Introduction to Medical Imaging

Definitions

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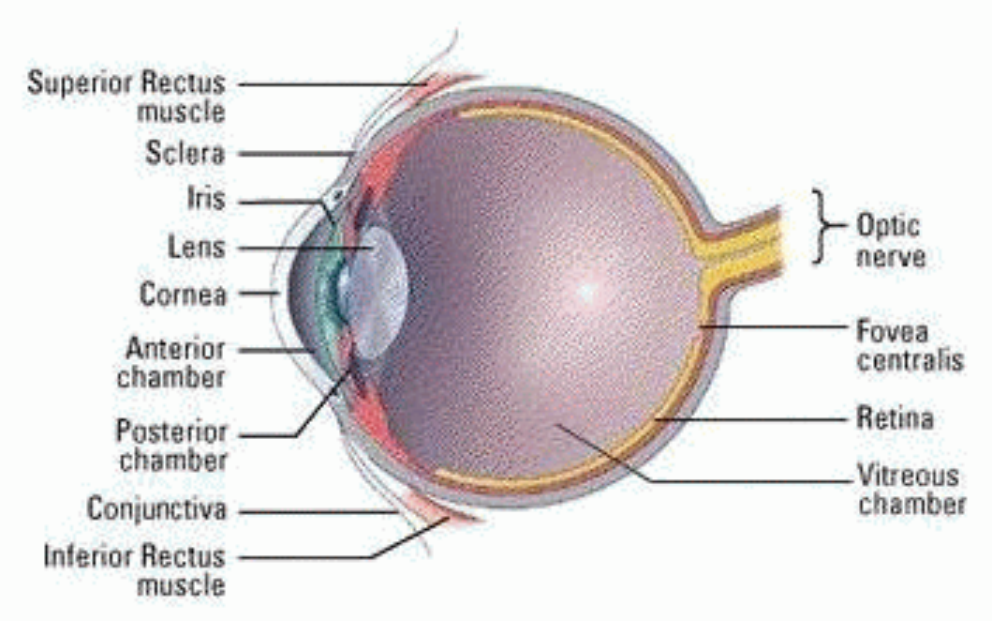
Human Eye

Two types of receptors on retina: rods and cones



Rods:

- spread all over the retinal surface (75 - 150 million)
- low resolution, no color vision, but very sensitive to low light

Cones:

- a dense array around the central portion of the retina, the fovea centralis (6 - 7 million)
- high-resolution, color vision, but require brighter light

