Algorithms in a digital camera

Processing digital camera images

WS 10/11

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Overview

- Basic algorithms
  - Autofocus
  - Auto exposure
  - Histogram
  - Color balancing
- Advanced algorithms

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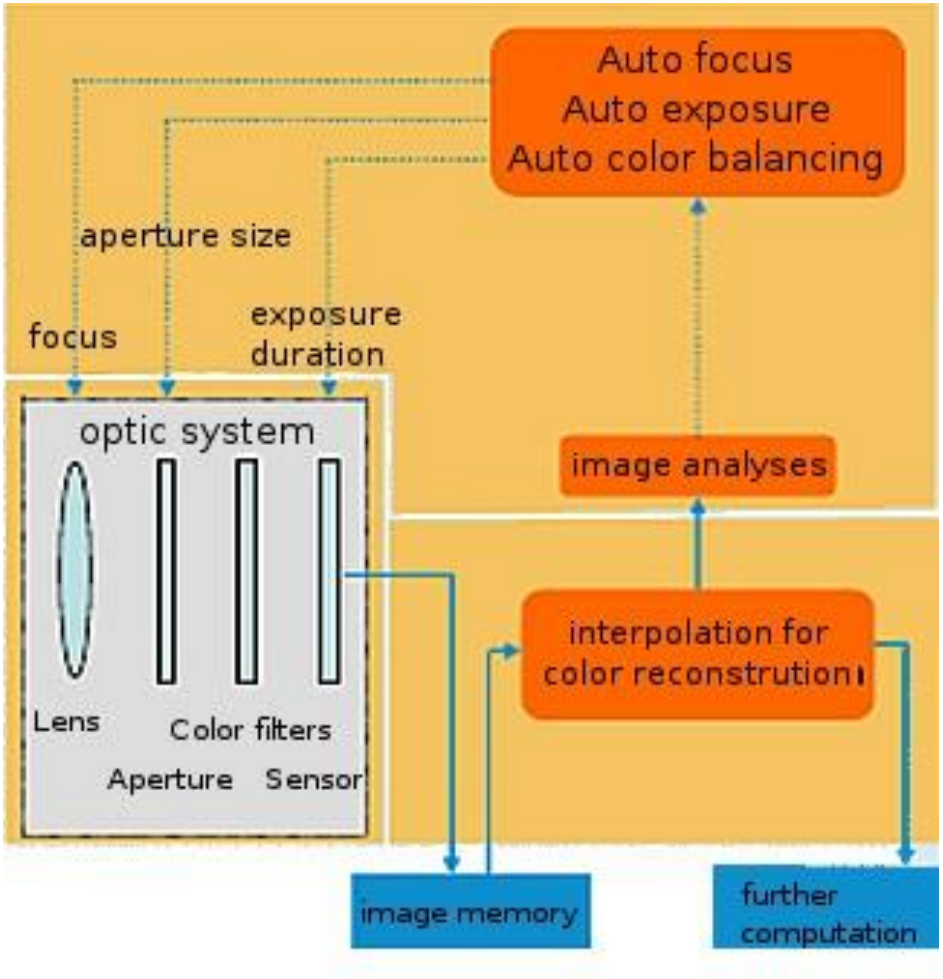
Camera pipeline



Autofocus

Autofocus

- In a small area of the sensor
- Goal: get the highest contrast

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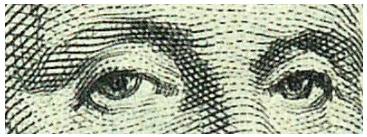
Autofocus algorithm

Step 1: Measure the contrast in the focus area

Step 2: A small change is made to the focusing distance

Step 3: Measure the contrast again and calculate if and by how much the contrast improved

Step 4: Use this information to set a new focusing distance



Repeat until a satisfactory focus has been achieved

Auto exposure

Exposure time

Duration, the aperture of a camera is open (shutter speed)

Underexposed

Overexposed

Correct exposure: the entire image is in a good region of the sensor

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Auto exposure algorithm

- Algorithm:

Step 1: Take a picture with a pre-determined EV_{pre}

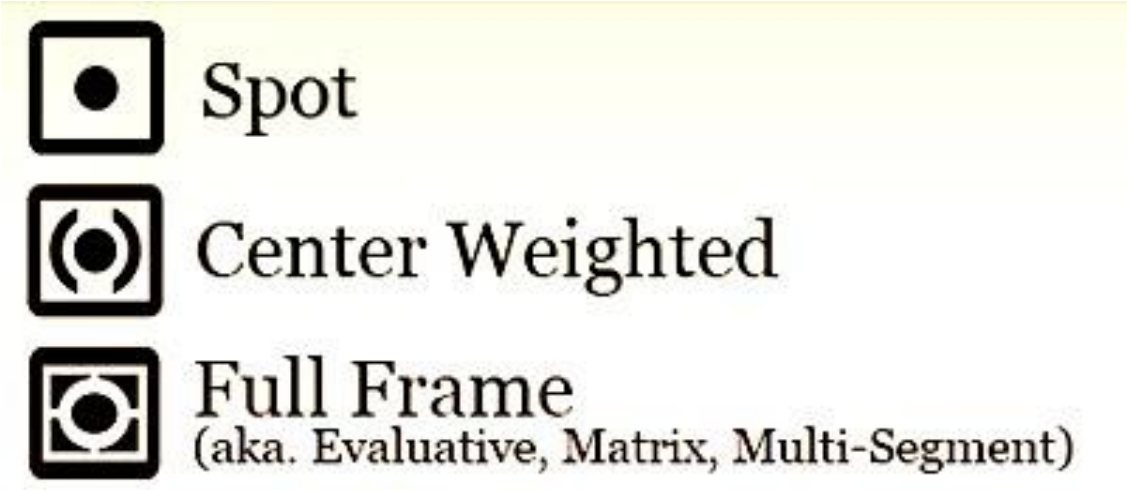
$$EV = \log_2\left(\frac{F^2}{T}\right) = 2\log_2(F) - \log(T)$$

Exposure Value (*EV*) specifies the relationship between aperture size, *F*, and exposure duration, *T*.

Auto exposure algorithm

Step 2: Convert the RGB values to Brightness *B*

Step 3: Derive a single number B_{pre} from the brightness picture



Auto exposure algorithm

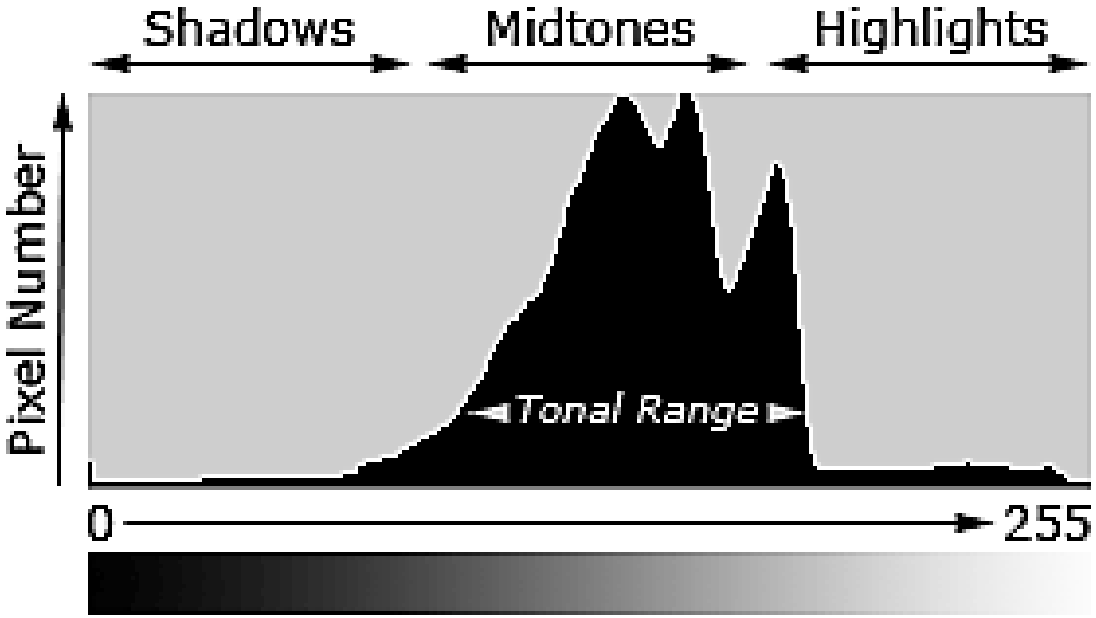
Step 4: Calculate the optimum exposure EV_{opt} , which should give us a brightness value close to B_{opt}

