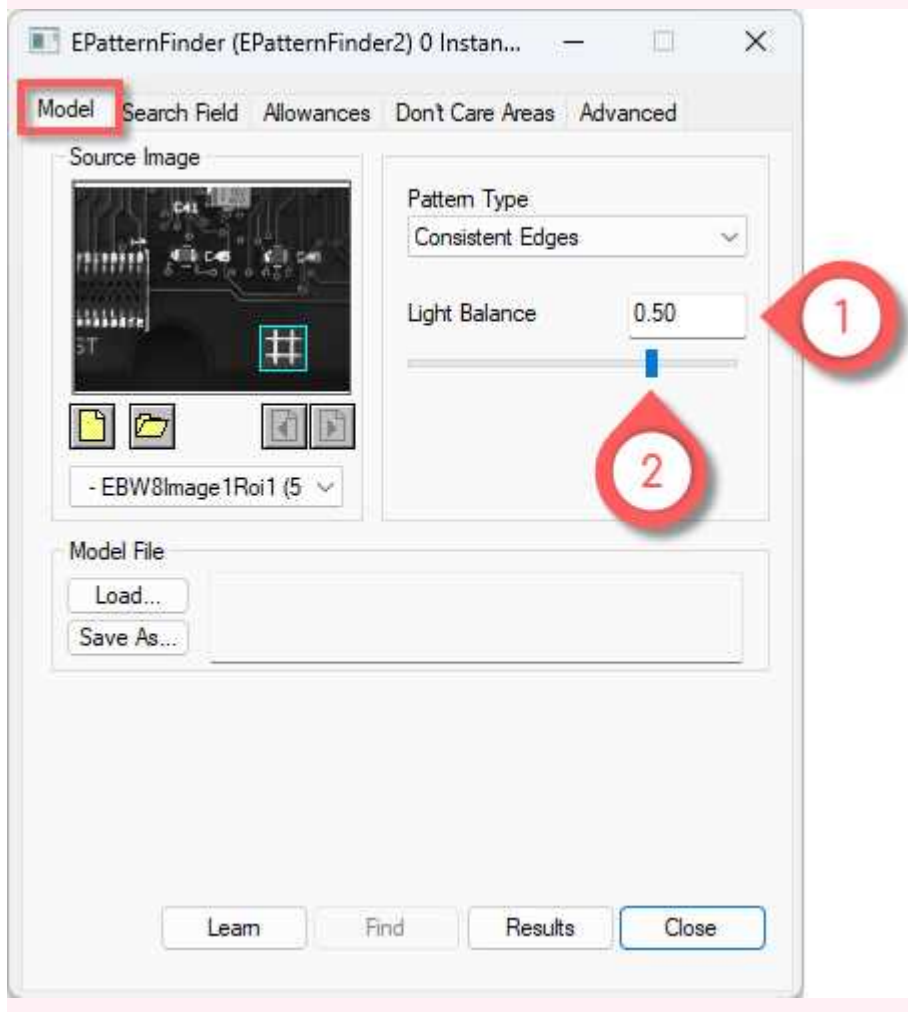
## Studio

In the **Model** tab:

1. Set the **Light Balance** and click **Learn**.

Or

2. Move the **Light Balance** slider. The result is immediately displayed on your model.



## Thin structure mode (advanced)

If the Pattern Type is Thin Structure:

- Use the parameter `SetThinStructureMode` to adjust the gray-level threshold of the model so that it fits the useful parts of the pattern:
  - **Auto:** **EasyFind** chooses automatically the best contrast for thin elements.
  - **Dark:** **EasyFind** selects thin elements darker than their neighborhood.
  - **Bright:** **EasyFind** selects thin elements brighter than their neighborhood.

## Code

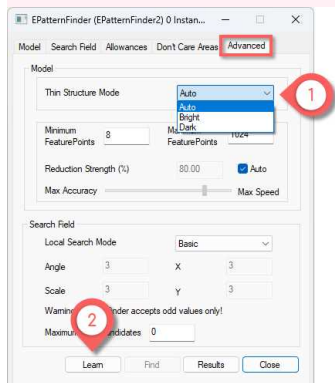
```
finder.SetThinStructureMode(ThinStructureMode_Auto);
```

## Studio

If the **Pattern Type** is **Thin Structure** in the **Model** tab:

In the **Advanced** tab:

1. Select the **Thin Structure Mode**.
2. **Learn**



## Number of feature points and reduction strength (advanced)



More feature points lead to a finer matching and a better positioning accuracy but also to a longer processing time.

- Use the parameters [SetMinFeaturePoints](#) and [SetMaxFeaturePoints](#) to adjust the number of feature points used to match the patterns.
  - By default, this number is computed automatically (between 8 and 1024).
- Use the parameter [SetReductionMode](#) to select the reduction mode:
  - **Auto** (default): the reduction strength is computed automatically.
  - **Manual**: use the parameter [SetReductionStrength](#) to set the reduction strength from more accuracy (0.0) to more speed (1.0).

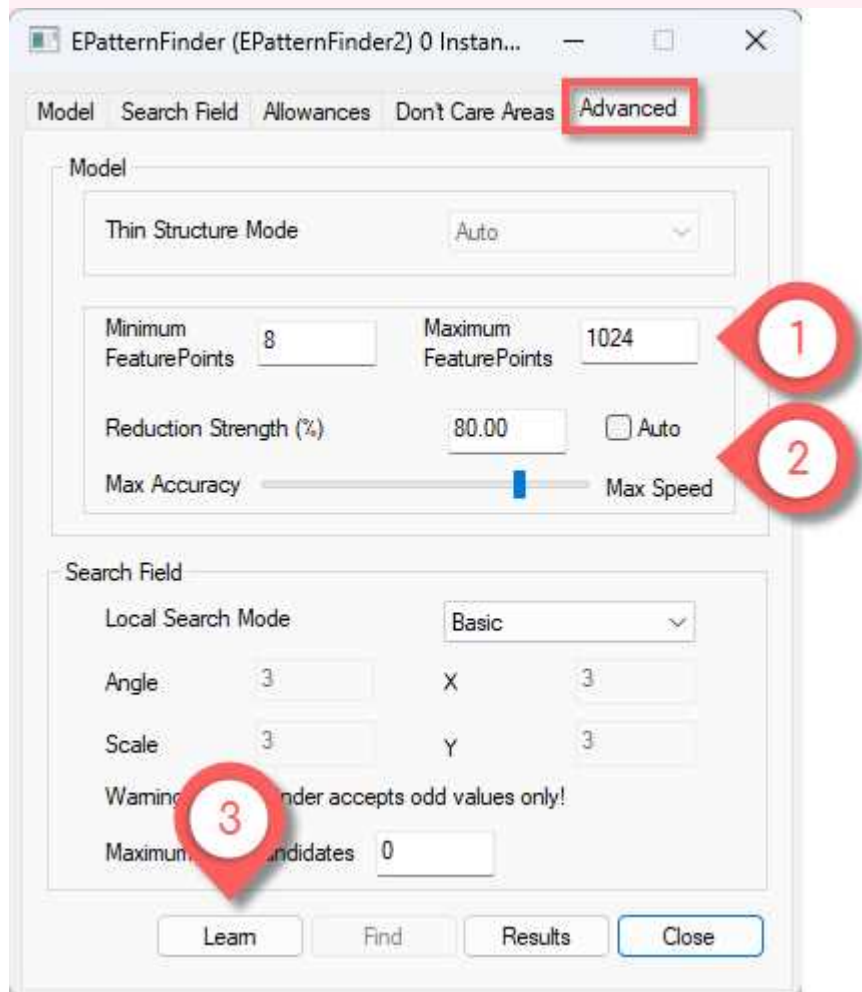
## Code

```
finder.SetMinFeaturePoints(8);
finder.SetMaxFeaturePoints(1024);
finder.SetReductionMode(EReductionMode_Manual);
finder.SetReductionStrength(0.80f);
```


**Studio**

In the **Advanced** tab:

1. Set the **Minimum Feature Points** and the **Maximum Feature Points**.
2. **Reduction Strength**:
  - Check **Auto** for automatic computation.
  - Or
  - Uncheck **Auto**.
  - Set the **Reduction Strength** or move the slider between **Max Accuracy** and **Max Speed**.
3. **Learn**



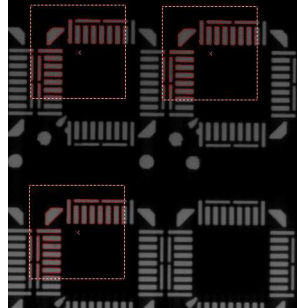
## Finding Parameters

 The following parameters are set and used in the process: "**Find Instances of the Model**" on page 117.



## Maximum number of expected instances

- Use the parameter `SetMaxInstances` to set the maximum number of instances that **EasyFind** returns.
- ▶ In this example the number was 3:



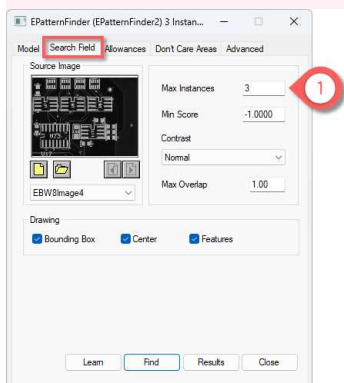
### Code

```
finder.SetMaxInstances(3);
```

### Studio

In the **Search Field** tab:

1. Set the **Max Instances**.



## Minimum score and contrast

---

If the Pattern Type is Thin Structure:



The score depends on the Contrast:

- Normal: the score is normalized between -1 and 1:
  - 1 means a perfect match with the same contrast as the model.
  - 0 means no match.
  - -1 means a perfect match but with the inverted contrast compared to the model.
- Inverse: the score is normalized between -1 and 1:
  - 1 means a perfect match with the inverted contrast compared to the model.
  - 0 means no match.
  - -1 means a perfect match but with the same contrast as the model.
- Any: the score is normalized between 0 and 1:
  - 1 means a perfect match with the same contrast or the inverted contrast compared to the model.
  - 0 means no match.



Global vs point by point contrast:

- Global: the score is computed as the normalized sum of the correlation of each point.
  - ▶ The feature points with a high gradient have more weight.
  - ▶ Global gives higher score on incomplete instances.
- Point by point: the score is computed as the mean of the normalized correlation of each point.
  - ▶ Each feature point has the same weight.
  - ▶ Point by point gives higher score on images with irregular lighting and instances with variable contrast.
- Use the parameter [SetMinScore](#) to set the minimum score for an instance to be accepted and returned.
  - The default value is -1.0 (no score filtering).
- If the Pattern Type is Consistent Edges, use the parameter [SetContrastMode](#) to select the contrast mode.
  - The default value is Normal.

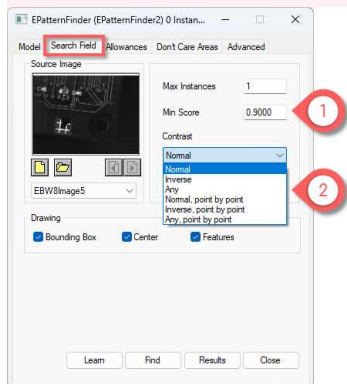
### Code

```
finder.SetMinScore(0.90f);  
finder.SetContrastMode(EFindContrastMode_Normal);
```

## Studio

In the **Search Field** tab:

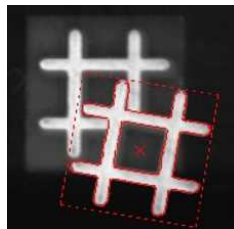
1. Set the **Min Score**.
2. Select the **Contrast**.



## Maximum overlap

**EasyFind** can filter out instances that completely or partially overlap with each other.

- Use the parameter **SetMaxOverlap** to defined the allowed overlap.
  - The maximum overlap is defined as the area of both instances intersection divided by the area of the smallest instance.
  - Set the parameter between 0.0 (no overlap allowed) and 1.0 (complete overlap allowed).
  - The default value is 1.0 (complete overlap allowed).



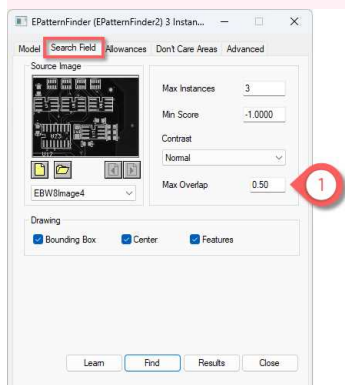
## Code

```
finder.SetMaxOverlap(0.50f);
```

## Studio

In the **Search Field** tab:

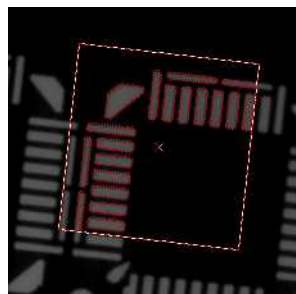
1. Set the **Max Overlap**.



## Angle and scale

The angle and scale ranges are defined by a bias and a tolerance:

- For example, with an angle bias of  $20^\circ$  and an angle tolerance of  $5^\circ$ , **EasyFind** returns instances with an angle between  $15^\circ$  and  $25^\circ$  with respect to the learned model ( $20^\circ \pm 5^\circ$ ).
- The default values are 100.0 for the scale bias and 0.0 for the other parameters. That means **EasyFind** returns only patterns with no rotation nor scaling.
- Use the parameters [SetAngleBias](#) and [SetAngleTolerance](#) to set the angle range.
- Use the parameters [SetScaleBias](#) and [SetScaleTolerance](#) to set the scale range.



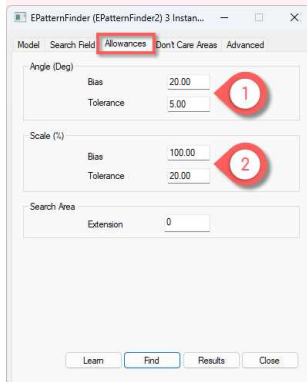
## Code

```
finder.SetAngleBias(20.00f);
finder.SetAngleTolerance(5.00f);
finder.SetScaleBias(100.00f);
finder.SetScaleTolerance(20.00f);
```

## Studio

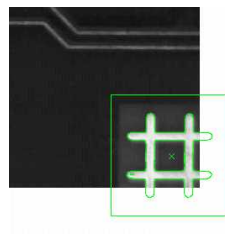
In the **Allowances** tab:

1. In the **Angle (Deg)** area, set the **Bias** and the **Tolerance**.
2. In the **Scale (%)** area, set the **Bias** and the **Tolerance**.



## Find partial patterns

- Use the parameter `SetFindExtension` to extend the search area (in pixels) and locate instances of thin structures and consistent edges that are partially out of the search field.



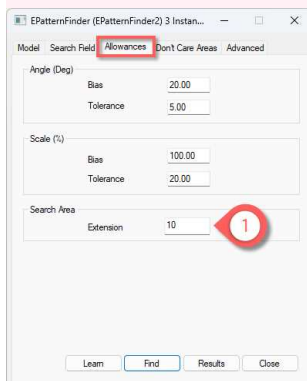
## Code

```
finder.SetFindExtension(10);
```

## Studio

In the **Allowances** tab:

1. In the **Search Area** area, set the **Extension**.



## Local search mode (advanced)

---



In the multistage approach:

- At the coarsest stage, **EasyFind** finds the pattern occurrence candidates.
  - At each of the following stages, their position and score are refined until the last and finest one. This refining is achieved by searching for better candidates in the neighborhood of each of the ones found in the previous stage.
- Use the parameter [SetLocalSearchMode](#) to set the extent of the neighborhood in which the better candidates are searched.
    - **Basic**: the default local search neighborhood  
Search extend: Angle and Scale = 3; X and Y = 3
    - **ExtendedTranslation**: the local search neighborhood is extended along the translation degrees of freedom.  
Search extend: Angle and Scale = 3; X and Y = 5
    - **ExtendedAll**: the local search neighborhood is extended along all the degrees of freedom.  
Search extend: Angle and Scale = 5; X and Y = 5
    - **ExtendedMore**: same as **ExtendedAll** but with a larger extension.  
Search extend: Angle and Scale = 7; X and Y = 9
    - **Custom**: manually define the search extend:  
Use [AngleSearchExtent](#) to set the Angle and [ScaleSearchExtent](#) to set the Scale  
Use [XSearchExtent](#) and [YSearchExtent](#) to set the translation along X and Y

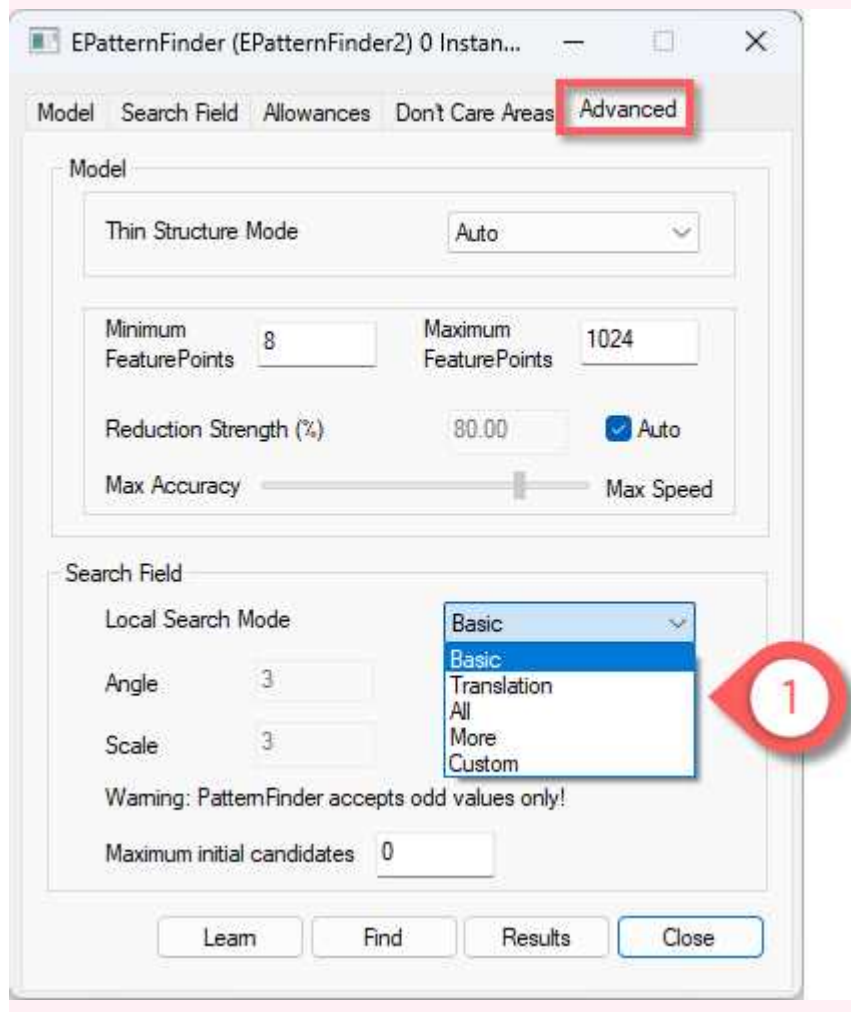
### Code

```
finder.SetLocalSearchMode(LocalSearchMode_Basic);
```

### Studio

In the **Advanced** tab:

1. In the **Search Field** area, select the **Local Search Mode**.
2. If you select the **Custom** mode, set the **Angle** and the **Scale**.



