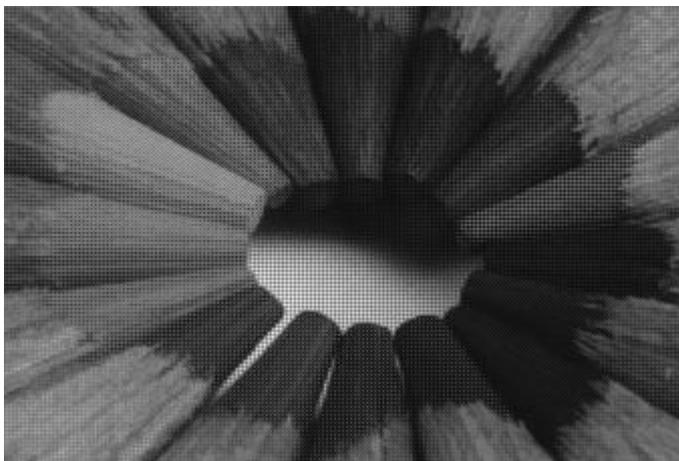


As you like it – Pixel preprocessing or RAW format

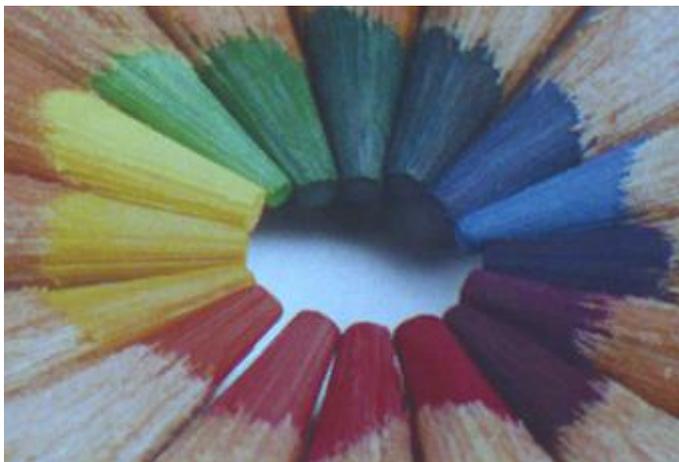
Depending on the application, the image data must fulfill different requirements. If you take a fast snapshot, you want a ready-to-use image from the camera. The image should look as good as possible and should not require any further post-processing. If you want to evaluate the image digitally and process it yourself, you usually need the sensor's raw data.

Background

The image data of a camera can be transferred in two different ways: as unprocessed raw data (RAW format) or as finished image with pixel preprocessing.



Sensor raw data



With pixel preprocessing

Work steps pixel preprocessing

In the pixel preprocessing several processing steps are performed to create a processed image.

Data formatting

Because the sensor does not output the data in the order pixel 1, pixel 2, pixel 3 etc., the data must be formatted. Also 10-bit data is converted internally into 12-bit format, for example.

TechTip: Pixel preprocessing and RAW format

Hot pixel correction

If pixels do not react or react not proportional on incident light, the pixels will be corrected automatically by their neighboring pixels in the hot pixel correction.

Image mirroring

The image is mirrored in vertical or horizontal direction.

Subsampling

Subsampling is a technique that skips multiple sensor pixels when reading out image data. The captured image has a lower resolution but still the same field of view compared to the full-resolution image.

Master and RGB gain

In digital imaging, a voltage proportional to the amount of incident light is output by the sensor for each pixel. To increase image brightness and contrast, this signal can be amplified by an analog gain and offset before the digitizing process. If this functionality is not implemented on sensor side, it is performed in the camera hardware.

Gamma

Unlike the sensor, the human eye works not linear but logarithmic. This means that in a linear rendering the human eye has difficulty to distinguish dark image areas. The gamma function raises dark image areas using a non-linear characteristic and optimizes the curve of the gray and color values for the visual sensitivity of the human eye.

LUT (lookup table)

With a lookup table (LUT) it is easy to apply characteristic curves to digital images. This is mainly advantageous for the evaluation and correction of color spaces. A LUT can also be used for false-color and negative representations. Gamma is also implemented by the LUT function.

Color interpolation (debayering)

A Bayer conversion is carried out to determine the RGB color information from the raw sensor data. This is also referred to as debayering.

Color correction

Color correction is a digital correction based on a color matrix which is adjusted individually for each sensor.

Color saturation

The intensity of the colors can be increased or decreased. Without color saturation you get a properly weighted monochrome image.

TechTip: Pixel preprocessing and RAW format

Color space conversion/bit reduction & packing

The format option specifies the format and bit depth which are used to write the image data into the memory. In the following tables you can see the examples of the two formats RGB24 and RGB32 with the respective bit depth:

	Software: RGB24	Software: RGB30	Hardware: RGB24	Hardware: RGB 30
Sensor: Used bit depth	8 bit	10 bit	12 bit	12 bit
Camera color calculation: bits/color	-	-	12 bit	12 bit
Transmission: effective bit depth	8 bit/pixel	10 bit/pixel	24 bit/pixel 8 bit/color	30 bit/pixel 10 bit/color
Transmission: total bytes per pixel	1 byte	2 bytes	3 bytes	4 bytes
Software color calculation: bits/color	8 bit	10 bit	-	-
Target memory: bits per color	8 bit	10 bit	8 bit	10 bit
End result: quality	+	++	++	+++