$$EV_{opt} = EV_{pre} + \log 2(B_{pre}) - \log 2(B_{opt})$$

B_{opt}: Brightness value from a calibration against a 18% grey card

Histogram

Shows the distribution of the pixel values



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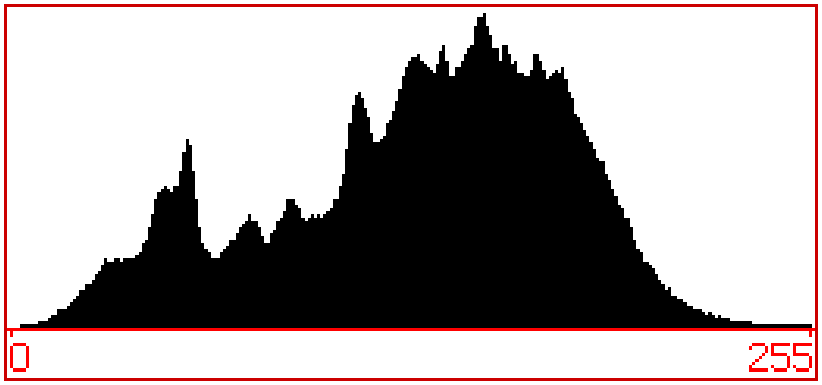
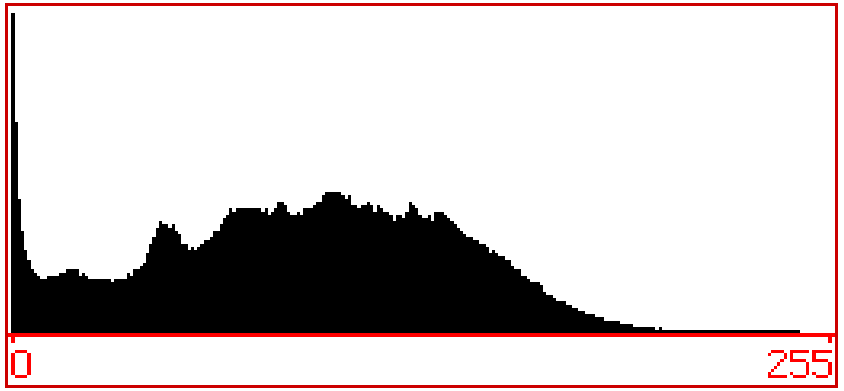
Histogram

Learn to “read” a histogram



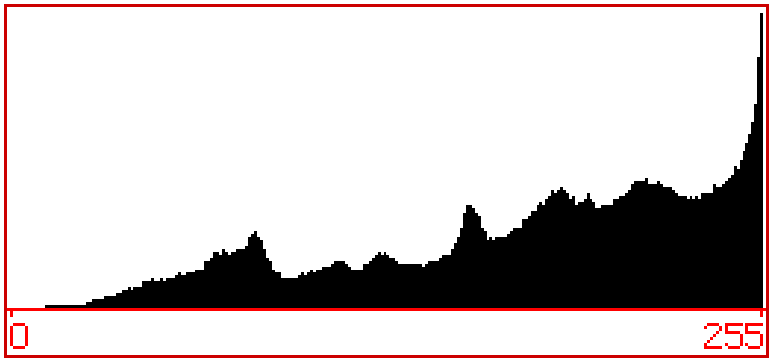
Correctly exposed image

Histogram



underexposed image

Histogram



overexposed image

Color balancing

Color balancing (e.g. White balancing)

- Humans adept to varying illumination conditions
- Image sensors cant, we have to compute it