## Maximum initial candidates (advanced)



During the search for matching patterns, **EasyFind** considers a set of candidates and progressively refines it:

- A large number of initial candidates can enable finding difficult or partial matches but at the cost of increasing the processing time.
- A small number of initial candidates can speed up the find process.
- Use the parameter `SetMaxInitialCandidates` to set the maximum number of initial candidates that **EasyFind** considers.
  - This number must be greater than or equal to the number of instances to be found.
  - By default, the value is chosen internally.

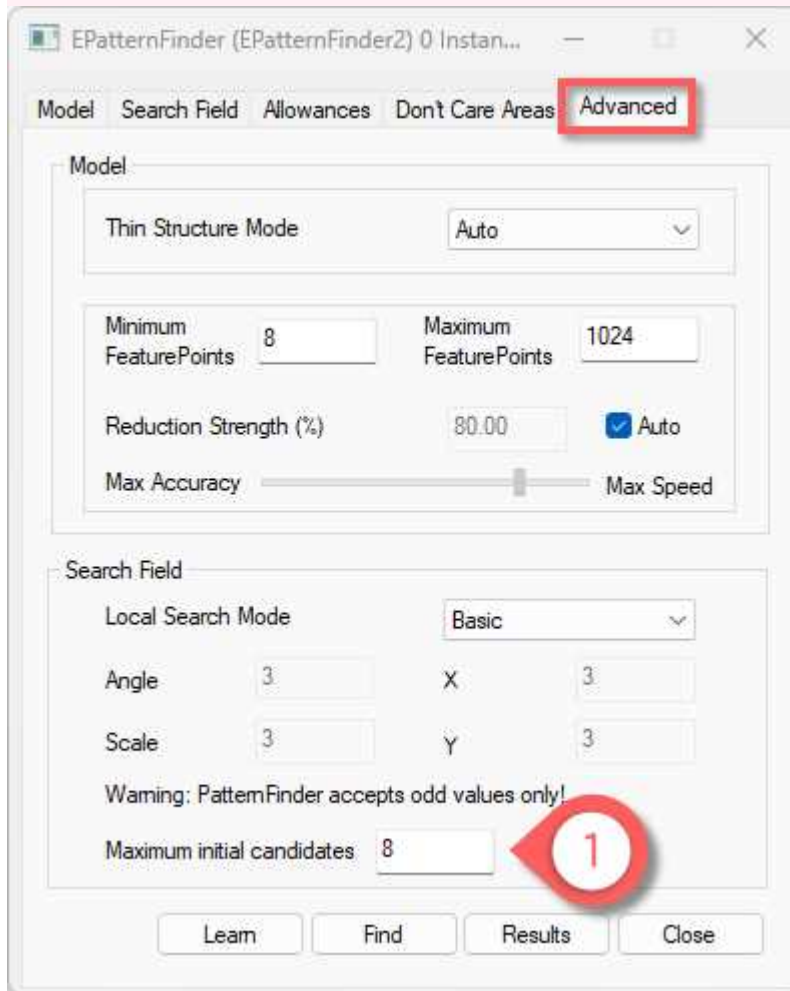
### Code

```
finder.SetMaxInitialCandidates(8);
```


## Studio

In the **Advanced** tab:

1. In the **Search Field** area, set the **Maximum initial candidates**.



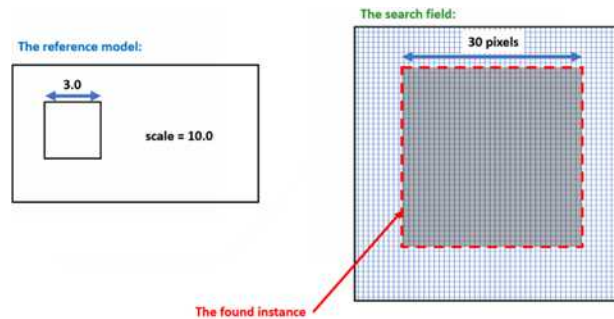
## Vector Model Parameters

-  The following parameters are set and used in the process: "[Learn the Model from Vectors](#)" on [page 115](#).



## Scaling the vector model

- Use the parameter [Scale](#) to set the scale of your vector model.
  - The scale represents the size of the instances in the search field (in pixels) divided by their size in the [EVectorModel](#).

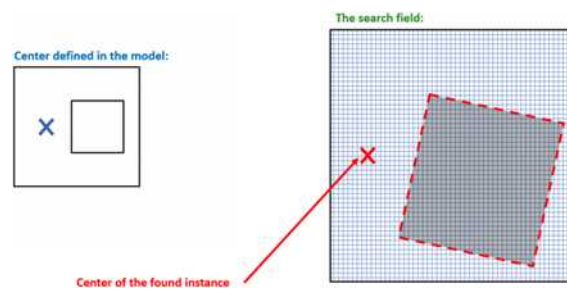


### Code

```
myModel.SetScale(10.0f);
```

## Centering the vector model

- Use the parameter [Center](#) to set or get the center of your vector model.
  - The center is the anchor point in the [EVectorModel](#) coordinate system.
  - After the Find, you can retrieve its position in the search field coordinates as illustrated below.

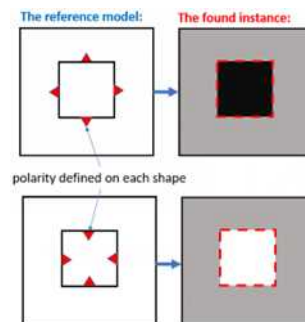


### Code

```
myModel.SetCenter( {2.0f, 2.0f} );
```

## Orienting the transitions in the vector model

- To search for light to dark or dark to light transitions, set the polarity attribute for the vector model in the `EVectorModel`.



### Code

```
// Sets the polarity of the EPolygonShape
polygon.SetProperty("polarity", "direct");
```

## 4.4. EasyMatch - Matching Area Patterns

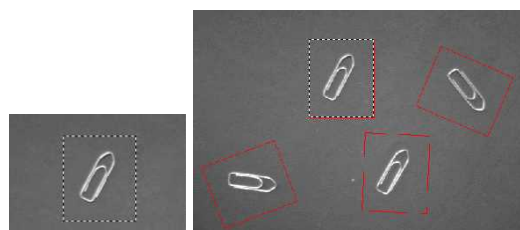
### Workflow

#### EasyMatch

##### Reference

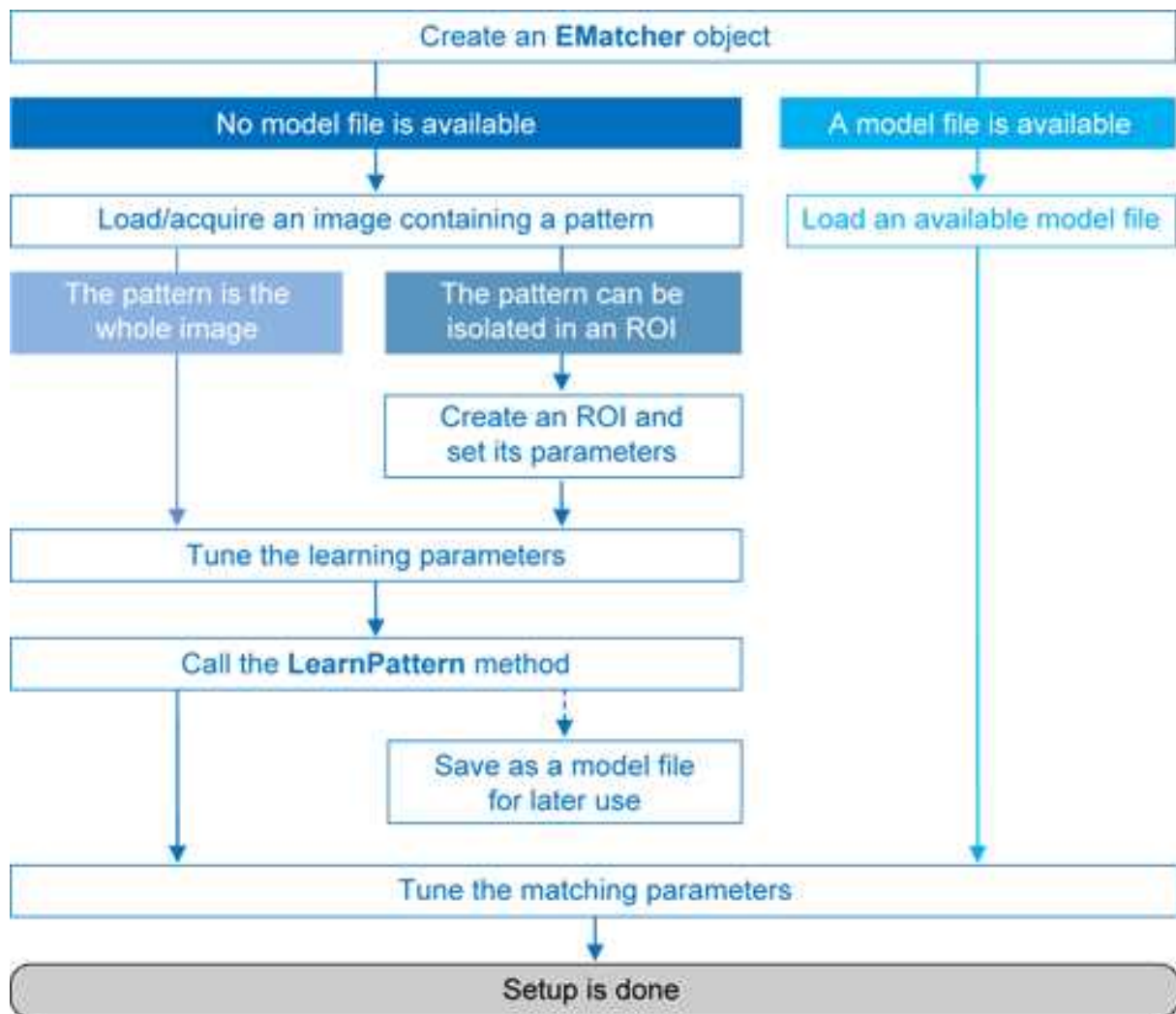
`EasyMatch` learns a pattern and finds exact matches:

- The pattern is learned by defining an ROI that contains the object to be matched. This ROI is created after iteratively learning from several images which contain the object.
- The parameters are tuned to ensure the pattern is found reliably.
- Images can now be searched for one or more occurrences of the pattern, which may be translated, rotated or scaled.

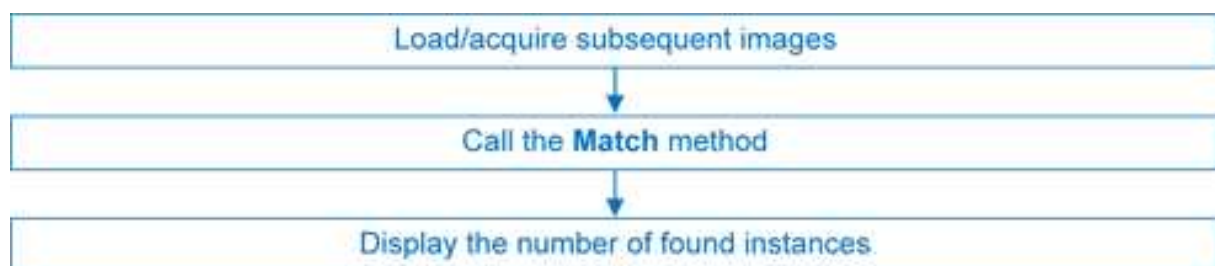


Learning and Matching a pattern

## Learning workflow



## Matching workflow



## Learning Process

Select an image containing the pattern/ROI to be searched for and call **LearnPattern**. Pass an arbitrary shaped region of interest (ERegion) to ignore the pixels outside of this region.

The resulting pattern can be saved as a model for later use. You can repeat this process to search for and save multiple patterns.

### Best pattern characteristics

- **repeatable**, you need to know if it can translate or rotate or scale.
- **represent the object to be located**.  
It should:
  - Keep the same appearance whatever the lighting conditions.
  - Remain at a fixed location with respect to the part.
  - Be rigid and not change shape.
- **exhibit good contrast in small and large scale**. It should be distinctly visible from a distance, and on a reduced image.
- **not be invariant under the degrees of freedom to be measured**. For instance, a pattern of black and white horizontal stripes cannot detect horizontal translation; a cog wheel cannot help measure large rotations.
- **have a neutral background**. If objects around the pattern in the ROI may change, this area should be neutralized by means of "don't care" pixels or a mask.
- **have contrasted margin around the objects** so that foreground and background intensities are seen.

### Customize Parameters

Parameters can be tuned to minimize processing time, but it still takes longer than EasyFind as the entire selected area is matched.

- **DontCareThreshold**: If don't care areas are required, the corresponding pixels must hold a value below the **DontCareThreshold**.  
If all the background can be ignored, merely adjusting the **DontCareThreshold** to the right thresholding value can do.  
Otherwise, when the don't care area is unrelated to the threshold pattern image, the **DontCareThreshold** should be set to 1 and all pixels belonging to the don't care area should be set to black (value 0).  
  
Alternatively, pass an arbitrary shaped region of interest (ERegion) to ignore the pixels outside of this region. It is equivalent to setting all pixels outside of the region to black and having a **DontCareThreshold** set to 1.
- **MinReducedArea**: To improve time performance, EasyMatch sub-samples the pattern. This parameter stipulates the minimum size of the pattern (as its area in pixels) during sub-sampling. The smaller the value, the faster the matching process, but, set too low, it decreases the matching process reliability.  
The value of **MinReducedArea** is computed automatically if **AdvancedLearning** is enabled (default behavior). Setting explicitly **MinReducedArea** will disable **AdvancedLearning**. A value of 64 is usually a good compromise.
- **AdvancedLearning**: If the pattern is defined as a ROI of an image, **AdvancedLearning** optimizes learning parameters, such as **MinReducedArea**, by using the whole image context. **AdvancedLearning** is enabled by default, as it leads to better results in case of tiled or periodic images. If **MinReducedArea** is set explicitly, **AdvancedLearning** is disabled. Please note that as **AdvancedLearning** changes the number of pixels in the pattern, it can have a significant impact on the matching process duration.

- **FilteringMode**: If the image has sharp gray-level transitions, it is better to choose a low-pass kernel instead of the usual uniform kernel.



Learning a pattern

## Matching Process

For each new image, one or more occurrences of the pattern is searched for, allowing it to translate, rotate or scale, using a single function call:

- **Match**: receives the target image/ROI as its argument and locates the desired occurrences of the pattern. You can pass an arbitrary shaped region of interest (ERegion) to ignore the pixels located outside of this region.

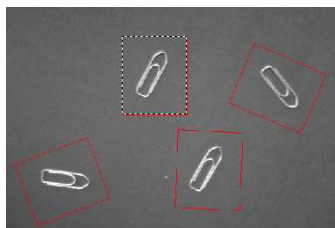
You can set these parameters:

- Rotation range: **MinAngle**, **MaxAngle**.
- Scaling range: **MinScale**, **MaxScale**.
- Anisotropic scaling range: **MinScaleX**, **MaxScaleX**, **MinScaleY**, **MaxScaleY**.

The following functions return the result of the matching:

- **NumPositions** returns the number of good matches found. A good match is defined as having a score higher than prescribed value (the **MinScore** threshold value).
- **GetPosition** returns the coordinates of the N-th good match. The positions are sorted by decreasing score.

If you want to match several patterns against the same image, create an **EMatcher** object for each pattern.



Matching a pattern

## Advanced Features

The best way to speed up this process is to minimize rotation and scaling, and limit the number of occurrences searched for.

- Learning time:
  - Optimize number of searches: Searching all positions takes too long, so a sequence of searches is performed at various scales (reductions). The coarsest reduction is quick and approximate. Subsequent reductions work in a close neighborhood to improve location, drastically reducing the number of positions to be tried. The location accuracy is given by  $2^K$ , where K is the reduction number.
  - [MinReducedArea](#). Indicates how small the pattern can be made for rough location.
- Matching time:
  - Correlation mode (way to compare the pattern and the image): [CorrelationMode](#). **Can be standard, offset-normalized, gain-normalized and fully normalized:** the correlation is computed on continuous tone values. Normalization copes with variable light conditions, automatically adjusting the contrast and/or intensity of the pattern before comparison.
  - Contrast mode (way to deal with contrast inversions): [ContrastMode](#). Lighting effects can cause an object to appear with inverted contrast, you can choose whether to keep inverted instances or not, and whether to match positive occurrences only, negative occurrences only or both.
  - Maximum positions (expected number of matches): [MaxPositions](#), [MaxInitialPositions](#). You can compel EasyMatch to consider more instances than needed at the coarse stage using the [MaxInitialPositions](#) parameter (this number is progressively reduced to reach [MaxPositions](#) in the final stage).
  - Minimum score (under which match is considered as false and is discarded): [MinScore](#), [InitialMinScore](#).
  - Sub-pixel accuracy: [Interpolate](#). The accuracy with which the pattern is measured can be chosen (the less accurate, the faster). By default, the position parameters for each degree of freedom are computed with a precision of a pixel. Lower precision can be enforced. One tenth-of-a-pixel accuracy can be achieved.
  - Number of reduction steps: [FinalReduction](#). Can speed up matching when coarse location is sufficient, range [0...[NumReductions](#)-1].
  - Non-square pixels: [GetPixelDimensions](#), [SetPixelDimensions](#). When images are acquired with non-square pixels, rotated objects appear skewed. Taking the pixel aspect ratio into account can compensate for this effect.
  - "Don't care" pixels (ignored for correlation score) below the [DontCareThreshold](#) value. When the pattern is inscribed in a rectangular ROI, some parts of the ROI can be ignored by setting the pixels values below a threshold level. The same feature can be used if parts of the template change from sample to sample.