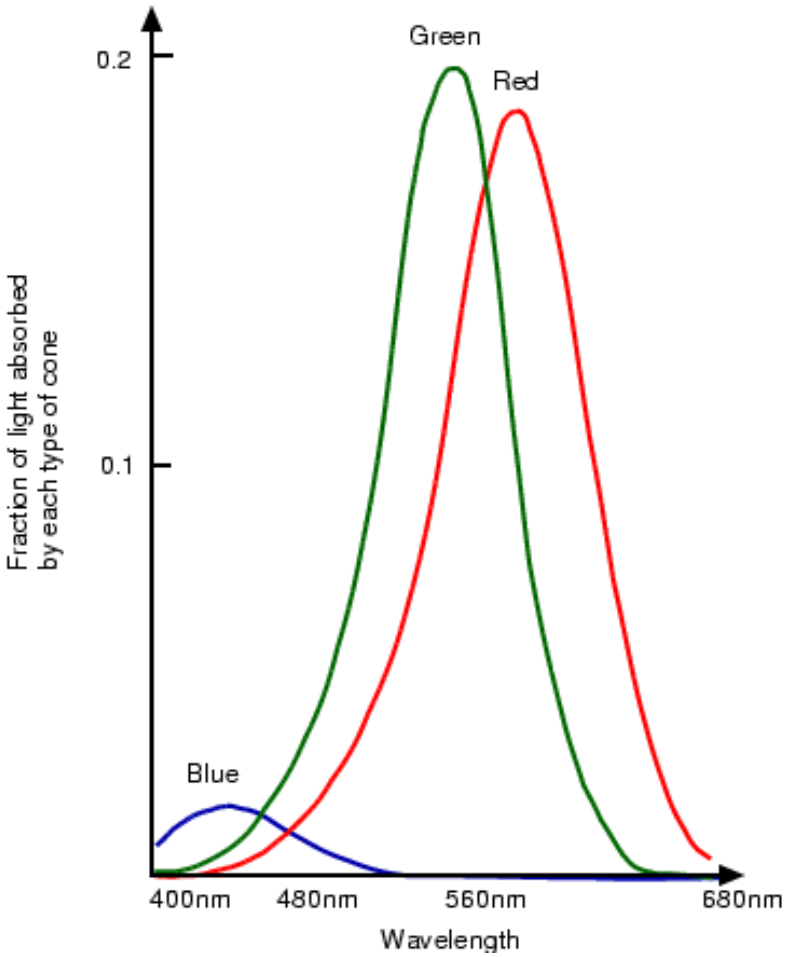
Color Perception

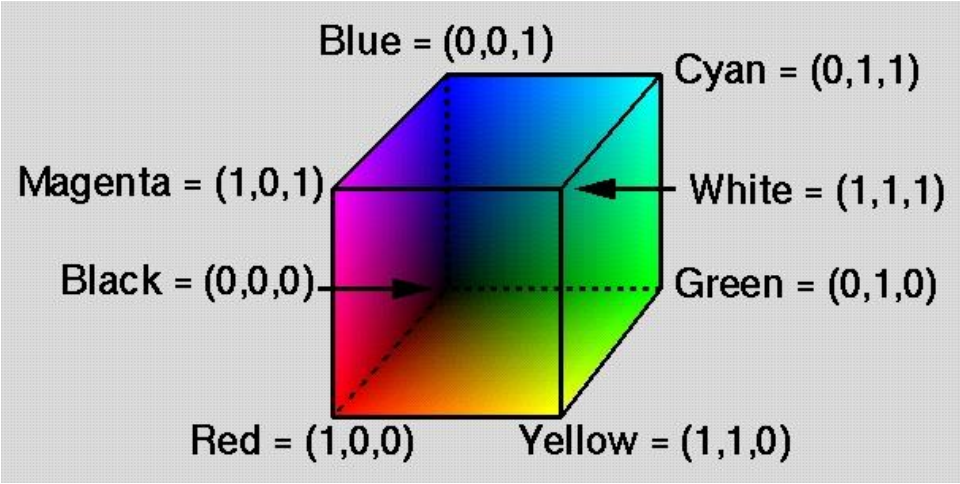
Tristimulus Theory:

- the eye has three types of color receptors: Red, Green, Blue.

Color reproduction:

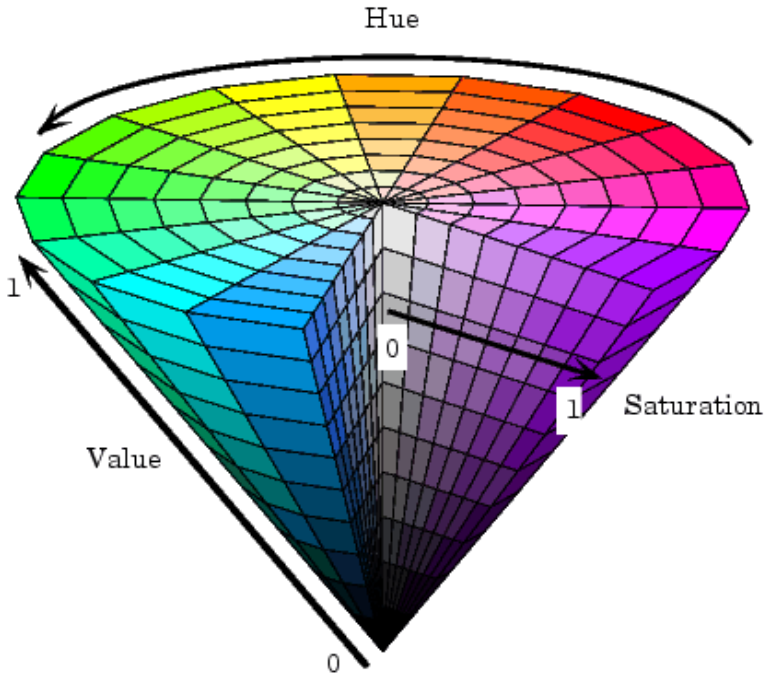
- one can generate (almost) any color on a monitor by mixing three primaries, RGB
- CRT monitor have 3 color guns: RGB