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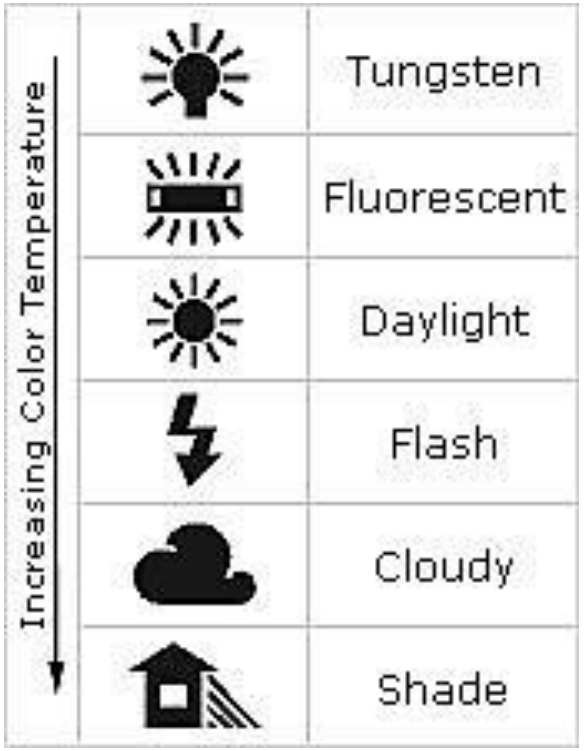
Color balancing

Two ways of balancing:

- Pre-computed sets
- Guess with a algorithm



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Color balancing

Grey world algorithm

Assumes, that the average color of the RGB values are equal (=grey)

$$R_{avg} = G_{avg} = B_{avg}$$

If not, compute coefficients to make them equal

$$\tilde{\alpha} = \frac{G_{avg}}{R_{avg}} \qquad \tilde{\beta} = \frac{G_{avg}}{B_{avg}}$$

Good results, if picture has many colors

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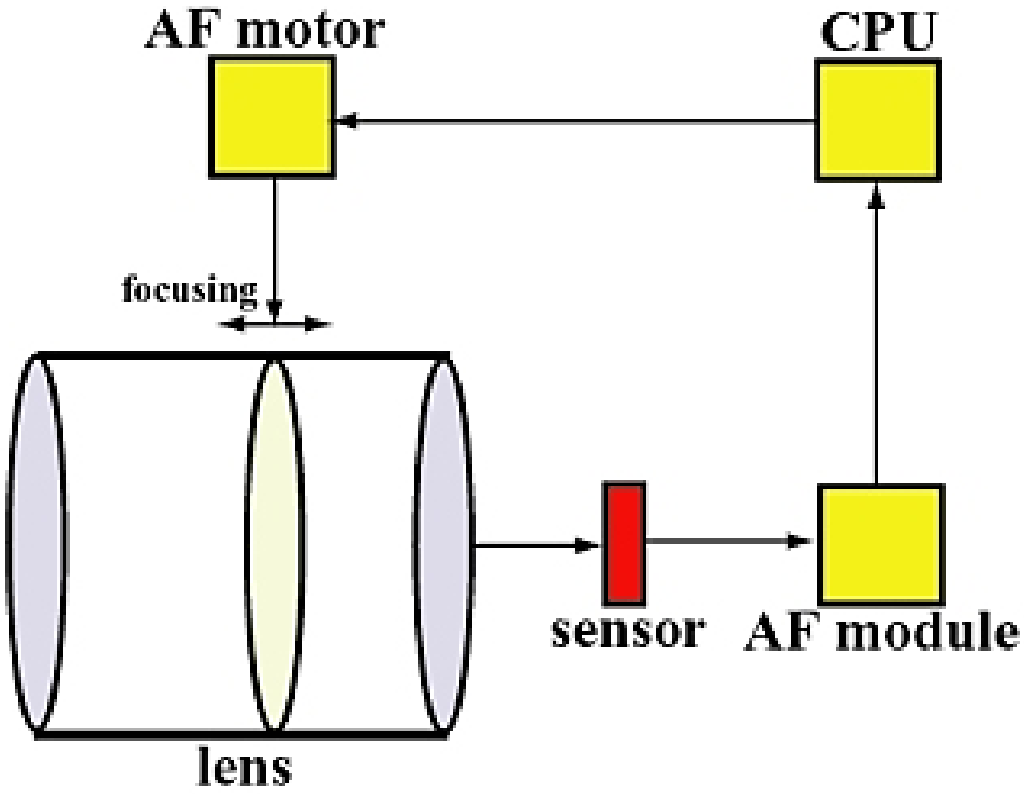
Advanced Algorithms

On camera implemented advanced algorithms:

- HDR
- Panorama stitching
- Face detection
- Focus bracketing
- …

Thank you for listening

Autofocus



Schematic auto focus system