Another way of specifying these ignored pixels is to use the region argument of the method [LearnPattern](#). The advantage of using the [ERegion](#) is that it is compatible with the [AdvancedLearning](#) feature, while [DontCareThreshold](#) isn't.

Our code snippet "Pattern Learning with ERegion" illustrates this.

- Overlapping:
  - **EasyMatch** can filter out instances that completely or partially overlap with each other in the search results if the parameter **MaxOverlap** is set to less than 1.0.  
The overlap is defined as the area of the intersection of the two instances divided by the area of the smallest instance.  
The maximum allowed overlap can take any value between 0 (no overlap allowed) and 1 (complete overlap allowed).
- Extension:
  - **EasyMatch** can match patterns that are partially outside of the matching ROI. While this feature is disabled by default, it can be tuned with the **Extension** parameter. Use this parameter to set the maximum number of pixels of a found pattern occurrence that may be outside the matching ROI.

## 4.5. EChecker2 - Validating Golden Templates

### EChecker2

- **EChecker2** is a tool that allows to inspect an image using a Golden Template validation.  
It works in 2 steps:
  - a. The *Model Creation* involves pre-processing a set of reference images to compute a model.  
You can create the model once and archive the results in a Golden Template model for later use.
  - b. The *Inspection* involves processing an image and checking its quality using the previously computed model.

These 2 operations are totally independent and can even be programmed in separate applications.
- **EChecker2** is part of the **EasyObject** library.
- The following sections present the relevant API functions for use in the training and inspection steps.

### EChecker2 vs. EChecker

---

- **EChecker2** supersedes the original **EChecker**:
  - It expands **EChecker** with an up-to-date API.
  - It adds the possibility to use geometrical pattern matching and a flexible number of fiducials.
  - It works with the newer **ECodedImage2**.
  - It only requires the **EasyObject** license.
- For all these reasons, the original **EChecker** is now considered legacy and deprecated.

## Creating a Model

During the model creation phase, the good images are processed to build the model that is used in the inspection phase. The model includes the pixel acceptance ranges, in the form of 2 threshold images, as well as the information needed to realign and normalize the images.

To create a model, 2 operations are performed: initialization and training.

### Initialization

- The initialization of the model creation process is done on a specific image, called the reference.
- On this reference, the following information are defined or computed:
  - The global gray level metrics are computed as reference for the normalization process. It is thus very important that the reference image is well lit and contrasted.
  - One or more **ERegions** are placed to define the location patterns (fiducial marks or landmarks).  
The location of these patterns is used as reference in the realignment process.



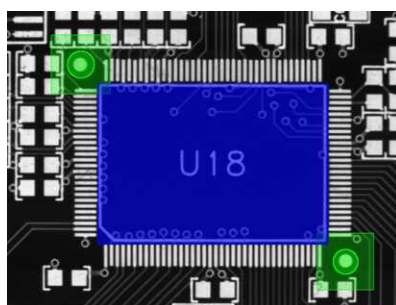
#### TIP

- If you use only 1 pattern, the only transformation handled is the translation.
- With 2 or more patterns, the scaling and the rotation are also processed.



#### NOTE

- As per **Open eVision 2.15**, you can only use either 1 or 2 regions.
  - The possibility to use more regions will be added in the future.
- An **ERegion** is defined to delimit the area to be inspected.  
This area should only include pixels of the rigid part (that moves with the fiducial marks), and not the background.
- To perform the initialization, use the method **EChecker2::Initialize**.



Initialization: the fiducial regions and tolerances (green) and the inspection region (blue)



## Training

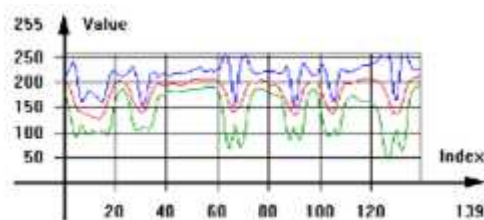
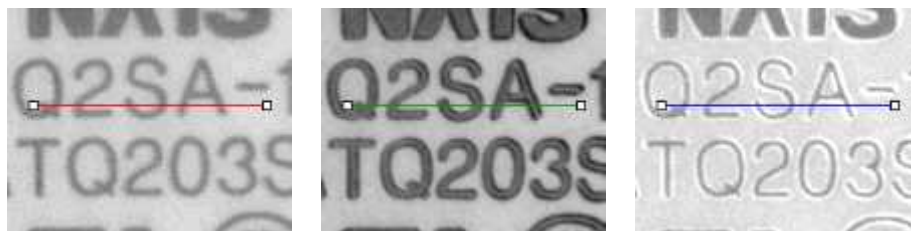
---

- After the initialization, the main training phase begins.
  - All the training images are processed and are averaged using statistical training (see below).
  - The training uses realignment to deal with displacement of the inspected part in the field of view.
  - The training uses gray-level normalization to deal with global illumination changes.
- Ideally, use 16 images or more in training to create the low and high threshold images that serve as the basis of the inspection process.
- To perform the training:
  - Use the method `EChecker2::Train` with class instances.
  - Use the method `EChecker2::TrainFromImageFiles` with a list of image files.

## Statistical training

---

- Use several training images to optimize the assessment of normal gray-level variations and acceptance intervals:
  - Consecutive images of the same part without any change (static test) generates a gray-level distribution that corresponds to the noise distribution.
  - Consecutive images of different defect-free parts reveal variations due to the parts themselves (as opposed to defects).



Accepted gray-level ranges

## Model creation parameters

---

- Choose the `TrainingMode` to fit your needs:
  - Quick for a quick training process and simpler cases (well defined defects and stable illumination).
  - Precise for more difficult cases.
  - Default: Precise mode.

- Set `NormalizationMode` to select the type of normalization used by `EChecker2`:
  - Moments: linear.
  - Threshold: non-linear.
  - NoNormalization: if your acquisition process already produces consistently lit images.
  - Default: Moments.
- Choose the `FiducialMatchingMode` to define the search of the fiducials inside the processed images:
  - Geometric for well-defined fiducials that can potentially suffer from occlusion.
  - Area for less-well defined fiducials.
  - Default: Geometric.
- Set `FiducialHorizontalTolerance` and `FiducialVerticalTolerance` to adjust the search distance for the fiducials from the reference position (after realignment).
  - Default: 30 pixels.
- Set `InspectionTolerance` to adjust the acceptance ranges during the inspection.
  - Use higher values to make the inspection process more tolerant to noise and/or texture.

**NOTE**

All these parameters have an influence on how the model is built, and, as such, if any of these parameters is changed, you must restart the model creation.

## Model serialization

---

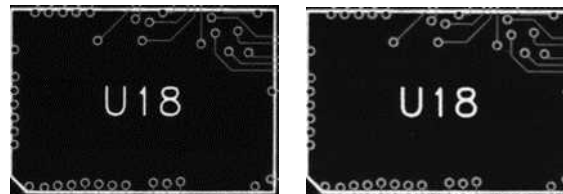
- After the training, use the methods `EChecker2::Save` and `EChecker2::Load` you can save the created model in a single file including all the relevant information and to retrieved it.

## Inspecting an Image

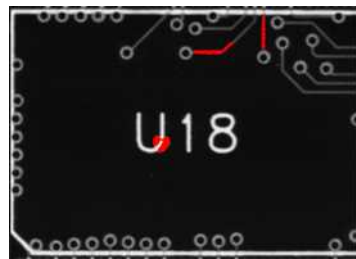
- Use the inspection on an image to assess it towards the trained model.  
The process is straightforward:
  - a. The sample image is realigned with the model.
  - b. The gray-level is normalized.
  - c. This gray-level is combined with the high and low threshold images to populate an `ECodedImage2`.
  - d. The computed blobs are made of pixels that fall out of the range defined by the threshold images and thus represent potential defects.



The realigned Image



The low and high threshold images



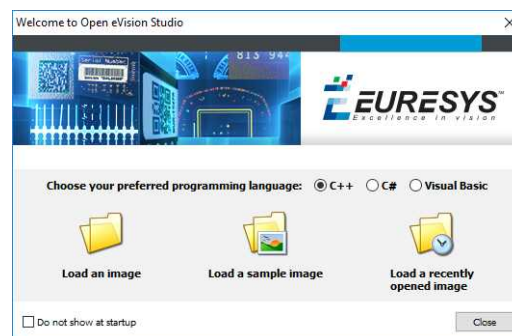
Detected defects after inspection

- When the inspection is done, you can discard the smaller defects (usually noise), as well as measure the geometric characteristics (location, size, orientation...) using the standard **EasyObject** processes.
- To perform the inspection, use the method [EChecker2::Inspect](#).

## 5. Using Open eVision Studio

### 5.1. Selecting your Programming Language

When you start **Open eVision Studio** for the first time, the following welcome screen is displayed:



1. Select your programming language.



#### TIP

Your selection is saved and your programming language will be automatically selected next time you start **Open eVision Studio**.



#### NOTE

When you change your programming language, any script present in the scripting window is automatically deleted and the window content is reset.

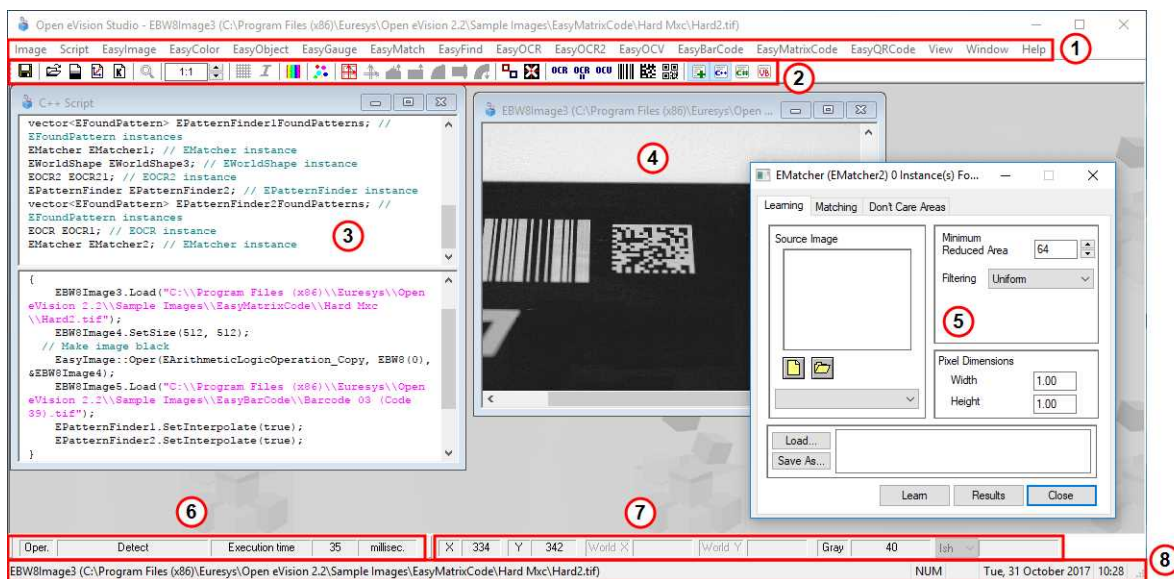
2. Click on one of the **Load** buttons to already load one or several images for later processing.
3. Check the **Do not show at startup** box to hide this welcome screen next time you start **Open eVision Studio**.



#### TIP

To access this welcome screen at any time, and change this setting, go to the **Help > Welcome Screen** menu.

## 5.2. Navigating the Interface



Open eVision Studio graphical user interface (GUI) is organized as follows:

1. The *main menu bar* gives you access to the functions and tools of all libraries.



### TIP

Open eVision Studio does not require any license and allows you to test all libraries. Of course, if you copy code from Open eVision Studio in your own application but you do not have the required license, you will receive a "missing license" error at run-time.

2. The *main toolbar* gives you quick access to main Open eVision objects such as images, shapes, gauges, bar codes, matrix codes...
3. The *script window* displays the code, in the programming language you selected, corresponding to the actions you perform in Open eVision Studio. You can save or copy this code in your own application at any time.
4. The *image windows* display the open images that you can process using the libraries and tools.
5. The *tool windows* enable you to easily configure all the available tools. The corresponding settings are automatically added in the script window for easy reuse.



### TIP

Most tool windows are floating and you can easily move them outside the Open eVision Studio main window to make better use of your screen size.

6. The *execution time bar* displays the precise time taken for the execution of the selected functions (measured in milliseconds or microseconds) on your computer. This accurate measurement helps you to evaluate the performance of your application.

7. The *color toolbar* displays current information such as the X and Y coordinates of the cursor on an image and the corresponding pixel value.
8. The *status bar* displays general information about the application such as the active image file path...

## 5.3. Running Tools on Images

### Step 1: Selecting a Tool

When you use **Open eVision Studio**, the first step is to select the library and the tool you want to use on your image.

To do so:

1. In the main menu bar, click on the library you want to use.
2. Click on the tool you want to use.



#### TIP

All libraries (except EasyImage, EasyColor and EasyGauge) expose only one tool named `New Xxx Tool`. Some of these libraries also expose additional functions.

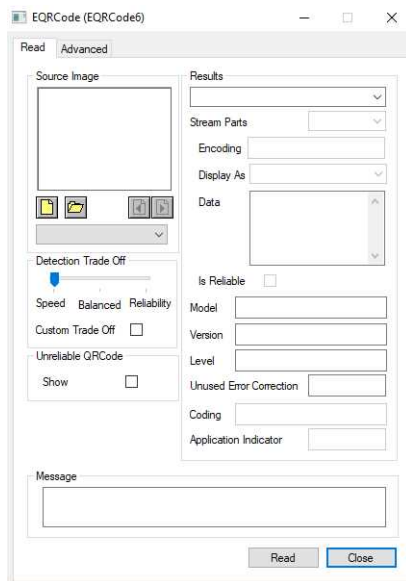
3. In the dialog box, enter a `Variable name` for the variable that is automatically created and that will contain the result of the processing.



Example of variable creation dialog box for EasyQRCode

4. Click `OK`.

The selected tool dialog box opens.



Example of variable creation dialog box for EasyQRCode

The next step is "Step 2: Opening an Image" on page 151.

## Step 2: Opening an Image

Once you have selected your library and your tool, you need to open an image to apply this tool.

In the **Source Image** area of the selected tool dialog box:

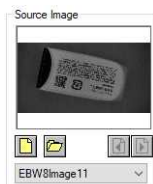
**1. Open an image:**

- ❑ Click on the **Open an Image** button and select one or several (using SHIFT and CTRL) images on your computer.
- ❑ Or select one of the images (or one of the ROIs, if any) already open in the drop-down list.



**NOTE**

You can select only images with an appropriate file format (JPG, PNG, TIFF or BMP) and in 8- and/or 24-bit depending on the library.



- 2. If you selected several images, activate one with the **Load Previous** or **Load Next** buttons.**

The tool is automatically applied on any loaded image and, at this stage, the result is displayed based on the tool default settings.

The next step is "[Step 3: Managing ROIs](#)" on page 152.

## Step 3: Managing ROIs

In some cases, most often to decrease the processing time or to single-out the object you want to read, you do not want to process the whole image but only one or several well defined rectangular parts of this image, or ROIs (Regions Of Interest).



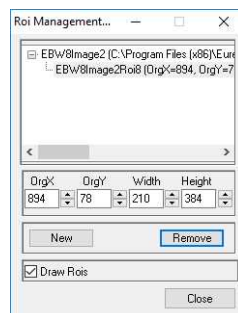
### TIP

In **Open eVision**, ROIs are attached to an image and exist only as long as the parent image is available.

### Creating a ROI

1. Open the image:
  - If the image is already open, activate the corresponding image window.
  - If the image is not open yet, go to the main menu: **Image** > **Open...** to open one.
2. To create an ROI, go to the main menu: **Image** > **ROI Management...**

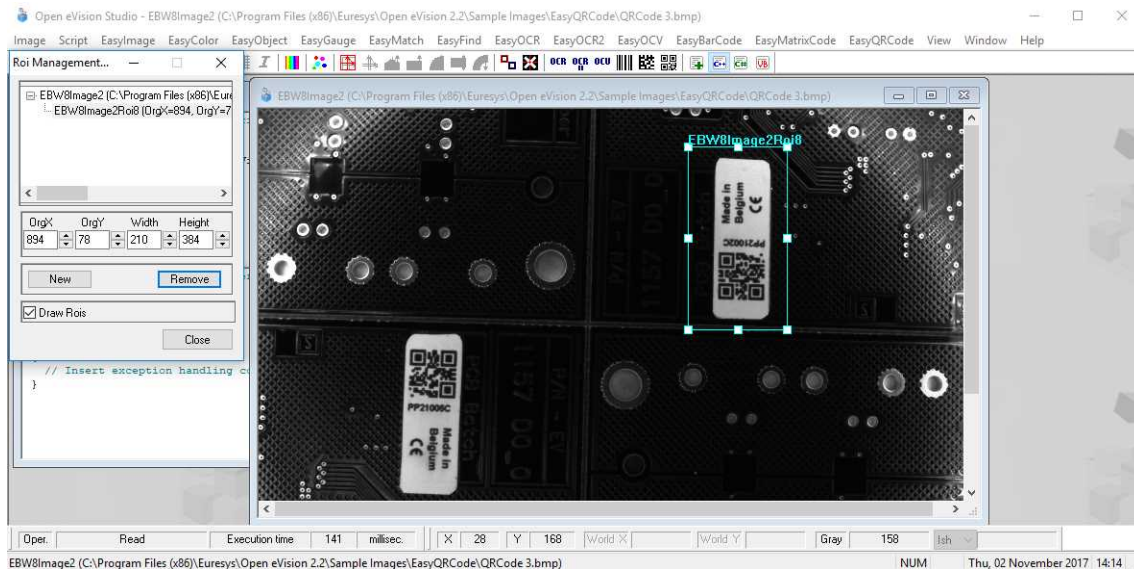
The **ROI Management** window is displayed as illustrated below.



3. Select the image in the tree.
4. Click on the **New** button.
5. In the dialog box, enter a **Variable name** for the new ROI.

The ROI is represented as a color rectangle on your image as illustrated below.





6. Drag the ROI corner and side handles to move it to the required position.

7. Click on the **Close** button to close the **ROI Management** window.

The next step is "[Step 4: Configuring the Tool](#)" on page 154.

## Managing ROIs

You can add, change and remove ROIs.