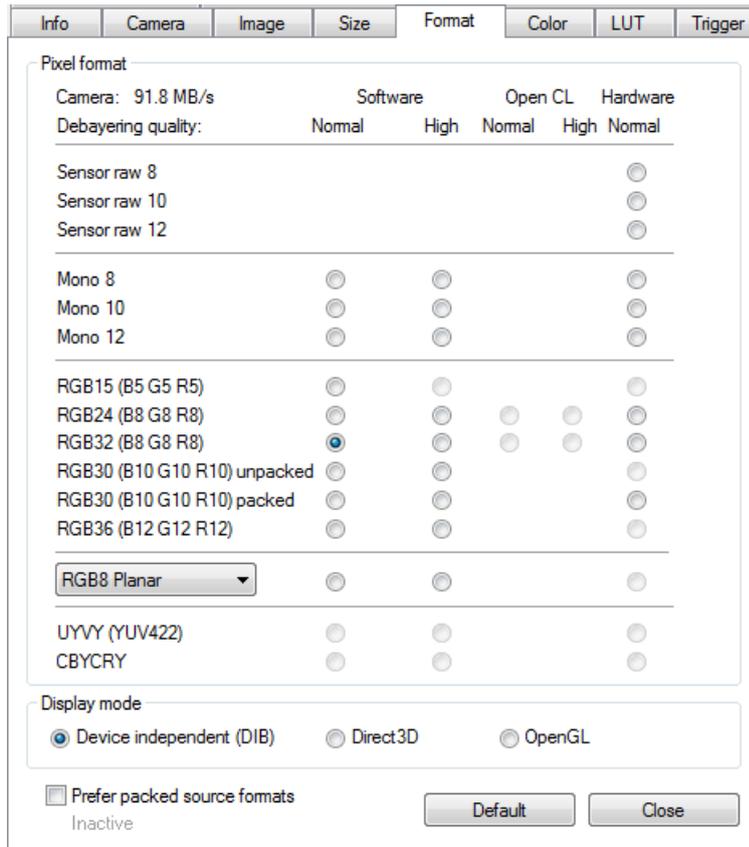
Settings in uEye Cockpit

To determine, if you use the image data as raw data or after pixel preprocessing, open in uEye Cockpit the camera properties and there the "Format" tab. If you need the unchanged raw data, select either Sensor raw 8, Sensor raw 10 or Sensor raw 12. If necessary, disable the hot pixel correction. For preprocessed images use another color format for example RGB32.

Via the debayering quality, you set the conversion algorithm of the color format. Depending on the color camera different possibilities are available:

- **Software**
The conversion is performed by software in the PC.
- **OpenCL**
The use of OpenCL requires that OpenCL is supported by the graphics card as the conversion is performed on the graphic card's processing unit. Note that OpenCL is not supported by monochrome cameras.
- **Hardware**
The conversion is performed in the camera. This option is only available for USB 3 uEye CP/LE/ML cameras. When you select hardware debayering, you can also perform the LUT, gamma and hot pixel correction functions directly in the camera.

Setting the color format



To convert the colors, a filter mask moves over the image and calculates a color value for each pixel from the surrounding pixels. The uEye API provides for the conversion via software or OpenCL two filter masks that differ in image quality and CPU load:

- Normal quality**
 A smaller filter mask is used for conversion. This algorithm has a low load on the CPU. The filter's averaging function may cause a slight blur. Noise is reduced. This filter is recommended for image processing tasks.
- High quality**
 A large filter mask is used for conversion. This algorithm offers very accurate color positioning and an increased level of detail. The CPU load is higher than with the normal filter. This filter is recommended for visualization applications.

The software conversion with high quality should only be used for sensors whose green pixels have the same sensitivity. This applies to all uEye CCD sensors and the CMOS sensors of the UI-122x/UI-322x/UI-522x. For all other sensors, we recommend using the standard filter mask.

Application areas

You use the sensor raw data if you need an absolute original image, for example for measurement evaluations, image processing or if you use an own program for imaging.

TechTip: Pixel preprocessing and RAW format

Images with pixel preprocessing are used for example for visualization tasks or processing color images – thus always if you need a finished image.

Summary

When you disable all functions of the pixel preprocessing, you get theoretically a RAW format. However, selecting the RAW format directly is easier and safer to use. If you use the RAW format, you can still use the hot pixel correction or sub-sampling. For the models UI-124x/UI-324x/UI-524x and UI-125x/UI-325x/UI-525x, you must disable the sensor's own hot pixel correction if you need the original RAW data particularly for measurements.

Depending on the camera model, it is possible to perform the pixel preprocessing directly in the camera and relieve the CPU. Also the calculation is more accurate because it is done internally with 12 bits per color. However, you must note that for color cameras the transmitted data volume increases and thus the frame rate is reduced at a low bandwidth.

The pixel preprocessing the in camera hardware offers many advantages, in particular for embedded systems. Here, packed color formats, among others, can be used for data transmission. The table below shows which steps of the pixel preprocessing can be performed in the camera hardware:

	USB 3.0	GigE	USB 2.0 CCD sensors Rev. 3	USB 2.0 CMOS sensors
Data formatting	x	x	x	
Hot pixel correction	x	x	x	
Image mirroring	x	x		
Subsampling	x	x	x	
Master and RGB gain	x	x	x	
Gamma	x	x	x	
LUT	x	x	x	
Color interpolation (debayering)	x			
Color correction	x			
Color saturation	x			
Color space conversion/ bit reduction & packing	x	x	x	

With the uEye API functions "is_SetColorMode/is_SetColorConverter" or the uEye .NET class "Converter" you can configure the settings of the color format.

For further information on the color formats, refer to the uEye manual at <http://de.ids-imaging.com/manuals-ueye.html>.

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