



Camera raw – the basics

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Why camera raw?

- With digital capture, some decisions about how a picture will look are applied in the processing of the sensor data after the picture is taken.
 - most notably white balance, color rendering, and output color encoding
- With film capture, these decisions are largely built into the film
 - the processing of the film can have some effect, but the changes possible are limited and once done cannot be redone
 - somewhat more flexibility with negative film
- With digitally captured images, if the raw data is saved, it is possible to revisit the post-capture processing choices and try different things as desired
 - but pre-capture choices like exposure and sensor gain settings cannot be redone

What is required for camera raw?

- A file format containing:
 - Camera sensor data that has not been white balanced or color rendered
 - Metadata providing the camera:
 - CFA pattern (if not demosaiced)
 - exposure settings
 - opto-electronic conversion function
 - spectral sensitivities (or scene color analysis matrices)
 - estimated adopted white
 - If the file format and metadata are standard, users can choose from camera raw processing applications that support the standard
- Software to process the image (order may vary)
 - Demosaicing (may be performed before saving raw file)
 - Image analysis (for image-specific process elements)
 - Noise reduction and sharpening
 - Lens flare removal
 - White balance
 - Scene color analysis transform
 - Color rendering
 - Output encoding

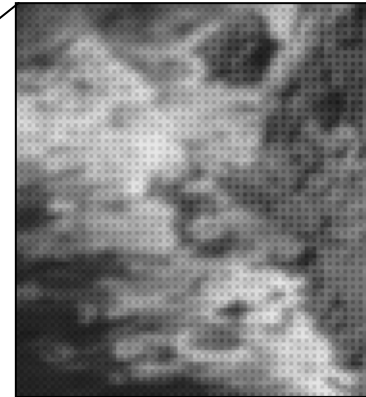
ISO 12234-2 TIFF/EP

- ISO standard format for camera raw image files
 - Work begun in 1992; metadata finalized mid-nineties
 - Supports required camera raw metadata, but very flexible
 - No reader or writer requirements specification
 - Used for most camera raw files
 - But metadata may be incomplete or non-standard
 - Generally, different cameras produce different “flavors” of TIFF/EP
 - Processing software may be limited in the number of flavors it can accept
- The Adobe DNG specification defines a specific flavor of TIFF/EP
 - Some additional metadata is defined for the convenience of the ACR application
 - The DNG converter takes different flavors of TIFF/EP and converts them to the specified flavor

Preparing the “raw” data

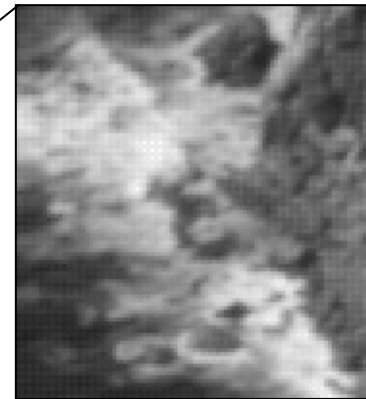
- Some processing steps are camera specific, and are best performed prior to saving the “raw” image data:
 - Defective pixel “retouching”
 - Dark current or dark frame subtraction
 - Correcting for lens falloff and pixel nonuniformity
- It is possible for a camera raw processing application to perform these operations as well, if the camera provides the necessary information as image metadata
 - But the form for such metadata is not standardized
- The camera can also apply:
 - A nonlinear transfer function to optimize bit depth utilization
 - Numerically lossless compression to reduce file size

Processing the raw data – starting with a CFA image



- ☐ Image analysis
 - for image-specific process elements
- ☐ Lens flare removal
- ☐ White balance
- ☐ Demosaicing
 - includes noise reduction and sharpening
- ☐ Scene color analysis transform
- ☐ Color rendering
- ✓ Output encoding

Processing the raw data – flare subtraction and white balancing



- ✓ Image analysis
 - for image-specific process elements
- ✓ Lens flare removal
- ✓ White balance
- ☐ Demosaicing
 - includes noise reduction and sharpening
- ☐ Scene color analysis transform
- ☐ Color rendering
- ✓ Output encoding

Processing the raw data – demosaicing



Scene colors as seen by the camera

- ✓ Image analysis
 - for image-specific process elements
- ✓ Lens flare removal
- ✓ White balance
- ✓ Demosaicing
 - includes noise reduction and sharpening
- ☐ Scene color analysis transform
- ☐ Color rendering
- ✓ Output encoding

Processing the raw data – scene color analysis transform



Scene colors corrected to
approximate human perception

- ✓ Image analysis
 - for image-specific process elements
- ✓ Lens flare removal
- ✓ White balance
- ✓ Demosaicing
 - includes noise reduction and sharpening
- ✓ Scene color analysis transform
- ☐ Color rendering
- ✓ Output encoding

Processing the raw data – color rendering



Color rendering adjusts scene colors to produce a more pleasing picture

- ✓ Image analysis
 - for image-specific process elements
- ✓ Lens flare removal
- ✓ White balance
- ✓ Demosaicing
 - includes noise reduction and sharpening
- ✓ Scene color analysis transform
- ✓ Color rendering
- ✓ Output encoding

Processing Summary

- This scene
 - minimum luminance – 783 cd/m²
 - mean luminance – 4,460 cd/m²
 - maximum luminance – 18,600 cd/m²
 - dynamic range – 24:1
- This capture
 - exposure time – 0.0017 sec
 - f-number – f/3.9
 - exposure index – 30