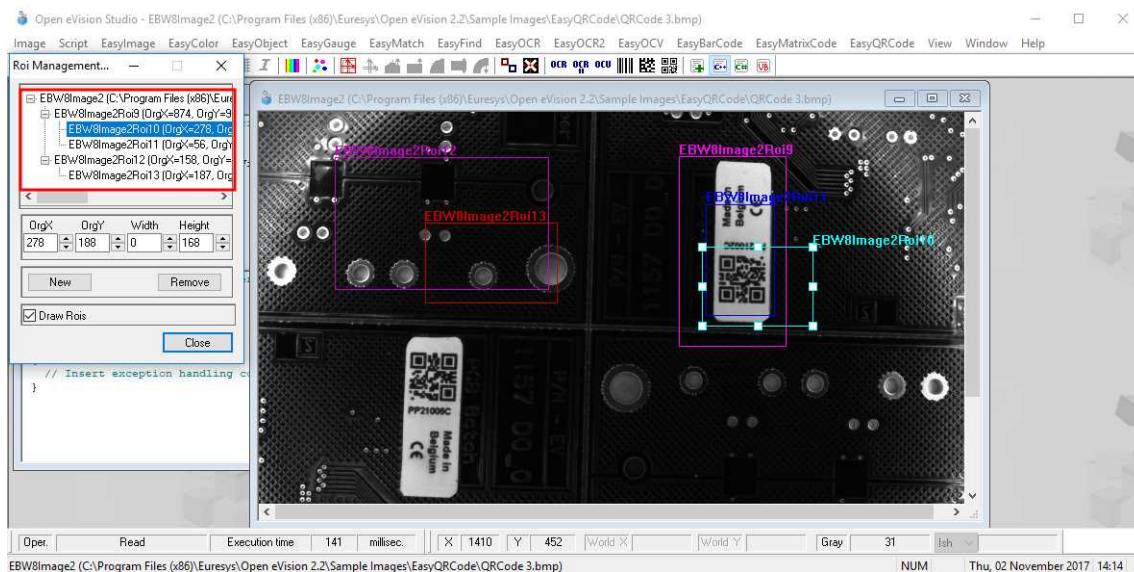
### TIP

An image can have several ROIs. Each ROI can be attached directly to the image (meaning that its position is relative to the image) or to another ROI (meaning that its position is relative to this 'parent' ROI).

1. To manage ROIs, go to the main menu: **Image** > **ROI Management...**

The **ROI Management** window is displayed with the ROI relation tree as illustrated below.

If the **Draw Rois** box is checked, all ROIs are displayed on the image with a different color.



2. Select an ROI in the ROI relation tree.
3. Drag the ROI corner and side handles to change the position and size of the selected ROI (as well as the position of all ROIs attached to it if any).
4. Click on the **New** button to add a new ROI attached to the selected ROI.

**TIP**

Select the image at the top of the ROI relation tree to attach the ROI directly to the image.

5. Click on the **Remove** button to delete the selected ROI (and all ROIs attached to it if any).
6. Click on the **Close** button to close the **ROI Management** window.

## Step 4: Configuring the Tool

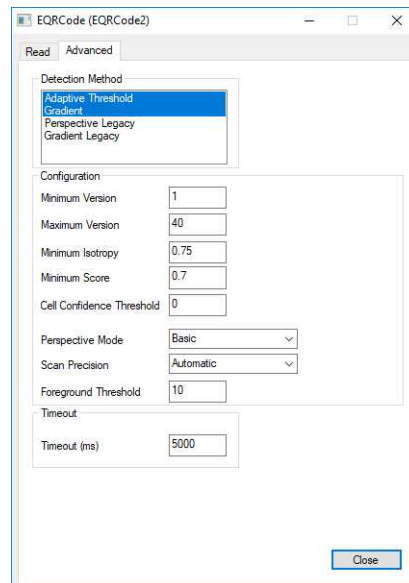
Once your image, including its ROIs if you created some, is ready, you need to configure your tool.

In the tool window:

1. Open the various tabs.

**TIP**

When you create a new tool, all parameters are set with their default value.



Example of the parameter tab of an EasyQRCode tool

2. In each tab, set the value of the parameters as desired.

Please refer to the "Functional Guide" and to the "Reference Manual" for detailed information about the parameters, their function and their default value.

For specific actions such as learning or using gauges, please refer to the "Functional Guide".

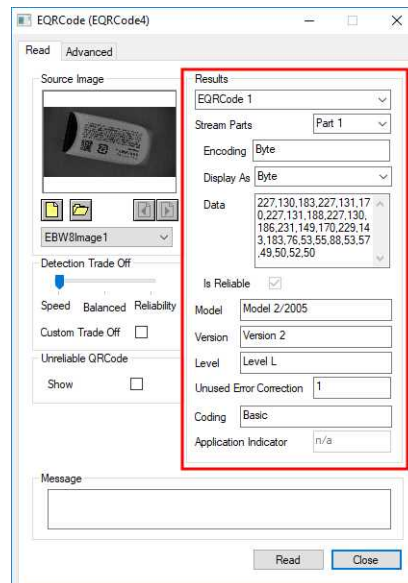
3. Run the tool and analyze the results as described in the next step "[Step 5: Running the Tool and Checking Execution Time](#)" on page 155.

## Step 5: Running the Tool and Checking Execution Time

Once your tool parameters are set, run your tool and, if desired, check the execution time on your computer.

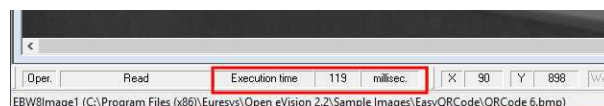
In the tool window:

1. Click on the **Read**, **Detect**, **Results** or **Execute** button (depending on the library function), to run the tool on the selected image.
2. Check the results on the image and in the Results field or area as illustrated below.



Example of results after reading a QRCode

3. If you do not have the expected results:
  - Try to change your parameters (start with default values then change one parameter at a time).
  - If your image is not good enough, try to enhance it as described in .
4. Check the execution time in the execution time bar at the bottom left of the main **Open eVision Studio** window.



The execution time



#### TIP

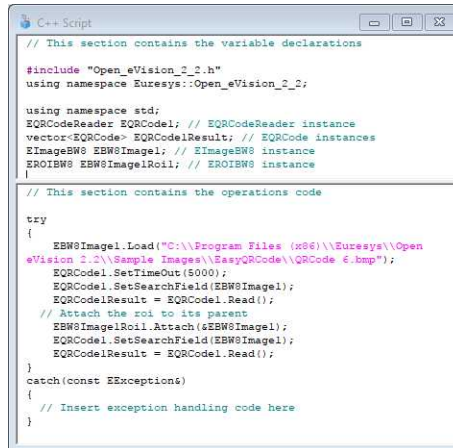
The execution time is the actual time that the processing took as measured on your computer. It depends your computer processor, memory, operating system... and, of course, on the processor load at the time of execution. Thus this execution time slightly varies from execution to execution.

5. To get a more representative execution time, click on the **Read**, **Detect**, **Results** or **Execute** button several times and calculate the mean execution time.
6. If your application requires that you reduce the execution time, try:
  - To change the tool parameters,
  - To add one or several ROIs on your image,
  - To enhance your image.

The next step is "[Step 6: Using the Generated Code](#)" on page 157.

## Step 6: Using the Generated Code

By default, **Open eVision Studio** translates all the operations you perform in the interface into code in the language you selected as illustrated below.



```

C++ Script
// This section contains the variable declarations
#include "Open_eVision_2_2.h"
using namespace Euresys::Open_eVision_2_2;

using namespace std;
EQRCoderReader EQRCoder; // EQRCoderReader instance
vector<EQRCoder> EQRCoderResult; // EQRCoder instances
IImageBWS EBWSImage; // IImageBWS instance
EROIENB EBWSImageRoll; // EROIENB instance
|

// This section contains the operations code

try
{
    EBWSImage.Load("C:\\Program Files (x86)\\Euresys\\Open
eVision 2.2\\Sample Images\\EasyQRCode\\QRCode_8.bmp");
    EQRCoder.SetTimeOut(5000);
    EQRCoder.SetSearchField(EBWSImage);
    EQRCoderResult = EQRCoder.Read();
    // Attach the Roll to its parent
    EBWSImageRoll.Attach(EBWSImage);
    EQRCoder.SetSearchField(EBWSImage);
    EQRCoderResult = EQRCoder.Read();
}
catch(const EException&)
{
    // Insert exception handling code here
}

```

Once your tool results suit you, you can save or copy this generated code to use it in your own application.

### Copy and paste the code in your application

In the script window:

1. Select the code section you want to copy.
2. Right click on this code and click **Copy** in the menu.
3. Go to your development environment tool and paste the code in place.

### Save the code

1. Go to the **Script** menu.
2. Click on **Save Script As...**
3. Enter a file name and path to save the code as a text file.

### Manage the generated code

In the **Script** menu, you can:

- Select the programming language (please note that if you change the language, the script window content is automatically deleted).
- Activate or deactivate the **Script Code Generation**. Deactivate this option if you want to perform some operations without saving them as code.

## 5.4. Pre-Processing and Saving Images

### When should you pre-process your images?

Of course, the best situation is to set up your image acquisition system to have good and easy to process images so the **Open eVision** tools run smoothly and efficiently.

If this is not possible or easy to achieve, you can pre-process your images or your ROIs to enhance and prepare them for the **Open eVision** tool you want to run.

Using the various available functions, you can adjust the gain and offset of your image, apply a convolution, threshold, scale, rotate and white balance your image, enhance contours... using EasyImage and EasyColor functions.

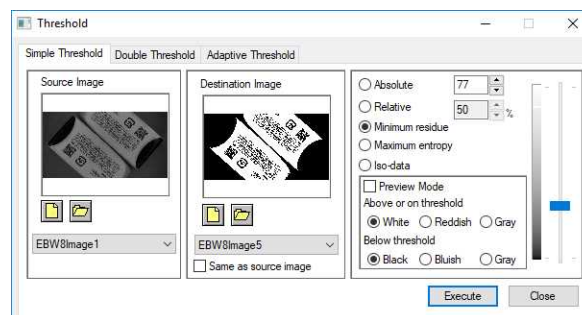
### Pre-processing images

The difference between pre-processing an image and running tools is that the pre-processing generates a new image while the tools mainly extract and retrieve information from the image without changing it.

To pre-process an image or an ROI:

1. In the main menu bar, click on the library you want to use (EasyImage or EasyColor).
2. Click on the function you want to use.

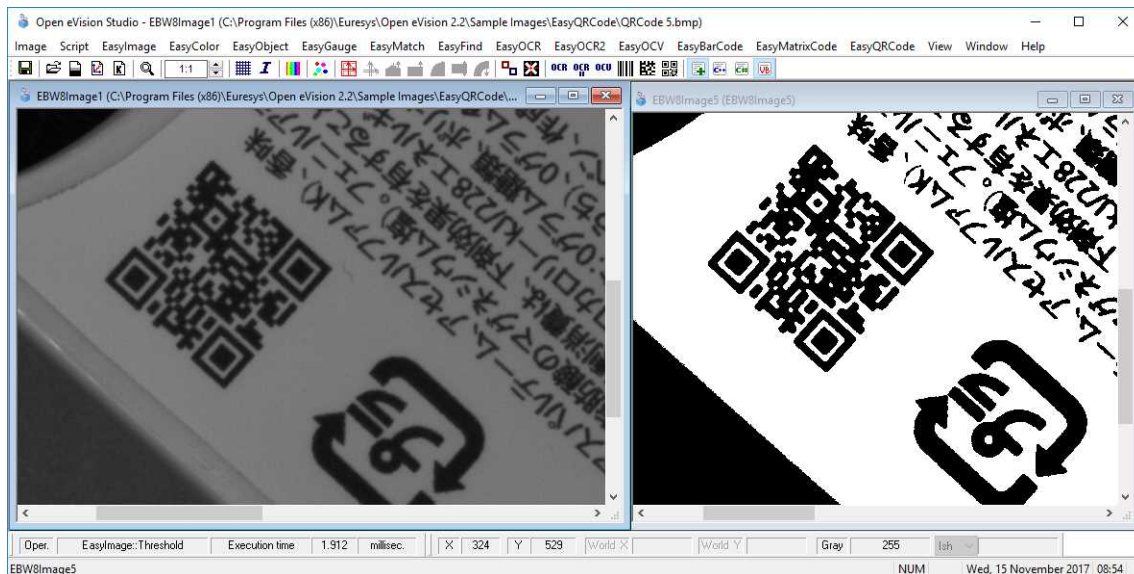
Most function dialog boxes are similar to the one illustrated below with 2 image selection areas and a parameter setting area.



Example of a pre-processing dialog box (Threshold with EasyImage)

3. If there are multiple versions for your selected function, open the corresponding tab.
4. In the **Source Image** area, open the source image (as described in "[Step 2: Opening an Image](#)" on page 151).
5. In the **Destination Image** area, open or create a new destination image.
6. Set your parameters.
7. Click on the **Execute** button.

The pre-processed image is available in the destination image as illustrated below.



Source and destinations images (Threshold with EasyImage)

8. If you want to use the destination image outside of **Open eVision Studio**, save it as described below.

### Saving an image

1. Click on the image you want to save to makes its window active.
2. To open the save menu either:
  - Right-click in the image
  - Or open the main menu > **Image**
3. Click on **Save as...**
4. Select the file format (JPEG, JPEG2000, PNG, TIFF or Bitmap).
5. Enter a name and select a path.
6. Click on the **Save** button.



## 6. Tutorials

### 6.1. EasyObject

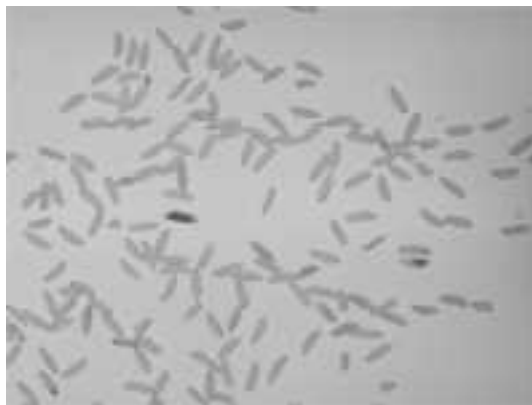
#### Removing Non-Significant Objects After Image Segmentation

["Image Segmenter" on page 188](#)

##### Objective

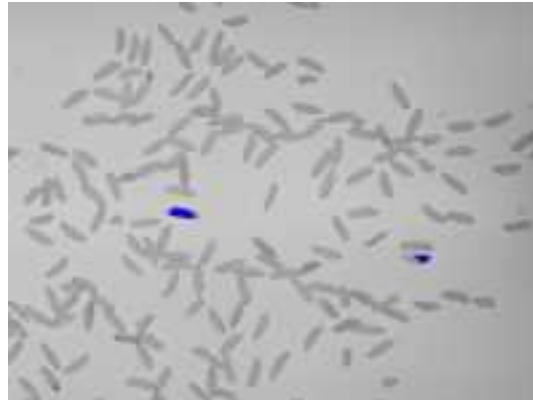
Following this tutorial, you will learn how to use EasyObject to detect bad rice grains (largely dark) among many normal rice grains (largely light).

You'll need first to load the source image (step 1). Then you'll perform the image segmentation, based on a threshold value (step 2). All the detected objects are dark, but some are too small to be significant. So, you'll set a minimum object area (number of pixels), and remove the smallest objects (step 3). Finally, you'll get only the objects that really represent bad rice grains.



Source image





Bad rice grains are detected

### Step 1: Load the source image

---

1. From the main menu, click **EasyObject**, then **New EasyObject Tool**.
2. Keep the default variable name for the new object, and click **OK**.
3. In the **Encoder** tab, click the **Open** icon of the Source Image area, and load the image file `EasyObject\Rice.jpg`.
4. Keep the default variable name for the new image, and click **OK**.

### Step 2: Perform image segmentation

---

1. In the **Encoder** tab, select the **Black Layer** check-box, and unselect the **White Layer** check-box.
2. Click the **...** button around the **Threshold** field. In the Threshold dialog box, select **Absolute**, enter '115', and click **OK**.
3. Click **Encode** to detect the dark objects. In the image, each object is drawn using a different color.
4. Click **Results** to display the list of all the detected objects. Clicking an object in the image highlights it in the list, and vice versa.

### Step 3: Remove the smallest objects

---

1. In the objects list, click **Columns**.
2. Tick the **Area** check-box, and click **OK**. In the list view, a new Area column appears, displaying each object area.
3. Click the Area column header to sort the objects. There are many small objects (area < 100) that may be considered as noise.
4. In the **Selection** tab, select **Area** from the Feature drop-down list. Select **'Less'** from the Mode drop-down list. In the Threshold field, enter '100'.
5. Click **Remove**. All the objects with an area smaller than 100 pixels have been removed from the list. The two remaining objects are the bad rice grains.

# Detecting Differences Between Images Using Min-Max References

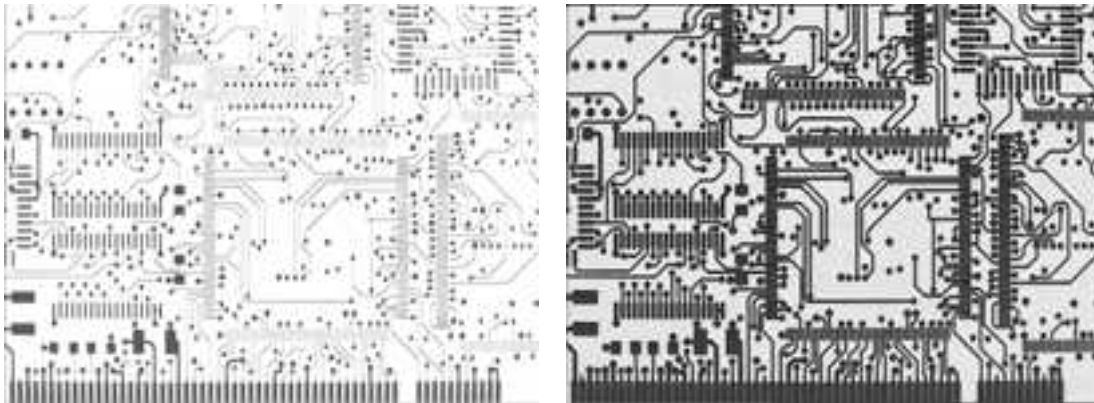
["Selecting and Sorting Blobs" on page 191](#)

## Objective

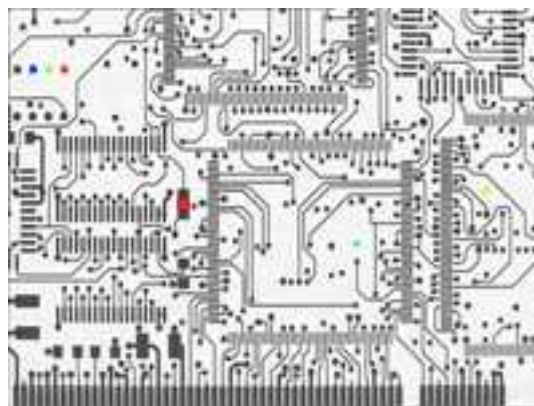
---

Following this tutorial, you will learn how to use EasyObject to compare images. In this example, we will check the quality of a PCB film.