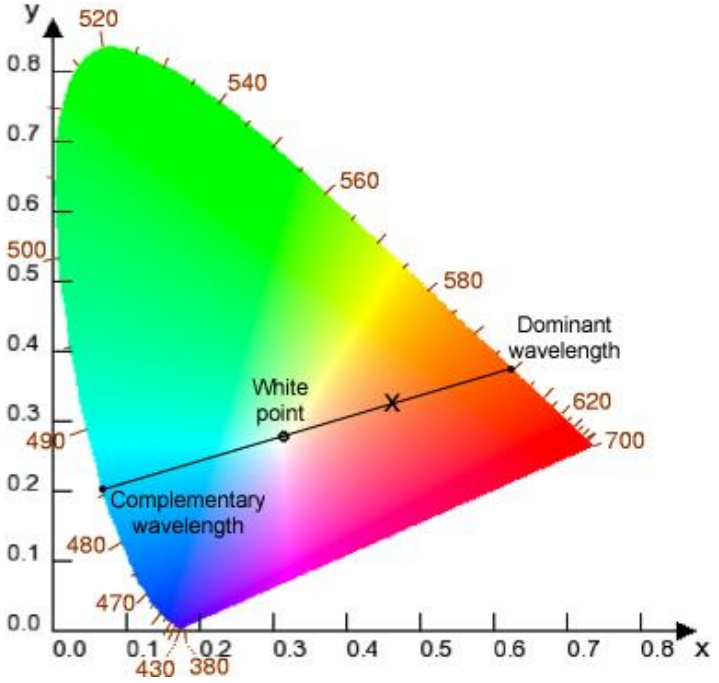


Color Spaces

HSV



CIE



*H*ue: color
*S*aturation: peak from white light
*V*alue: overall integral across all λ

CIE L$\alpha\beta$: equal distances mean equal perceptive differences

Digital Image

Image:

- 2D matrix of pixels

Image resolution:

- number of pixels along each matrix dimension

300 150 75 37

resolution

Each pixel has a value:

- a single value if greylevel image
- a triple RGB if color image

Dynamic Range

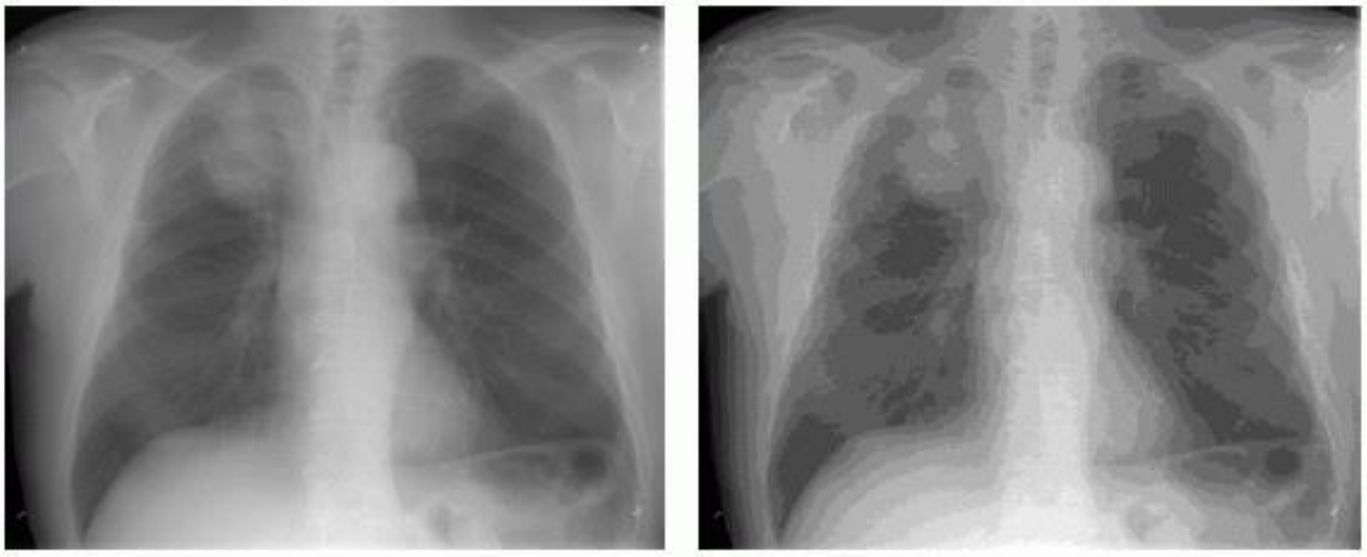
Each pixel is represented by a number of bits

Quantization:

- process of discretizing a continuous value into bits

Minimal number of bits = 6 (64 greylevels or 4 levels for R,G,B)

- most medical digital images have 12 bits (4096 grey levels)



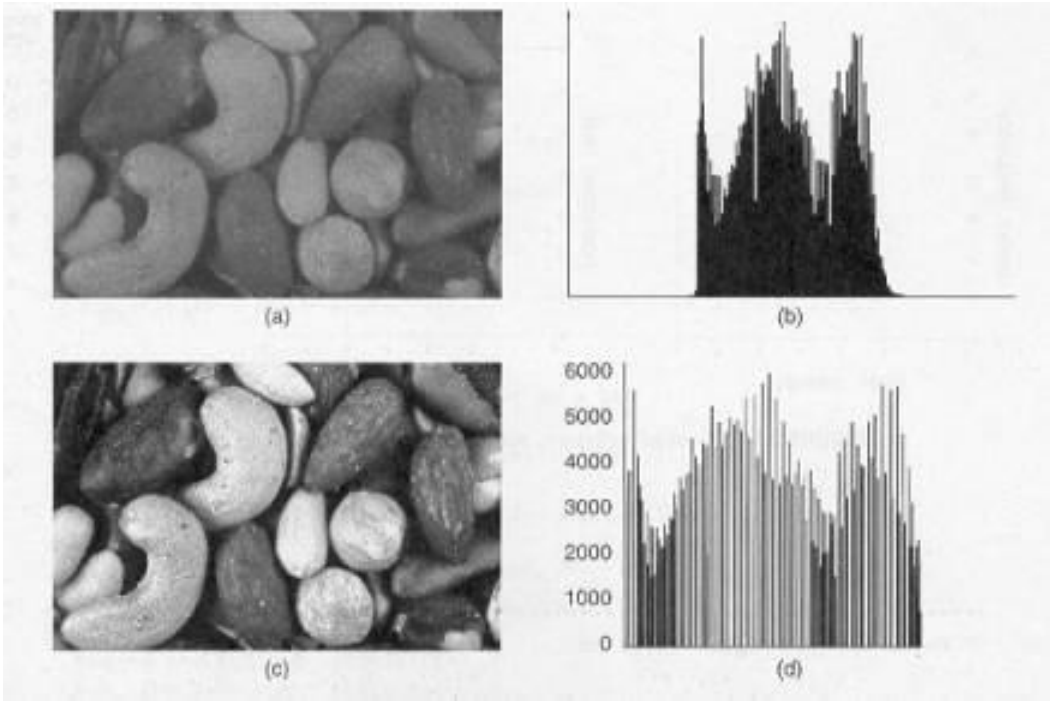
8 bits 4 bits

- not enough bits leads to quantization artifacts and loss of resolution

Histogram

A histogram counts the number of pixels at each greylevel

- $h(v)$ = number of pixels having grey value v / total number of pixels



partial bandwidth

full bandwidth

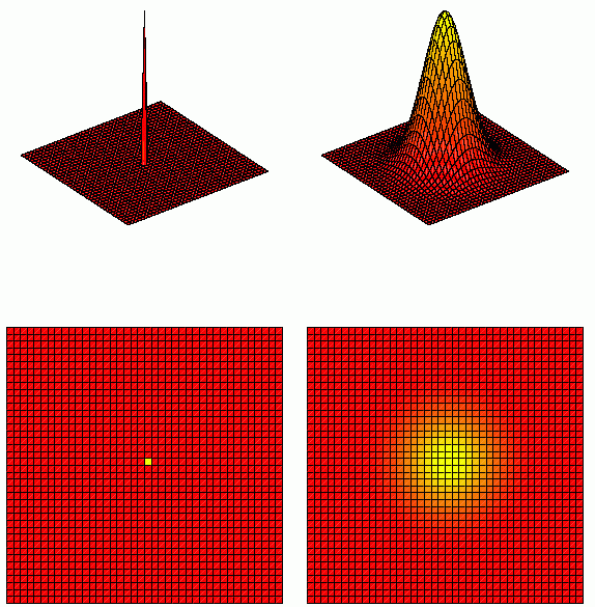
Good contrast requires a histogram with full bandwidth