You'll need first to load a reliable source image (step 1), from which two reference images (min and max) will be built (step 2). Then you'll load another image to be inspected (step 3), and perform the comparison with the min and max reference images (step 4). The differences will be detected.



High (left) and low (right) threshold reference images



In another image, differences are detected

## Step 1: Load the source image

---

1. From the main menu, click **EasyObject**, then **Make Min Max**.
2. Click the **Open** icon of the Source Image area, and load the image file EasyObject\Film0k.png.

3. Enter 'filmOk' for the name of the new image, and click **OK**.

## Step 2: Build min and max reference images

---

1. Click **Execute**. Min and Max reference images are created, based on the source image.
  - filmOkMax is computed by dilating filmOk a given number of times ('geometric margin') and adding a constant ('gray level margin') to every pixel. filmOkMin is computed by eroding filmOk the same number of times and subtracting the same constant to every pixel.
  - The geometric margin can be seen as a position tolerance between the image to be inspected and the reference.
  - The gray level margin introduces a tolerance to lighting variations.

## Step 3: Load an image to be inspected

---

1. From the main menu, click **EasyObject**, then **New EasyObject Tool**.
2. Keep the default variable name for the new object, and click **OK**.
3. In the **Encoder** tab, click the **Open** icon of the Source Image area, and load the image file EasyObject\FilmBad.png.
4. Enter 'filmBad' for the name of the new image, and click **OK**.

## Step 4: Compare the image with the reference images

---

1. In the **Encoder** tab, select **ImageRange** in the segmentation method drop-down list.
2. Disable the **White Layer** check-box, and enable the **Black Layer** check-box.
3. Click the **...** button around the High Image field. Select **filmOkMax** in the drop-down list, and click **OK**.
4. Click the **...** button around the Low Image field. Select **filmOkMin** in the drop-down list, and click **OK**.
5. Click **Encode**. Eight differences are highlighted in the image.
6. Click **Results** to get further information about the detected objects. They may be further filtered and analyzed using object features selection and sorting capabilities of EasyObject.

# Detecting Printing Errors Using a Flexible Mask

["Generating a Flexible Mask from an Encoded Image" on page 192](#)

## Objective

---

Following this tutorial, you will learn how to use a flexible mask to target and search specific areas in the image.

You'll need first to load a source image (step 1), and a flexible mask image (step 2), that can be automatically applied on the source image to separate do-care areas (that must be considered) and don't-care areas (that should not be considered). Then, you'll perform the inspection only on do-care areas (step 3).



Source image



Mask image



Results

### Step 1: Load the source image

---

1. From the main menu, click **EasyObject**, then **New EasyObject Tool**.
2. Keep the default variable name for the new object, and click **OK**.
3. In the **Encoder** tab, click the **Open** icon, and load the image file `EasyObject\Mobile3.jpg`.

4. Keep the default variable name for the new image, and click **OK**.

## Step 2: Load the flexible mask image

---

1. In the **Encoder** tab, click the **Open** icon, and load the flexible mask image file `EasyObject\MobileMask.bmp`.
2. Enter 'mask' for the name of the new image, and click **OK**. In the **Mask** area of the **Encoder** tab, notice that the mask image is selected from the drop-down list: the mask is automatically applied on the source image, because its name contains 'mask', and because it has been loaded from the coded image dialog box. The source image preview in the dialog box shows (in red diagonal lines) the don't-care area, that is the area that will be not be considered when encoding the source image.

## Step 3: Inspect the image

---

1. In the **Segmentation** area of the **Encoder** tab, click the **...** button to display the threshold dialog box.
2. Select Absolute and enter 202 for the threshold. Click **OK** to close the dialog box.
3. Click **Encode** to locate the objects (in the do-care areas only). In the source image, each object is drawn using a different color. Three printing errors can be observed:
  - The digit '7' is partially printed.
  - The '+' sign is missing.
  - The handset is printed on a lighter tone.
4. Click Results to display the statistics on each object.
  - Selecting an object in the list highlights it in the image.
  - Selecting **Columns** and **Drawing** will display more options.

## 6.2. EasyGauge

### Measuring the Rotation Angle of an Object

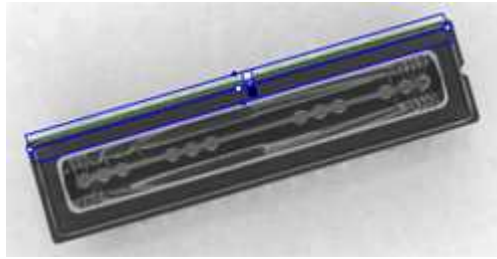
["Line Fitting" on page 195](#)

#### Objective

---

Following this tutorial, you will learn how to use EasyGauge to measure the rotation angle of a CCD sensor package. As we only need to retrieve an angle value, it's not required to work in a calibrated field of view. All geometrical parameters and results will be express as numbers of pixels.

You'll need to load the source image (step 1), and attach a line fitting gauge (step 2). The inspection is automatically performed (step 3).



Line fitting gauge

### Step 1: Load the source image

---

1. From the main menu, click **EasyGauge**, then **New World Shape**.
2. Keep the default variable name, and click **OK**.
3. From the **Gauges** tab, click the **Open** icon, and load the image file EasyImage\CCD.tif.
4. Keep the default variable name for the new image object, and click **OK**.

### Step 2: Attach a line gauge to the image

---

1. In the **Gauges** tab of the world shape dialog box, right-click the world shape icon, select **New** > **Line Gauge** from the contextual menu.
2. Keep the default variable name, and click **OK**. The line location gauge appears on the image. It consists of the following elements:
  - A blue line segment along which the transitions search is carried out.
  - Five white handles, allowing the user to move and rotate the segment.
  - A gray arrow, indicating in which direction the segment is traversed.
  - Black and white rectangles, indicating which kind of transition is searched for.
  - Green line, indicating the transition points found (if any).
3. Using the handles, move, rotate and extend the line gauge, so that it is positioned on the upper edge of the CCD package, with the gray arrow pointing downwards.
4. In the **Measurement** tab of the line gauge dialog box, choose 'White to Black' from the Type dropdown list and 'From Begin' from the Choice dropdown list.

### Step 3: Perform the inspection

---

1. The image is automatically inspected. However, clicking **Process** in the world shape dialog box will insert the corresponding code into the script window.
2. Click the **Results** tab to retrieve the measured angle value.
3. To see the individual fitting points, select the **Points** checkbox under the Draw Samples area.

## Measuring the Diameter of a Circle

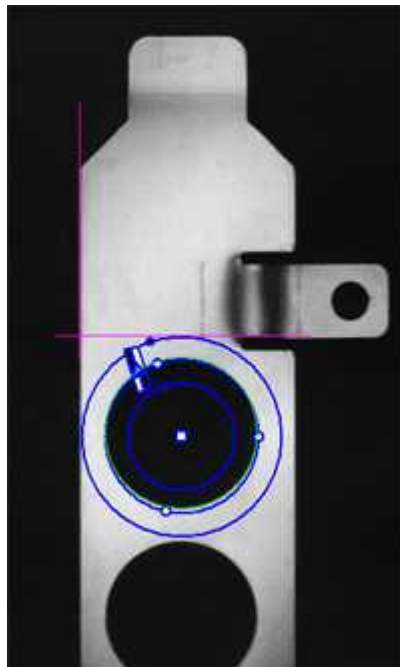
"Circle Fitting" on page 196

## Objective

---

Following this tutorial, you will learn how to use EasyGauge to measure the diameter of a circle in an image.

You'll first load an image for calibration —a dot grid— (step 1), and calibrate the field of view (step 2). Then you'll load the source image for inspection (step 3), and attach a circle fitting gauge (step 4). The inspection is automatically performed (step 5). All measurement results are expressed in physical units..



Measuring the diameter of a circle

### Step 1: Load the calibration image

---

1. From the main menu, click **EasyGauge**, then **New World Shape**.
2. Keep the default variable name, and click **OK**.
3. In the **Dot Grid Calibration** tab, click the **Open** icon, and load the image file EasyGauge\Dot Grid 1.tif.
4. Keep the default variable name for the new image object, and click **OK**.

### Step 2: Calibrate the field of view

---

- Click **Calibrate**. From now on, the field of view is calibrated, and all results will be expressed in physical units.

### Step 3: Load the source image

---

1. From the **Gauges** tab, click the **Open** icon, and load the image file EasyGauge\Bracket 6.tif.
2. Keep the default variable name, and click **OK**.

## Step 4: Attach a circle gauge to the image

---

1. In the **Gauges** tab of the world shape dialog box, right-click the frame shape icon, select **New** > **Circle Gauge** from the contextual menu.
2. Keep the default variable name, and click **OK**.
3. The circle location gauge appears on the image. It consists of the following elements:
  - A blue ring in which the circle is searched for.
  - A blue nominal circle.
  - Six white handles, allowing the user to move and rotate the segment.
  - A gray arrow, indicating in which direction the segment is traversed.
  - Black and white rectangles, indicating which kind of transition are searched for.
  - A green arc of circle, indicating the circle found (if any).
4. Using the handles, drag the circle fitting gauge around the upper bracket hole. Adjust the nominal circle on the hole edge and extend the searching area if necessary.
5. In the **Measurement** tab of the circle gauge dialog box, select 'From Begin' from the Choice dropdown list.

## Step 5: Perform the inspection

---

1. The image is automatically inspected. However, clicking **Process** in the world shape dialog box will insert the corresponding code into the script window.
2. Click the **Results** tab to retrieve the measured diameter. All measurement results are expressed in physical units.

# Measuring a Distorted Rectangle

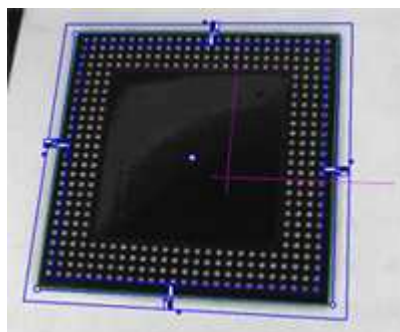
["Rectangle Fitting" on page 197](#)

## Objective

---

Following this tutorial, you will learn how to use EasyGauge to perform measurements on a distorted rectangle component.

To obtain measurement results in physical units, we need to work in a calibrated field of view. You'll need first to load an image for calibration —a dot grid— (step 1), and calibrate the field of view (step 2). Then you'll load the distorted image (step 3), and attach a rectangle fitting gauge (step 4). The inspection is automatically performed (step 5). All measurement results are expressed in physical units.





## Measuring a distorted rectangle

### Step 1: Load the calibration image

---

1. From the main menu, click **EasyGauge**, then **New World Shape**.
2. Keep the default variable name, and click **OK**.
3. In the **Dot Grid Calibration** tab, click the **Open** icon, and load the image file EasyGauge\Dot Grid 5.tif. This dot grid has been acquired in the same conditions and has the same distortion as the image we want to inspect.
4. Keep the default variable name for the new image object, and click **OK**.

### Step 2: Calibrate the field of view

---

- Click **Calibrate**. From now on, the field of view is calibrated, and all results will be expressed in physical units.

### Step 3: Load the distorted image

---

1. From the **Gauges** tab, click the **Open** icon, and load the image file EasyGauge\Distorted Component.tif.
2. Keep the default variable name, and click **OK**.

### Step 4: Attach a rectangle gauge to the image

---

1. In the **Gauges** tab, right-click the world shape icon, and select **New** > **Rectangle Gauge** from the contextual menu.
2. Keep the default variable name, and click **OK**. The rectangle gauge dialog box is opened, and the rectangle gauge is drawn on the image. It consists of the following elements:
  - A blue rectangular ring in which the rectangle is searched for.
  - A blue nominal rectangle.
  - Eleven white handles, allowing the user to move and extend the search area.
  - Gray arrows, indicating in which direction segments are examined.
  - Black and white rectangles, indicating which kind of transition are searched for.
  - A green rectangle, indicating the rectangle found (if any).
3. Due to the perspective effect, the rectangle gauge doesn't look like a rectangle. Using the central handle, move the rectangle gauge in the image and observe the rectangle deformation. Due to the calibration, the rectangle gauge shape adapts to the field of view deformation. Extend the searching area, and adjust the nominal rectangle on the component edges.
4. In the **Measurement** tab of the rectangle gauge dialog box, select 'White To Black' from the Type dropdown list and 'From Begin' from the Choice dropdown list.

### Step 5: Perform the inspection

---

1. The image is automatically inspected. However, clicking **Process** in the world shape dialog box will insert the corresponding code into the script window.
2. Click the **Results** tab to retrieve the measured X and Y sizes. All measurement results are expressed in physical units.

# Locating Points Regarding to a Coordinate System

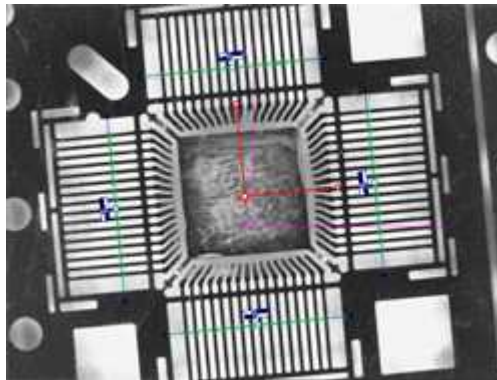
"Point Location" on page 195

## Objective

---

Following this tutorial, you will learn how to use EasyGauge to perform lead frames inspection. This operation determines the dimension, position, curvature, size, angle or diameter of the lead frames with an excellent accuracy. Robustness is ensured by powerful edge-point selection mechanisms that are intuitive and easy to tune, allowing measurement in cluttered images.

You'll first load an image for calibration — a dot grid— (step 1), and calibrate the field of view (step 2). Then you'll load the lead frame image (step 3), and set a coordinate system (a frame shape). Regarding to this coordinate system, you can define point gauges (steps 5-6). Finally, you'll load another lead frame image, that has a slight angle deviation, so the coordinate system has to be rotated (steps 7-8). The inspection is then automatically performed (step 9). All measurement results are expressed in physical units.



Four point gauges over four sets of leads

## Step 1: Load the calibration image

---

1. From the main menu, click **EasyGauge**, then **New World Shape**.
2. Keep the default variable name, and click **OK**.
3. In the **Dot Grid Calibration** tab, click the **Open** icon, and load the image file EasyGauge\Dot Grid 2.tif.
4. Keep the default variable name for the new image object, and click **OK**.

## Step 2: Calibrating the field of view

---

1. Click **Calibrate**. From now on, the field of view is calibrated, and all results will be expressed in physical units.

## Step 3: Loading a lead frame image

---

1. From the **Gauges** tab, click the **Open** icon, and load the image file EasyGauge\Lead Frame 1.tif.
2. Keep the default variable name, and click **OK**.

## Step 4: Setting a coordinate system

---

1. In the **Gauges** tab of the world shape dialog box, right-click the world shape icon, select **New > Frame Shape** from the contextual menu.
2. Keep the default variable name, and click **OK**. The frame shape icon appears in the world shape dialog box.
3. Drag the frame shape center approximately to the square center of the image.

## Step 5: Attaching a point gauge to the frame shape

---

1. In the **Gauges** tab of the world shape dialog box, right-click the frame shape icon, select **New > Point Gauge** from the contextual menu.
2. Keep the default variable name, and click **OK**. The point location gauge appears on the image. It consists of the following elements:
  - A blue line segment along which the transitions search is carried out.
  - Three white handles, allowing the user to move and rotate the segment.
  - A gray arrow, indicating in which direction the segment is traversed.
  - Black and white rectangles, indicating which kind of transition is searched for.
  - Green crosses, indicating the transition points found (if any).
3. Place the point location gauge over a set of leads: in the **Position** tab of the point gauge dialog box, set the Center Y property to 7, and the Tolerance property to 5.

## Step 6: Attaching other point gauges to the frame shape

---

1. From the **Gauges** tab of the world shape dialog box, create three other point gauges (refer to step 5).
2. Place these point location gauges over the remaining sets of leads :
  - Center Y = -7, Tolerance = 5
  - Center X = 7, Tolerance = 5, Angle = 90
  - Center X = -7, Tolerance = 5, Angle = 90

## Step 7: Loading another lead frame image

---

1. From the **Gauges** tab, click the Open icon, and load the image file EasyGauge\Lead Frame 2.tif.
2. Keep the default variable name for the new image, and click **OK**.

## Step 8: Tuning the coordinate system

---

1. In the frame shape dialog box, set the Angle property to 5.8.
2. Drag the frame shape center approximately to the square center of the image. All point location gauges automatically follow.

## Step 9: Performing the inspection

---

1. The image is automatically inspected. However, clicking Process in the world shape dialog box will insert the corresponding code into the script window.

2. From the point gauge dialog boxes, click the Results tab to retrieve the located points coordinates. All measurement results are expressed in physical units. The values refer to the frame shape system.

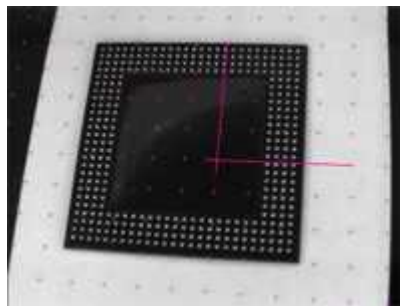
## Unwarping a Distorted Image

### Objective

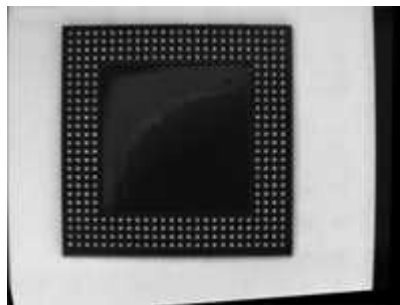
---

Following this tutorial, you will learn how to use EasyGauge to perform grid calibration, and unwarped a distorted image.

You'll first load an image for calibration —a dot grid— (step 1), and calibrate the field of view (step 2). Then you'll load the distorted image (step 3), and perform the unwarping operation (step 4).



Distorted image



Unwarped image

### Step 1: Load the calibration image

---

1. From the main menu, click **EasyGauge**, then **New World Shape**.
2. Keep the default variable name, and click **OK**.
3. In the **Dot Grid Calibration** tab, click the **Open** icon, and load the image file EasyGauge\Dot Grid 5.tif. This dot grid has been acquired in the same conditions and has the same distortion as the image we want to unwarped.
4. Keep the default variable name for the new image object, and click **OK**.

## Step 2: Calibrate the field of view

---

- Click **Calibrate**.

## Step 3: Load the distorted image

---

1. From the **Unwarping** tab, click the **Open** icon, and load the image file EasyGauge\Distorted component.tif.
2. Keep the default variable name, and click **OK**.

## Step 4: Unwarp the distorted image

---

1. In the Destination Image area, click **New** icon to create a new image.
2. Keep the default image settings, and click **OK**.
3. Select **Interpolate** checkbox to improve resulting image quality.
4. Click **Unwarp**. In the destination image, all distortions are corrected.

## 6.3. EasyFind

### Detecting Highly-Degraded Occurrences of a Reference Model in Multiple Files

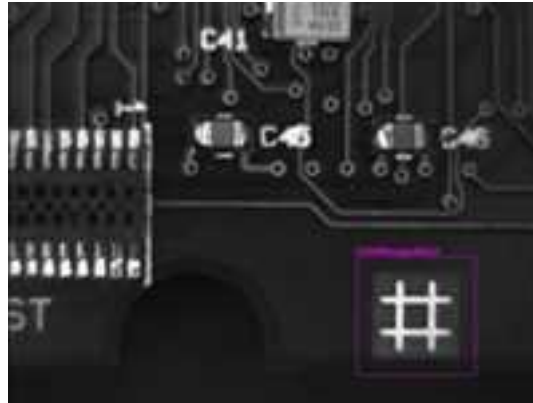
["Pattern Finding and Retrieving Results" on page 204](#)

#### Objective

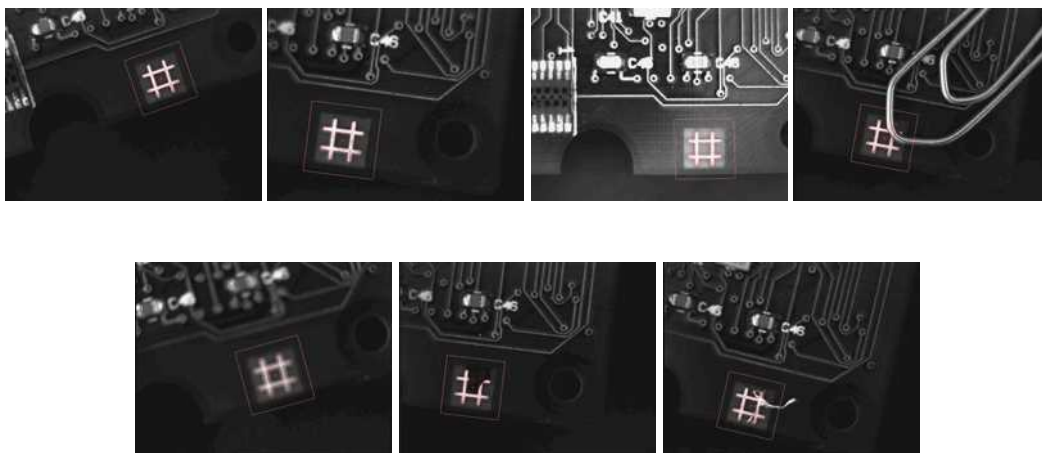
---

Following this tutorial, you will learn how to use EasyFind to detect in multiple images highly-degraded occurrences of a reference model. The degradation can be due to noise, blur, occlusion, missing parts or unstable illumination conditions.

You'll need first to load a reference image, define an ROI where EasyFind will learn the reference model, and set rotation and scaling tolerances for the expected occurrences to search for (steps 1-4). Then you're ready to open multiple files, and perform automatic detection of occurrences (even highly-degraded) of the reference model (steps 5-6).



Reference model



Occurrences of the reference model are found, even if highly-degraded

### Step 1: Load the reference image

---

1. From the main menu, click **EasyFind**, then **New EasyFind Tool**.
2. Keep the default variable name for the new PatternFinder object, and click **OK**. The PatternFinder management dialog box is opened.
3. In the **Model** tab, click the **Open** icon, and load the image file EasyFind\Fiducial 1.tif.
4. Keep the default variable name for the new image object, and click **OK**.

### Step 2: Create an ROI to define the reference model on the reference image

---

1. In the image, right-click and select **New ROI...** item from the menu.
2. Keep the default variable name for the new ROI object, and click **OK**. A default ROI is placed over the image (blue rectangle with handles). The ROI management dialog box is opened.
3. Drag the ROI over the reference model and resize it using its handles. Alternatively, enter the following coordinates in the ROI dialog box: 500, 365, 170, 170 for OrgX, OrgY, Width, and Height respectively, and click **Close**.

### Step 3: Learn the reference model

---

1. In the PatternFinder **Model** tab, select the ROI object from the source image drop-down list, and click **Learn**. The reference model is perfectly detected (green edges).
2. In the PatternFinder **Search Field** tab, select the Image object from the source image drop-down list. Tick the Draw Features check-box.

The model location and feature points are highlighted in the source image.

### Step 4: Set rotation and scaling tolerances

---

- In the PatternFinder **Allowances** tab, set both angle tolerance and scale tolerance to 25.0.

### Step 5: Select multiple images

---

1. In the PatternFinder **Search Field** tab, click the **Open** icon. Select the images files EasyFind\Fiducial 2.tif to Fiducial 8.tif (use the shift key to select multiple files), and click **Open**.
2. Keep the default variable name for the new Image object, and click **OK**. The last image appears. The reference model is found, even if highly-degraded.
3. Detection of the reference model is automatically performed. It is not necessary to click Find once a new image appears, as inspection is automatically performed. However, clicking **Find** will insert the corresponding code into the script windows.
4. Click **Results** to find more information about the found instance.

### Step 6: Browse multiple images

---

- In the PatternFinder **Search Field** tab, click the **Load Next** or **Load Previous** icons.

The image files appear, and the reference model is automatically detected.

## Improving the Score of Found Instances by Using "Don't Care Areas"

["Setting Search Parameters" on page 203](#)

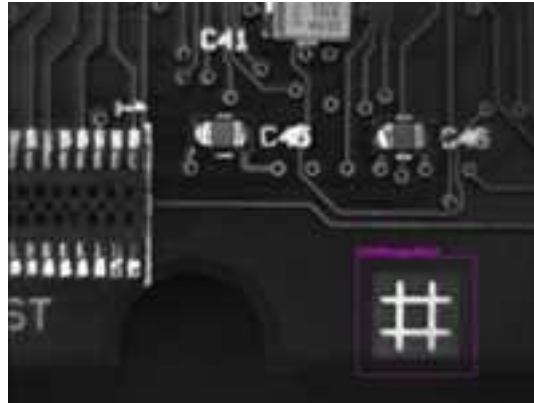
### Objective

---

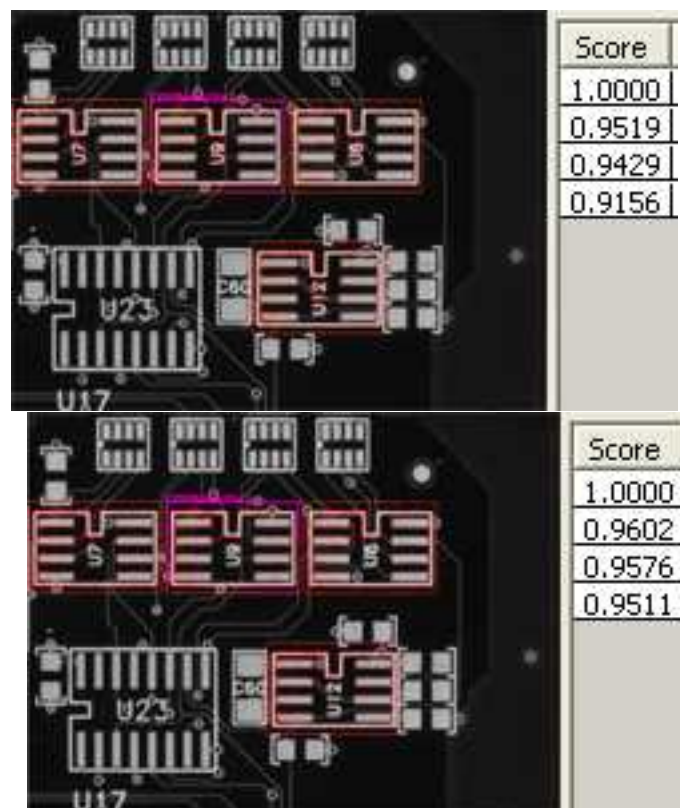
Following this tutorial, you will learn how to use EasyFind to handle "don't care areas" in geometric pattern matching. "Don't care areas" help to define in the image the meaningful features only, by masking the areas that might change from image to image, such as text and numbers.

You'll need first to load a reference image, define an ROI where EasyFind will learn the reference model, and set a rotation tolerance for the expected instances to search for (steps 1-4). Then you're ready to perform automatic detection of instances of the reference model, without using "don't care areas" (step 5). As the matching scores of the found instances are not high enough, you'll define a "don't care area" on the reference model, and restart the detection. The matching scores are slightly better (steps 6-7).





Reference model



Found instances and matching scores, without (left) and with (right) using "don't care areas"

### Step 1: Loading the reference image

1. From the main menu, click **EasyFind**, then **New EasyFind Tool**.
2. Keep the default variable name for the new PatternFinder object, and click **OK**. The PatternFinder management dialog box is opened.
3. In the **Model** tab, click the **Open** icon, and load the image file EasyFind\Solder Pad 1.tif.
4. Keep the default variable name for the new Image object, and click **OK**.



## Step 2: Creating an ROI to define the reference model on the reference image

---

1. In the image, right-click and select **New ROI...** item from the menu.
2. Keep the default variable name for the new ROI object, and click **OK**. A default ROI is placed over the image (blue rectangle with handles). The ROI management dialog box is opened.
3. Drag the ROI over the reference model and resize it using its handles. Alternatively, enter the following coordinates in the ROI dialog box: 200, 130, 190, 130 for OrgX, OrgY, Width, and Height respectively, and click **Close**.

## Step 3: Learning the reference model

---

1. In the PatternFinder **Model** tab, select the ROI object from the source image drop-down list, and click **Learn**. The reference model is detected.
2. In the PatternFinder **Search Field** tab, select the Image object from the source image drop-down list. Tick the **Draw Features** check-box. The model location and feature points are highlighted in the source image.

## Step 4: Setting a rotation tolerance

---

1. In the PatternFinder **Allowances** tab, set the angle tolerance to 5.0.

## Step 5: Detecting instances of the reference model without "don't care areas"

---

1. In the PatternFinder **Search Field** tab, set **Max Instances** to 4, and click **Find**. The instances matching the reference model are highlighted.
2. Click **Results** to see the matching score of each found instance. Even though the scores are good, we can still improve them slightly by using a "don't care area" to mask the text appearing in the learned pattern.

## Step 6: Defining the "don't care area"

---

1. In the PatternFinder **Don't Care Areas** tab, select the **Rectangle** radio button from the **Blacken Inside** group.
2. In the ROI defining the reference model, move your mouse pointer on the top-left corner of the text "U9", left-click and drag the don't care area (rectangle with red stripes) to mask out the text.

## Step 7: Detecting instances of the reference model with "don't care areas"

---

1. In the PatternFinder **Don't Care Areas** tab, click **Learn**, and then click **Find**.

The instances matching the reference model are still highlighted, but the text is not found anymore.

2. Click **Results** to compare the new matching scores.

They are slightly better.

## 6.4. EasyMatch

### Learning a Pattern and Creating an EasyMatch Model File

"Pattern Learning" on page 206

#### Objective

---

Following this tutorial, you will learn how to use EasyMatch to learn a model from a reference image, and save it as an EasyMatch model file.

You'll need first to load the reference image (step 1). Then, you'll learn it as the reference model (step 2). And you'll save the model as an EasyMatch model file (step 3).



Reference image

#### Step 1: Load the reference image

---

1. From the main menu, click **EasyMatch**, then **New Match Tool**.
2. Keep the default variable name for the new matcher object, and click **OK**.
3. In the **Learning** tab, click the **Open** icon, and load the image file `EasyMatch\FrameModel.tif`.
4. Keep the default variable name for the new image object, and click **OK**.

#### Step 2: Learn the reference image

---

- In the **Learning** tab, click **Learn** to acquire the model pattern.

#### Step 3: Save the model file

---

1. In the **Learning** tab, click the **Save As...** button.
2. Type a file name for the new EasyMatch model file. Its extension will be `.mch`.
3. Click **Save**.

### Matching a Pattern According to a Model File

"Pattern Matching and Retrieving Results" on page 207

#### Objective

---

Following this tutorial, you will learn how to use EasyMatch to load an EasyMatch model file, and search for occurrences of the pattern in an image.

You'll need first to load the model file, and a source image where the model will be searched for (steps 1-2). Then the pattern matching is fully automatic (step 3).



Occurrences of the model are automatically highlighted

### Step 1: Load the model file

---

1. From the main menu, click **EasyMatch**, then **New Match Tool**.
2. Keep the default variable name for the new matcher object, and click **OK**.
3. In the **Learning** tab, click **Load...** to open the model file EasyMatch\Switch.MCH. The model contains all necessary information about the pattern we are searching for.

### Step 2: Load a source image

---

1. In the **Matching** tab, click the **Open** icon, and load the image file EasyMatch\Switch1.tif.
2. Keep the default variable name for the new image object, and click **OK**.

### Step 3: Perform the pattern matching

---

1. The pattern matching is automatically performed on the source image, and the matching occurrences are highlighted. Clicking **Execute** will insert the corresponding code into the script windows.
2. Further information about each occurrence can be found by clicking **Results**.
3. Click in a row to see the corresponding occurrence highlighted in the image.

## Learning a Pattern According to an ROI

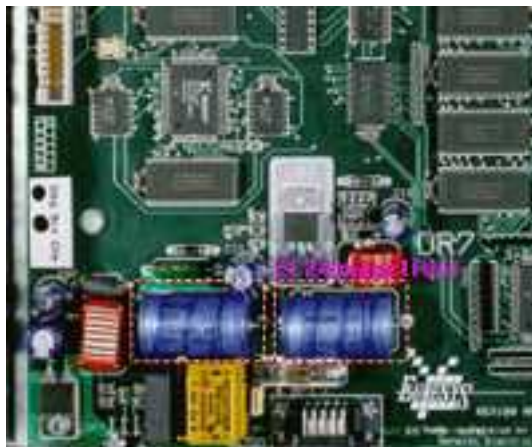
"Pattern Learning" on page 206

## Objective

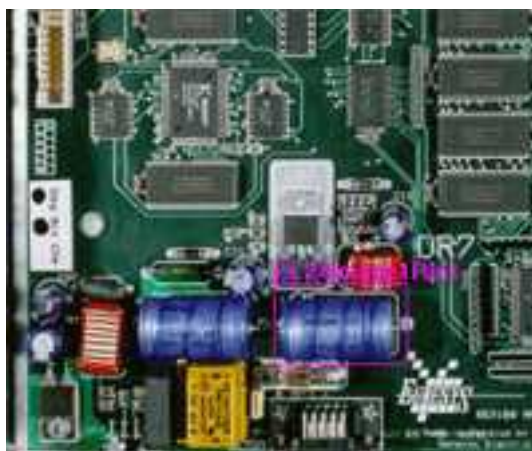
---

Following this tutorial, you will learn how to use EasyMatch to learn a model from an ROI in a source image, and to perform pattern matching on the same image.

You'll need first to load the source image, and define an ROI inside (steps 1-2). Then, you'll have to learn the model, using this ROI (step 3). Finally, you'll perform pattern matching in the source image (step 4), and will find additional occurrences of the model.



ROI that will be learned



Occurrences matching the model ROI

## Step 1: Load the source image

---

1. From the main menu, click **Image**, then **Open**.
2. Load the image file EasyMatch\BOARD.JPG.
3. Keep the default variable name for the new image object, and click **OK**.

## Step 2: Define an ROI

---

1. Right-click in the image, and select **New ROI...** from the contextual menu.

2. Keep the default variable name for the new ROI object, and click **OK**. A default ROI is placed over the image (blue rectangle with handles).

The ROI management dialog box is opened.

3. Resize the ROI and move it around one of the blue capacitors at the lower left part of the image.

### Step 3: Learn a model from the ROI

---

1. From the main menu, click **EasyMatch**, then **New Match Tool**.
2. Keep the default variable name for the new matcher object, and click **OK**.
3. In the **Learning** tab of the matcher dialog box, select the ROI object from the Source Image drop-down list, and click **Learn** to acquire the model pattern.

### Step 4: Match the pattern

---

1. In the **Matching** tab, increase the **Max Occurrences** field to 2.
2. Select the image object from the Source Image drop-down list.
3. Click **Execute**. The occurrences of the learned model are highlighted in the source image.
4. Further information about each occurrence can be found by clicking **Results**.
5. Click in a row to see the corresponding occurrence highlighted in the image.

## Improving the Score of Matching Instances by Using "Don't Care Areas"

["Setting Search Parameters" on page 206](#)

### Objective

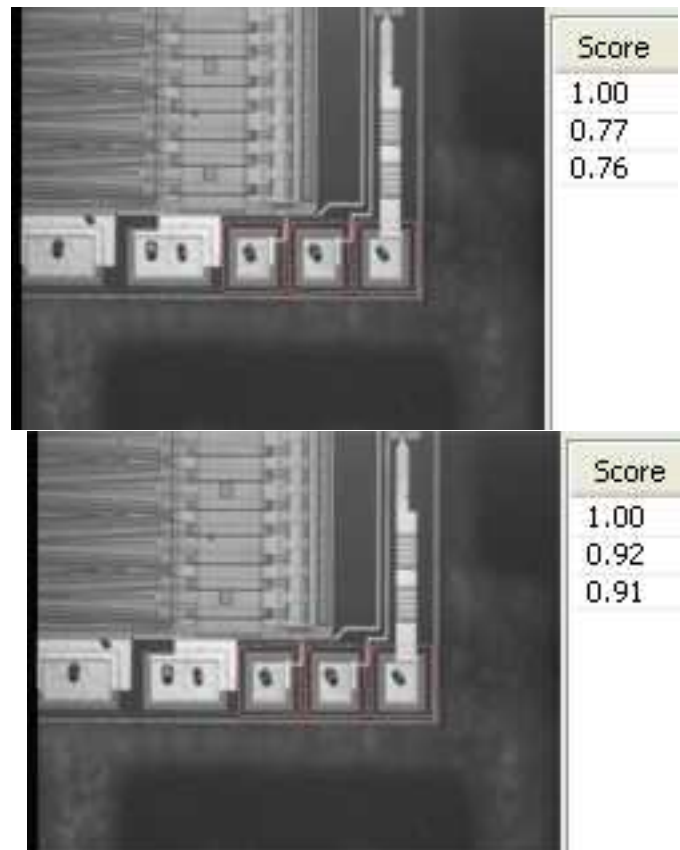
---

Following this tutorial, you will learn how to use EasyMatch to handle "don't care areas". "Don't care areas" help to define in the image the meaningful features only, by masking the areas that might change from image to image.