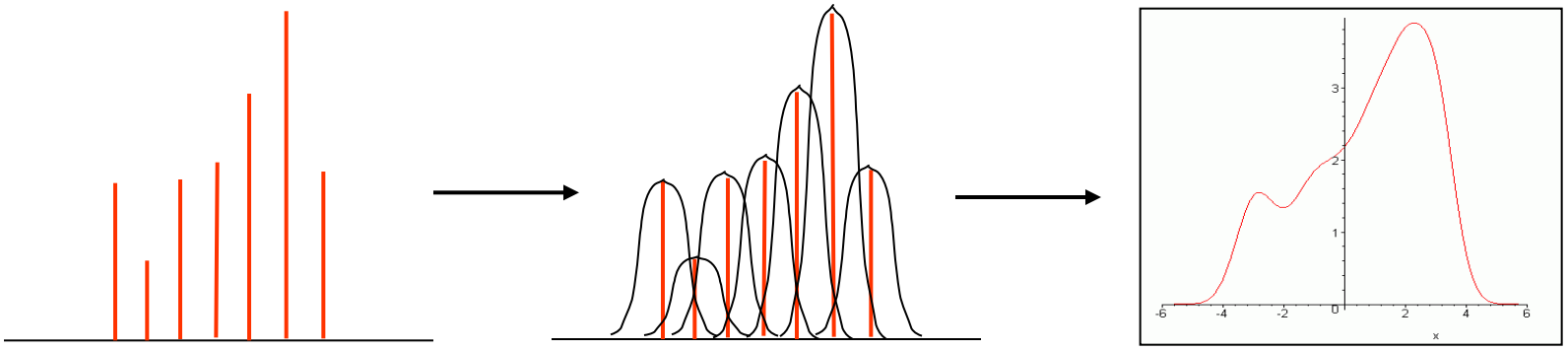
Point Spread Function

Each pixel is not a sharp spike, but represented by a point spread function (PSF)

The PSFs overlap and form a continuous function (for the eye)

Smaller PSFs give sharper images





Contrast

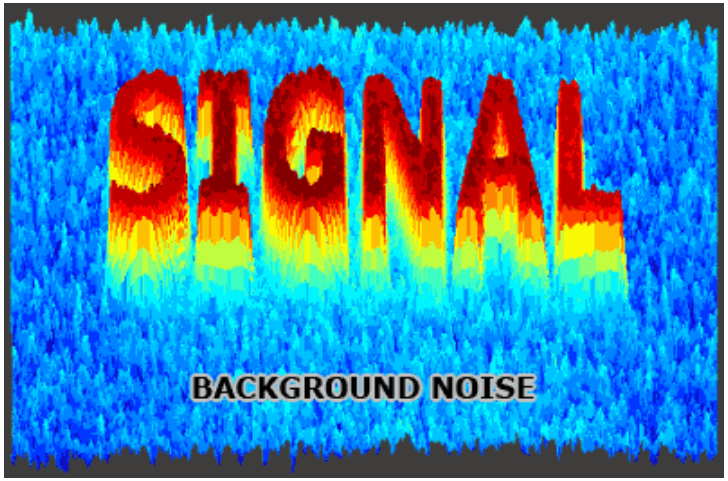
Difference of brightness in adjacent regions of the image