You'll need first to load a reference image and learn the reference model (steps 1-2). Then you'll perform automatic pattern matching of instances of the reference model, without using "don't care areas" (step 3). As the matching scores of the found instances are not high enough, you'll define a "don't care area" on the reference model, and restart the detection. The matching scores are much better (steps 4-5).



Reference model



Found instances and matching scores, without (left) and with (right) using "don't care areas"

### Step 1: Load the reference image

---

1. From the main menu, click **EasyMatch**, then **New Match Tool**.
2. Keep the default variable name for the new Matcher object, and click **OK**. The Matcher management dialog box is opened.
3. In the **Learning** tab, click the **Open** icon, and load the image file EasyMatch\Die Pad Model 1.bmp.
4. Keep the default variable name for the new Image object, and click **OK**.

### Step 2: Learn the reference model

---

- Click **Learn** to acquire the model pattern.

### Step 3: Detect instances of the reference model without "don't care areas"

---

1. In the **Matching** tab, click the **Open** icon, and load the image file EasyMatch\Die Pad 1.bmp.
2. Keep the default variable name for the new Image object, and click **OK**. An instance matching the reference model is highlighted.
3. Increase the **Max Occurrences** field to 3. Enable the **Sub-Pixel Interpolate** check-box to increase the matching precision.

4. Enter '-10.0' as the Minimum Angle (Deg). (Check that the angle is displayed in degrees. If not, select the angles unit from **View > Option** menu.)
5. Enter '10.0' as the Maximum Angle (Deg).
6. Click **Execute**. The pattern locations are highlighted in the source image.
7. Click **Results** to see the matching score of each found instance. The last two scores are rather bad. This is mainly due to the bright rectangle on the upper part of the reference image we have learned. We can improve the scores by using a "don't care area" to mask this bright area.

#### Step 4: Define the "don't care area"

---

1. In the **Don't Care Areas** tab, select the **Rectangle** radio button from the **Blacken Inside** group.
2. In the reference image, move your mouse pointer on the lower left corner of the bright rectangle, left-click and drag the don't care area (rectangle with red stripes) to the upper right corner of the bright rectangle to mask out this area.
3. In the **Don't Care Areas** tab, click **Learn**.

#### Step 5: Detect instances of the reference model with "don't care areas"

---

1. In the **Matching** tab, click **Execute**. The instances matching the reference model are still highlighted.
2. Click **Results** to compare the new matching scores. They are much better.

## 7. Code Snippets



## 7.1. Basic Types

### Loading and Saving Images

Functional Guide | Reference: [Load](#), [Save](#), [SaveJpeg](#)

```

////////////////////////////////////
// This code snippet shows how to load and save an image. //
////////////////////////////////////

// Images constructor
EImageBW8 srcImage= new EImageBW8();
EImageBW8 dstImage= new EImageBW8();

// Load an image file
srcImage.Load("mySourceImage.bmp");

// ...

// Save the destination image into a file
dstImage.Save("myDestImage.bmp");

// Save the destination image into a jpeg file
// The default compression quality is 75
dstImage.Save("myDestImage.jpg");

// Save the destination image into a jpeg file
// set the compression quality to 50
dstImage.SaveJpeg("myDestImage50.jpg", 50);

```

### Interfacing Third-Party Images

Functional Guide | Reference: [SetImagePtr](#)

```

////////////////////////////////////
// This code snippet shows how to link an Open eVision image //
// to an externally allocated buffer. //
////////////////////////////////////

// Images constructor
EImageBW8 srcImage= new EImageBW8();

// Size of the third-party image
int sizeX = bufferSizeX;
int sizeY = bufferSizeY;

//Pointer to the third-party image buffer
IntPtr imgPtr = bufferPointer;

// ...

// Link the Open eVision image to the third-party image
// Assuming the corresponding buffer is aligned on 4 bytes
srcImage.SetImagePtr(sizeX, sizeY, imgPtr);

```

## Retrieving Pixel Values

Functional Guide | Reference: [GetImagePtr](#)

```

////////////////////////////////////
// This code snippet shows the recommended method to access //
// the pixel values in a BW8 image. //
////////////////////////////////////

using System.Runtime.InteropServices;

IntPtr pixAddr;
byte pix;

//...

for(int y = 0; y < height; ++y)
{
    pixAddr = bw8Image.GetImagePtr(0,y);
    for(int x = 0; x < width; ++x)
        pix = Marshal.ReadByte(pixAddr,x);
}

```

## ROI Placement

Functional Guide | Reference: [Attach](#), [SetPlacement](#)

```

////////////////////////////////////
// This code snippet shows how to attach an ROI to an image //
// and set its placement. //
////////////////////////////////////

// Image constructor
EImageBW8 parentImage= new EImageBW8();

// ROI constructor
EROIBW8 myROI= new EROIBW8();

// Attach the ROI to the image
myROI.Attach(parentImage);

//Set the ROI position
myROI.SetPlacement(50, 50, 200, 100);

```

## Vector Management

Functional Guide | Reference: [Empty](#), [AddElement](#)

```

////////////////////////////////////
// This code snippet shows how to create a vector, fill it //
// and retrieve the value of a given element. //
////////////////////////////////////

// EBW8Vector constructor
EBW8Vector ramp= new EBW8Vector();
EBW8 bw8 = new EBW8();

```

```
// Clear the vector
ramp.Empty();

// Fill the vector with increasing values
for(int i= 0; i < 128; i++)
{
    bw8.Value = (byte)i;
    ramp.AddElement(bw8);
}

// Retrieve the 10th element value
EBW8 value = ramp.GetElement(9);
```

## Exception Management

Functional Guide | Reference: [GetPixel](#), [What](#)

```
////////////////////////////////////
// This code snippet shows how to manage //
// Open eVision exceptions.           //
////////////////////////////////////

try
{
    // Image constructor
    EImageC24 srcImage= new EImageC24();

    // ...

    // Retrieve the pixel value at coordinates (56, 73)
    EC24 value= srcImage.GetPixel(56, 73);
}

catch(EException exc)
{
    // Retrieve the exception description
    string error = exc.What();
}
```

## 7.2. EasyObject

### Constructing the Blobs

#### Image Encoder

Functional Guide | Reference: [Encode](#), [SetBlackLayerEncoded](#), [SetWhiteLayerEncoded](#), [SetMode](#), [SetAbsoluteThreshold](#), [GetGrayscaleSingleThresholdSegmenter](#)

```

////////////////////////////////////
// This code snippet shows how to build blobs belonging to //
// the white layer according to the minimum residue method //
// and how to build blobs belonging to the black layer    //
// according to an absolute threshold.                    //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// Image encoder
EImageEncoder encoder= new EImageEncoder();

// Coded image
ECodedImage2 codedImage= new ECodedImage2();

// ...

// Build the blobs belonging to the white layer,
// the segmentation is based on the Minimum Residue method
encoder.Encode(srcImage, codedImage);

// Build the blobs belonging to the black layer,
// the segmentation is based on an absolute threshold (110)
Euresys.Open_eVision_1_1.Segmenters.EGrayscaleSingleThresholdSegmenter segmenter=
encoder.GrayscaleSingleThresholdSegmenter;
segmenter.BlackLayerEncoded= true;
segmenter.WhiteLayerEncoded= false;

segmenter.Mode= EGrayscaleSingleThreshold.Absolute;
segmenter.AbsoluteThreshold= 110;

encoder.Encode(srcImage, codedImage);

```

#### Image Segmenter

Functional Guide | Reference: [SetSegmentationMethod](#), [GetGrayscaleDoubleThresholdSegmenter](#), [SetHighThreshold](#), [SetLowThreshold](#)

```

////////////////////////////////////
// This code snippet shows how to build blobs according to //
// a user-defined image segmenter.                          //
////////////////////////////////////

// Image constructor

```

```

EImageBW8 srcImage= new EImageBW8();

// Image encoder
EImageEncoder encoder= new EImageEncoder();

// Coded image
ECodedImage2 codedImage= new ECodedImage2();

// ...

// Set the segmentation method to GrayscaleDoubleThreshold
encoder.SegmentationMethod= ESegmentationMethod.GrayscaleDoubleThreshold;

// Retrieve the segmenter object
Euresys.Open_eVision_1_1.Segmenters.EGrayscaleDoubleThresholdSegmenter segmenter=
encoder.GrayscaleDoubleThresholdSegmenter;

// Set the high and low threshold values
segmenter.HighThreshold= 150;
segmenter.LowThreshold= 50;

// Specify the layers to be encoded (neutral layer only)
segmenter.BlackLayerEncoded= false;
segmenter.NeutralLayerEncoded= true;
segmenter.WhiteLayerEncoded= false;

// Encode the image
encoder.Encode(srcImage, codedImage);

```

## Holes Extraction

Functional Guide | Reference: [GetHoleCount](#), [GetHole](#), [GetObjCount](#), [GetObj](#)

```

////////////////////////////////////
// This code snippet shows how to retrieve blobs' holes. //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// Image encoder
EImageEncoder encoder= new EImageEncoder();

// Coded image
ECodedImage2 codedImage= new ECodedImage2();

// ...

// Encode the image
encoder.Encode(srcImage, codedImage);

// Retrieve holes for all the blobs
for (uint blobIndex = 0; blobIndex < codedImage.GetObjCount(); blobIndex++)
{
    EObject blob = codedImage.GetObj(blobIndex);

    // Browse the holes of the current object
    for (uint holeIndex = 0; holeIndex < blob.HoleCount; holeIndex++)
    {
        // Retrieve a given hole
        EHole hole = blob.GetHole(holeIndex);
    }
}

```

```

    }
}

```

## Continuous Mode

Functional Guide | Reference: [SetContinuousModeEnabled](#), [FlushContinuousMode](#)

```

////////////////////////////////////
// This code snippet shows how to build blobs //
// in the continuous mode context. //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// Image encoder
EImageEncoder encoder= new EImageEncoder();

// Coded image
ECodedImage2 codedImage= new ECodedImage2();

// ...

// Enable the continuous mode
encoder.ContinuousModeEnabled= true;

// Loop to acquire 50 different chunks
for (int count = 0; count < 50 ; count++)
{
    // Store the new chunk into srcImage
    // ...

    // Encode the current chunk
    encoder.Encode(srcImage, codedImage);
}

// Flush the continuous mode
encoder.FlushContinuousMode(codedImage);

```

## Computing Blobs Features

Functional Guide | Reference: [GetGravityCenter](#), [GetObj](#)

```

////////////////////////////////////
// This code snippet shows how to retrieve blobs' features. //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// Image encoder
EImageEncoder encoder= new EImageEncoder();

// Coded image
ECodedImage2 codedImage= new ECodedImage2();

// ...

```

```
// Encode the source image
encoder.Encode(srcImage, codedImage);

for (uint index = 0; index < codedImage.GetObjCount(); index++)
{
    // Retrieve the selected blob gravity center
    EObject blob = codedImage.GetObj(index);
    float centerX = blob.GravityCenter.X;
    float centerY = blob.GravityCenter.Y;
}
}
```

## Selecting and Sorting Blobs

Functional Guide | Reference: [AddObjects](#), [ElementCount](#), [RemoveUsingUnsignedIntegerFeature](#), [Sort](#)

```
////////////////////////////////////
// This code snippet shows how to build blobs, select //
// some of them and sort the selected ones.          //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// Image encoder
EImageEncoder encoder= new EImageEncoder();

// Coded image
ECodedImage2 codedImage= new ECodedImage2();

// ...

// Encode the source image
encoder.Encode(srcImage, codedImage);

// Create a blob selection
EObjectSelection selection= new EObjectSelection();
selection.AddObjects(codedImage);

// Remove the Small blobs
selection.RemoveUsingUnsignedIntegerFeature(EFeature.Area, 100, ESingleThresholdMode.Less);

// Retrieve the number of remaining blobs
uint numBlobs= selection.ElementCount;

// Sort the remaining blobs based on their area
selection.Sort(EFeature.Area, ESortDirection.Ascending);

// Retrieve the selected blobs
for (uint index = 0; index < numBlobs; index++)
{
    float centerX= selection.GetElement(index).GravityCenterX;
    float centerY= selection.GetElement(index).GravityCenterY;
}
}
```

# Using Flexible Masks

## Constructing Blobs

Functional Guide | Reference: [Encode](#)

```

////////////////////////////////////
// This code snippet shows how to build blobs inside //
// a region defined by a flexible mask.             //
////////////////////////////////////

// Images constructor
EImageBW8 srcImage= new EImageBW8();
EImageBW8 mask = new EImageBW8();

// Image encoder
EImageEncoder encoder= new EImageEncoder();

// Coded image
ECodedImage2 codedImage= new ECodedImage2();

// ...

// Encode the source image regions
// corresponding to the mask do care areas
encoder.Encode(srcImage, mask, codedImage);

```

## Generating a Flexible Mask from an Encoded Image

Functional Guide | Reference: [RenderMask](#)

```

////////////////////////////////////
// This code snippet shows how to generate a flexible //
// mask from an encoded image.                       //
////////////////////////////////////

// Images constructor
EImageBW8 srcImage= new EImageBW8();
EImageBW8 mask= new EImageBW8();

// Image encoder
EImageEncoder encoder= new EImageEncoder();

// Coded image
ECodedImage2 codedImage= new ECodedImage2();

// ...

// Encode the source image
encoder.Encode(srcImage, codedImage);

// The source image and the mask must have the same size
mask.SetSize(srcImage);

// Create the mask based on the white layer
// of the coded image
codedImage.RenderMask(mask, 1);

```



## Generating a Flexible Mask from a Blob Selection

Functional Guide | Reference: [RenderMask](#)

```

////////////////////////////////////
// This code snippet shows how to generate a flexible //
// mask from a selection of blobs.                //
////////////////////////////////////

// Images constructor
EImageBW8 srcImage= new EImageBW8();
EImageBW8 mask= new EImageBW8();

// Image encoder
EImageEncoder encoder= new EImageEncoder();

// Coded image
ECodedImage2 codedImage= new ECodedImage2();

// ...

// Encode the source image
encoder.Encode(srcImage, codedImage);

// The source image and the mask must have the same size
mask.SetSize(srcImage);

// Create a blob selection
EObjectSelection selection= new EObjectSelection();
selection.AddObjects(codedImage);

// Remove the Small blobs
selection.RemoveUsingUnsignedIntegerFeature(EFeature.Area, 100, ESingleThresholdMode.Less);

// Create the mask based on the blob selection
selection.RenderMask(mask);

// Sort the remaining blobs based on their area
selection.Sort(EFeature.Area, ESortDirection.Descending);

// Create the mask corresponding to the largest blob
selection.GetElement(0).RenderMask(mask);

```

## Using the Object Template Matcher

Functional Guide | Reference: [EObjectTemplateMatcher](#)

```

////////////////////////////////////
// This code snippet shows how to use EObjectTemplateMatcher //
// for alignment and template matching                //
////////////////////////////////////

// Encode the template image
EImageEncoder encoder = new EImageEncoder();
ECodedImage2 coded_img = new ECodedImage2();

EImageBW8 template_img = new EImageBW8();
encoder.Encode(template_img, coded_img);

```

```
EObjectSelection object_select = new EObjectSelection();
object_select.AddObjects(coded_img);

// Initialize EObjectTemplateMatcher
EObjectTemplateMatcher object_matcher = new EObjectTemplateMatcher();
object_matcher.EnableAlignment = true; // optional
object_matcher.MaximumDistance = 60; // optional

// set the template
object_matcher.BuildTemplate(object_select);

// Encode the test image
EImageBW8 test_img = new EImageBW8();
encoder.Encode(test_img, coded_img);

// Build a selection of test objects
object_select.Clear();
object_select.AddObjects(coded_img);
object_select.RemoveUsingUnsignedIntegerFeature(EFeature.Area, 10, ESingleThresholdMode.Less); // optional
filter

// Perform the alignment and the matching
object_matcher.SortSelection(object_select);

// Get the number of matches
int num = object_matcher.NumberOfPairedObjects;

// Retrieve the template indexes for each selection object
int[] template_indexes = object_matcher.TemplateIndexes;
```

## 7.3. EasyGauge

### Point Location

Functional Guide | Reference: [SetTransitionType](#), [SetTransitionChoice](#), [SetCenterXY](#), [SetTolerance](#), [Measure](#), [GetMeasuredPoint](#), [GetX](#), [GetY](#)

```

////////////////////////////////////
// This code snippet shows how to create a point location tool, //
// adjust the transition parameters, set the nominal gauge      //
// position, perform the measurement and retrieve the result.  //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// EPointGauge constructor
EPointGauge pointGauge= new EPointGauge();

// Adjust the transition parameters
pointGauge.TransitionType= ETransitionType.Wb;
pointGauge.TransitionChoice= ETransitionChoice.Closest;

// Set the gauge nominal position
pointGauge.SetCenterXY(256.0f, 256.0f);

// Set the gauge length to 10 units and the angle to 45°
pointGauge.SetTolerances(10.0f, 45.0f);

// Measure
pointGauge.Measure(srcImage);

// Get the measured point coordinates
float measuredX = pointGauge.GetMeasuredPoint().X;
float measuredY = pointGauge.GetMeasuredPoint().Y;

// Save the point gauge measurement context
pointGauge.Save("myPointGauge.gge");

```

### Line Fitting

Functional Guide | Reference: [SetTransitionType](#), [SetTransitionChoice](#), [SetTransitionIndex](#), [SetLine](#), [Measure](#), [GetMeasuredLine](#), [GetOrg](#), [GetEnd](#)

```

////////////////////////////////////
// This code snippet shows how to create a line measurement tool, //
// adjust the transition parameters, set the nominal gauge      //
// position, perform the measurement and retrieve the result.  //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// ELineGauge constructor
ELineGauge lineGauge= new ELineGauge();

```

```
// Adjust the transition parameters
lineGauge.TransitionType= ETransitionType.Bw;
lineGauge.TransitionChoice= ETransitionChoice.NthFromEnd;
lineGauge.TransitionIndex= 2;

// Set the line fitting gauge position,
// length (50 units) and orientation (20°)
EPoint center= new EPoint(256.0f, 256.0f);
ELine line= new ELine(center, 50.0f, 20.0f);
lineGauge.Line= line;

// Measure
lineGauge.Measure(srcImage);

// Get the origin and end point coordinates of the fitted line
EPoint originPoint = lineGauge.MeasuredLine.Org;
EPoint endPoint = lineGauge.MeasuredLine.End;

// Save the point gauge measurement context
lineGauge.Save("myLineGauge.gge");
```

## Circle Fitting

Functional Guide | Reference: [SetTransitionType](#), [SetTransitionChoice](#), [SetCircle](#), [Measure](#), [GetMeasuredCircle](#), [GetCenter](#), [GetRadius](#)

```
////////////////////////////////////
// This code snippet shows how to create a circle measurement tool, //
// adjust the transition parameters, set the nominal gauge           //
// position, perform the measurement and retrieve the result.      //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// ECircleGauge constructor
ECircleGauge circleGauge= new ECircleGauge();

// Adjust the transition parameters
circleGauge.TransitionType= ETransitionType.Bw;
circleGauge.TransitionChoice= ETransitionChoice.LargestAmplitude;

// Set the Circle fitting gauge position, diameter (50 units),
// starting angle (10°), and amplitude (270°)
EPoint center= new EPoint(256.0f, 256.0f);
ECircle circle= new ECircle(center, 50.0f, 10.0f, 270.0f);
circleGauge.Circle = circle;

// Measure
circleGauge.Measure(srcImage);

// Get the center point coordinates and the radius of the fitted circle
float centerX = circleGauge.MeasuredCircle.Center.X;
float centerY = circleGauge.MeasuredCircle.Center.Y;
float radius = circleGauge.MeasuredCircle.Radius;

// Save the point gauge measurement context
circleGauge.Save("myCircleGauge.gge");
```

## Rectangle Fitting

Functional Guide | Reference: [SetTransitionType](#), [SetTransitionChoice](#), [SetRectangle](#), [Measure](#), [GetMeasuredRectangle](#), [GetSizeX](#), [GetSizeY](#), [GetAngle](#)

```

////////////////////////////////////
// This code snippet shows how to create a rectangle measurement tool, //
// adjust the transition parameters, set the nominal gauge position, //
// perform the measurement and retrieve the result. //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// ERectangleGauge constructor
ERectangleGauge rectangleGauge= new ERectangleGauge();

// Adjust the transition parameters
rectangleGauge.TransitionType= ETransitionType.Bw;
rectangleGauge.TransitionChoice= ETransitionChoice.LargestAmplitude;

// Set the rectangle fitting gauge position,
// size (50x30 units) and orientation (15°)
rectangleGauge.SetCenterXY(256.0f, 256.0f);
rectangleGauge.SetSize(50.0f, 30.0f);
rectangleGauge.Angle = 15.0f;

// Measure
rectangleGauge.Measure(srcImage);

// Get the size and the rotation angle of the fitted rectangle
float sizeX = rectangleGauge.MeasuredRectangle.SizeX;
float sizeY = rectangleGauge.MeasuredRectangle.SizeY;
float angle = rectangleGauge.MeasuredRectangle.Angle;

// Save the point gauge measurement context
rectangleGauge.Save("myRectangleGauge.gge");

```

## Wedge Fitting

Functional Guide | Reference: [SetTransitionType](#), [SetTransitionChoice](#), [SetWedge](#), [Measure](#), [GetMeasuredWedge](#), [GetInnerRadius](#), [GetOuterRadius](#)

```

////////////////////////////////////
// This code snippet shows how to create a wedge measurement tool, //
// adjust the transition parameters, set the nominal gauge //
// position, perform the measurement and retrieve the result. //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// EWedgeGauge constructor
EWedgeGauge wedgeGauge= new EWedgeGauge();

// Adjust the transition parameters
wedgeGauge.TransitionType= ETransitionType.Bw;
wedgeGauge.TransitionChoice= ETransitionChoice.NthFromBegin;

```

```
wedgeGauge.TransitionIndex= 0;

// Set the wedge fitting gauge position, diameter (50 units),
// breadth (-25 units), starting angle (0°) and amplitude (270°)
EPoint center= new EPoint(256.0f, 256.0f);
EWedge wedge= new EWedge(center, 50.0f, -25.0f, 0.0f, 270.0f);
wedgeGauge.Wedge= wedge;

// Measure
wedgeGauge.Measure(srcImage);

// Get the inner and outer radius of the fitted wedge
float innerRadius = wedgeGauge.MeasuredWedge.InnerRadius;
float outerRadius = wedgeGauge.MeasuredWedge.OuterRadius;

// Save the point gauge measurement context
wedgeGauge.Save("myWedgeGauge.gge");
```

## Gauge Grouping

### Gauge Hierarchy

Functional Guide | Reference: [Attach](#), [SetName](#), [Save](#)

```
////////////////////////////////////
// This code snippet shows how to create a gauge hierarchy //
// and save it into a file. //
////////////////////////////////////

// EWorldShape constructor
EWorldShape worldShape= new EWorldShape();

// Gauges constructor
ERectangleGauge rectangleGauge= new ERectangleGauge();
ECircleGauge circleGauge1= new ECircleGauge();
ECircleGauge circleGauge2= new ECircleGauge();

// ...

// Attach the rectangle gauge to the EWorldShape
rectangleGauge.Attach(worldShape);

// Attach the circle gauges to the rectangle gauge
circleGauge1.Attach(rectangleGauge);
circleGauge2.Attach(rectangleGauge);

// Set the first circle gauge name
circleGauge1.Name= "myCircleGauge1";

// ...

// Save worldShape together with its daughters
worldShape.Save("myWorldShape.gge", true);
```

## Complex Measurement

Functional Guide | Reference: [Load](#), [GetNumDaughters](#), [Process](#), [GetDaughter](#), [GetShapeNamed](#)

```

////////////////////////////////////
// This code snippet shows how to trigger the measurement //
// of a whole gauge hierarchy and retrieve the results. //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// EWorldShape constructor
EWorldShape worldShape= new EWorldShape();

// Load the EWorldShape together with its daughters
worldShape.Load("myWorldShape.gge", true);

// Retrieve the number of worldShape's daughters
uint numDaughters= worldShape.NumDaughters;

// ...

// Trigger the measurement of all the
// gauges attached to the EWorldShape
worldShape.Process(srcImage, true);

// Retrieve the measurement result of
// the first daughter (a rectangle gauge)
ERectangleGauge rectangleGauge= (ERectangleGauge)worldShape.GetDaughter(0);
float sizeX= rectangleGauge.MeasuredRectangle.SizeX;

// Retrieve the measurement result of a
// daughter gauge called "myCircleGauge1"
ECircleGauge circleGauge= (ECircleGauge)worldShape.GetShapeNamed("myCircleGauge1");
EPoint center= circleGauge.MeasuredCircle.Center;

```

## Calibration using EWorldShape

Functional Guide | [Reference](#)

## Calibration by Guesswork

Functional Guide | Reference: [SetSensor](#), [GetXResolution](#), [GetYResolution](#)

```

////////////////////////////////////
// This code snippet shows how to perform a calibration //
// by guesswork. //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// EWorldShape constructor
EWorldShape worldShape= new EWorldShape();

// ...

// Compute the calibration coefficients
// Field of view: 32x24 mm
worldShape.SetSensor(srcImage.Width, srcImage.Height, 32.0f, 24.0f);

```

```
// Retrieve the spatial resolution
float resolutionX= worldShape.XResolution;
float resolutionY= worldShape.YResolution;
```

## Landmark-Based Calibration

Functional Guide | Reference: [EmptyLandmarks](#), [AddLandmark](#), [Calibrate](#)

```
////////////////////////////////////
// This code snippet shows how to perform a landmark-based //
// calibration.                                           //
////////////////////////////////////

// EWorldShape constructor
EWorldShape worldShape= new EWorldShape();

// ...

// Reset the calibration context
worldShape.EmptyLandmarks();

// Loop on the landmarks
for(int index= 0; index < numLandmarks; index++)
{
    // Get the I-th landmark as a pair of EPoint(x, y)
    EPoint sensorPoint, worldPoint;

    // Retrieve and store the relevant data into worldPoint and sensorPoint
    sensorPoint = myIthLandmark_Sensor;
    worldPoint = myIthLandmark_World;

    // Add the I-th pair
    worldShape.AddLandmark(sensorPoint, worldPoint);
}

// Perform the calibration
worldShape.Calibrate((int)ECalibrationMode.Skewed);
```

## Dot Grid-Based Calibration

Functional Guide | Reference: [EmptyLandmarks](#), [AddPoint](#), [RebuildGrid](#), [AutoCalibrate](#)

```
////////////////////////////////////
// This code snippet shows how to perform a dot grid-based //
// calibration.                                           //
////////////////////////////////////

// EWorldShape constructor
EWorldShape worldShape= new EWorldShape();

// ...

// Reset the calibration context
worldShape.EmptyLandmarks();

// Loop on the dots
for(int index= 0; index < numDots; index++)
{
```



```

// Get the I-th dot as an EPoint(x, y)
EPoint dotPoint;

// Retrieve and store the relevant data into dotPoint
dotPoint = myIthDot;

// Add the I-th dot
worldShape.AddPoint(dotPoint);
}

// Reconstruct the grid topology
// pitch X and Y = 5 units
worldShape.RebuildGrid(5, 5);

// Perform the calibration
// the calibration modes are computed automatically
worldShape.AutoCalibrate(true);

```

## Coordinates Transform

Functional Guide | Reference: [SensorToWorld](#), [WorldToSensor](#)

```

////////////////////////////////////
// This code snippet shows how to convert coordinates from //
// the Sensor space to the World space and conversely.    //
////////////////////////////////////

// EWorldShape constructor
EWorldShape worldShape= new EWorldShape();

// EPoint constructor
EPoint sensor= new EPoint();
EPoint world= new EPoint();

// ...

// Perform the calibration
worldShape.Calibrate((int)ECalibrationMode.Scaled | (int)ECalibrationMode.Skewed);

// Retrieve the world coordinates of a point, knowing its sensor coordinates
world= worldShape.SensorToWorld(sensor);

// Retrieve the sensor coordinates of a point, knowing its world coordinates
sensor= worldShape.WorldToSensor(world);

```

## Image Unwarping

Functional Guide | Reference: [SetupUnwarp](#), [Unwarp](#)

```

////////////////////////////////////
// This code snippet shows how to unwarp an image based //
// of the computed calibration coefficients.            //
////////////////////////////////////

// Images constructor
EImageBW8 srcImage= new EImageBW8();
EImageBW8 dstImage= new EImageBW8();

```

```
// EWorldShape constructor
EWorldShape worldShape= new EWorldShape();

// Lookup table constructor
EUnwarpingLut lut= new EUnwarpingLut();

// ...

// Perform the calibration
worldShape.Calibrate((int)ECalibrationMode.Tilted | (int)ECalibrationMode.Radial);

// Setup the lookup table for unwarping
worldShape.SetupUnwarp(lut, srcImage, true);

// Perform the image unwarping
worldShape.Unwarp(lut, srcImage, dstImage, true);
```

## 7.4. EasyFind

### Pattern Learning

Functional Guide | Reference: [Learn](#)

```

////////////////////////////////////
// This code snippet shows how to learn a pattern //
// defined by a region of interest (ROI).         //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// ROI constructor
EROIBW8 pattern= new EROIBW8();

// EPatternFinder constructor
EPatternFinder finder= new EPatternFinder();

// ...

// Attach the ROI to the source image
// and set its position
pattern.Attach(srcImage);
pattern.SetPlacement(214, 52, 200, 200);

// Learn the pattern
finder.Learn(pattern);

```

### Setting Search Parameters

Functional Guide | Reference: [SetMaxInstances](#), [SetAngleTolerance](#), [SetMinScore](#), [Save](#)

```

////////////////////////////////////
// This code snippet shows how to tune pattern finding //
// search parameters and save them into a file.         //
////////////////////////////////////

// Image constructor
EImageBW8 pattern= new EImageBW8();

// EPatternFinder constructor
EPatternFinder finder= new EPatternFinder();

// ...

// Learn the pattern
finder.Learn(pattern);

// Set the maximum number of occurrences
finder.MaxInstances= 5;

// Set the rotation tolerances
finder.AngleTolerance= 20.0f;

```

```
// Set the minimum score
finder.MinScore= 0.70f;

// Save the finding context into a model file
finder.Save("myModel.fnd");
```

## Pattern Finding and Retrieving Results

Functional Guide | Reference: [Load](#), [Find](#), [GetScore](#), [GetCenter](#)

```
////////////////////////////////////
// This code snippet shows how to perform pattern //
// finding operations and retrieve the results.    //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// EPatternFinder constructor
EPatternFinder finder= new EPatternFinder();

// EFoundPattern constructor
EFoundPattern[] foundPattern= null;

// ...

// Load a model file
finder.Load("myModel.fnd");

// Perform the pattern finding
foundPattern= finder.Find(srcImage);

// Retrieve the number of instances
int numInstances= foundPattern.Length;

// Retrieve the score and the
// position of the first instance
float score= foundPattern[0].Score;
float centerX= foundPattern[0].Center.X;
float centerY= foundPattern[0].Center.Y;
```

## Learning Using a DXF File

Functional Guide | Reference: [LoadDXF](#), [Find](#)

```
////////////////////////////////////
// This code snippet shows how to perform        //
// pattern learning and finding operations        //
// using a DXF file.                             //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage = new EImageBW8();
// EPatternFinder constructor
EPatternFinder finder = new EPatternFinder();
// EVectorModel constructor
EVectorModel myModel = new EVectorModel();
// Load the model from a dxf file
myModel.LoadDXF("myModel.dxf");
```

```
// Learn the model
finder.Learn(myModel);
// EFoundPattern constructor
EFoundPattern[] foundPattern = null;
// ...
// Perform the pattern finding
foundPattern = finder.Find(srcImage);
```

## Learning Using an EPolygonShape

Functional Guide | Reference: [SetPolygon](#), [Find](#)

```
////////////////////////////////////
// This code snippet shows how to perform //
// pattern learning and finding operations //
// using EPolygonShape to define the model.//
////////////////////////////////////
// Image constructor
EImageBW8 srcImage = new EImageBW8();
// EPatternFinder constructor
EPatternFinder finder = new EPatternFinder();
// EVectorModel constructor
EVectorModel myModel = new EVectorModel();
// Get the root EFrameShape of the model
EFrameShape root = myModel.Root;
// EPolygonShape constructor
EPolygonShape polygon = new EPolygonShape();
// Define the vertices of a polygon
EPoint[] vertices = new EPoint[] { new EPoint(0, 0), new EPoint(1, 0), new EPoint(1, 1), new EPoint(0, 1) };
// Define the polygon
EPolygon basePolygon = new EPolygon(vertices, true);
// Define the EPolygonShape
polygon.Polygon = basePolygon;
// Attach the EPolygonShape to the root EFrameShape
polygon.Attach(root);
// Sets the polarity of the EPolygonShape
polygon.SetProperty("polarity", "direct");
// Learn the model
finder.Learn(myModel);
// EFoundPattern constructor
EFoundPattern[] foundPattern = null;
// ...
// Perform the pattern finding
foundPattern = finder.Find(srcImage);
```

## 7.5. EasyMatch

### Pattern Learning

Functional Guide | Reference: [LearnPattern](#)

```

////////////////////////////////////
// This code snippet shows how to learn a pattern //
// defined by a region of interest (ROI).          //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// ROI constructor
EROIBW8 pattern= new EROIBW8();

// EMatcher constructor
EMatcher matcher= new EMatcher();

// ...

// Attach the ROI to the source image
// and set its position
pattern.Attach(srcImage);
pattern.SetPlacement(214, 52, 200, 200);

// Learn the pattern
matcher.LearnPattern(pattern);

```

### Setting Search Parameters

Functional Guide | Reference: [SetMaxPositions](#), [SetMinAngle](#), [SetMaxAngle](#), [SetMinScore](#), [SetInterpolate](#), [Save](#)

```

////////////////////////////////////
// This code snippet shows how to tune pattern matching //
// search parameters and save them into a file.          //
////////////////////////////////////

// Image constructor
EImageBW8 pattern= new EImageBW8();

// EMatcher constructor
EMatcher matcher= new EMatcher();

// ...

// Learn the pattern
matcher.LearnPattern(pattern);

// Set the maximum number of occurrences
matcher.MaxPositions= 5;

// Set the rotation tolerances
matcher.MinAngle= -20.0f;

```

```

matcher.MaxAngle= 20.0f;

// Enable sub-pixel accuracy
matcher.Interpolate= true;

// Set the minimum score
matcher.MinScore= 0.70f;

// Save the matching context into a model file
matcher.Save("myModel.mch");

```

## Pattern Matching and Retrieving Results

[Functional Guide](#) | Reference: [Load](#), [Match](#), [GetNumPositions](#), [GetPosition](#)

```

////////////////////////////////////
// This code snippet shows how to perform pattern //
// matching operations and retrieve the results. //
////////////////////////////////////

// Image constructor
EImageBW8 srcImage= new EImageBW8();

// EMatcher constructor
EMatcher matcher= new EMatcher();

// ...

// Load a model file
matcher.Load("myModel.mch");

// Perform the matching
matcher.Match(srcImage);

// Retrieve the number of occurrences
uint numOccurrences= matcher.NumPositions;

// Retrieve the first occurrence
EMatchPosition myOccurrence= matcher.GetPosition(0);

// Retrieve its score and position
float score= myOccurrence.Score;
float centerX= myOccurrence.CenterX;
float centerY= myOccurrence.CenterY;

```

## Pattern Learning with ERegion

[Functional Guide](#) | Reference: [LearnPattern](#)

```

////////////////////////////////////
// This code snippet shows how to learn a pattern //
// whose region of interest is defined by an ERegion //
////////////////////////////////////

EImageBW8 srcImage = new EImageBW8();
EROIBW8 pattern = new EROIBW8();
EMatcher matcher = new EMatcher();
// ...

```

```
// Attach the ROI to the source image and set its position
pattern.Attach(srcImage);
pattern.SetPlacement(214, 52, 200, 200);

// pattern is a 200*200 square but here we are only
// interested in the inner circle

// OLD method (warning, advanced learning is not compatible with this)
matcher.DontCareThreshold = 1;
// must paint the part of pattern we are not interested in in black
matcher.LearnPattern(pattern);

// NEW method (compatible with advanced learning)
ECircleRegion region = new ECircleRegion(100.0f, 100.0f, 100.0f);
matcher.LearnPattern(pattern, region);
```