- grey-level (luminance) contrast
- color contrast

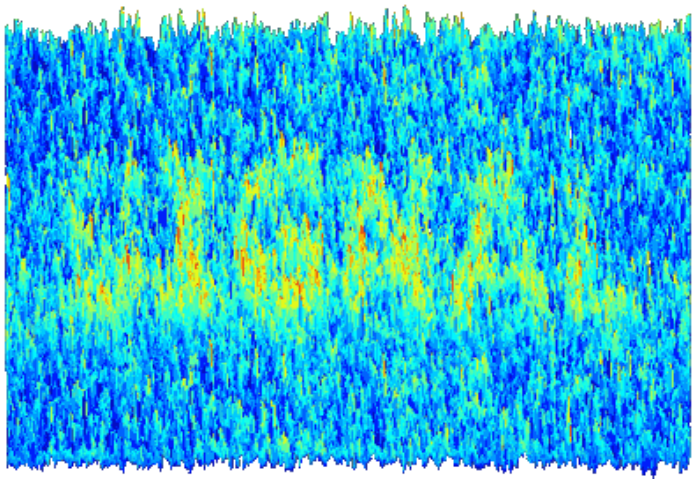
Signal-to-Noise Ratio

Signal-to-Noise ratio (SNR) = S_{RMS} / N_{RMS}

- RMS: root mean square

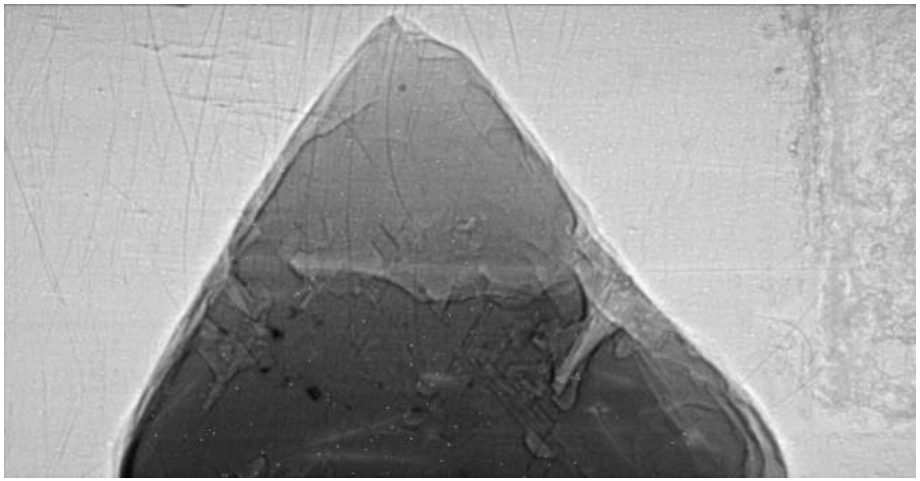


high SNR

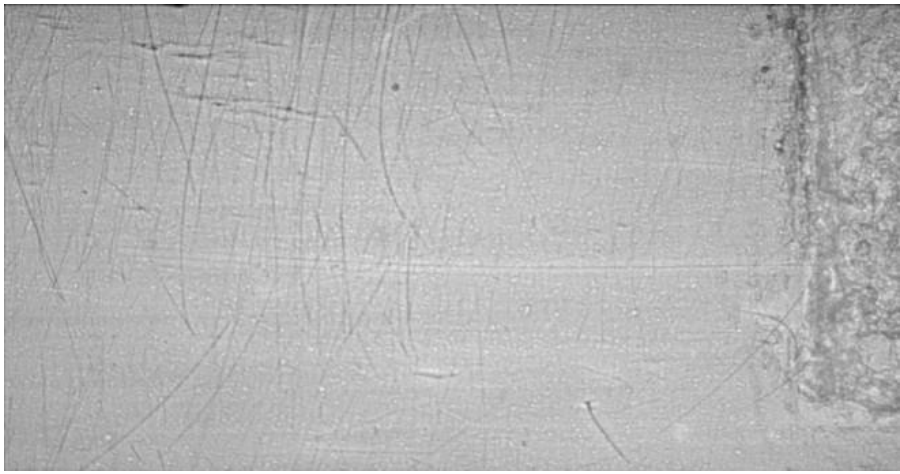


low SNR

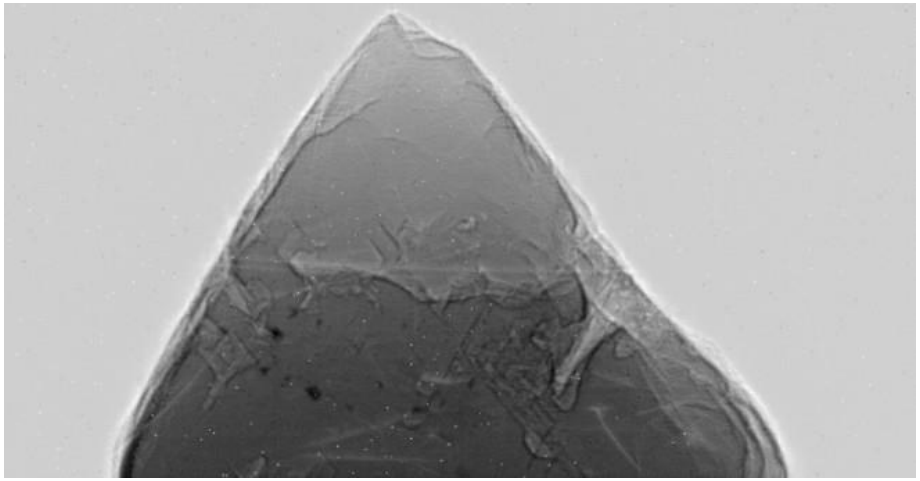
Flat Field Correction



without correction



flat field: noise and scratches



with correction