Digital image processing

Árpád BARSI
BME Dept. Photogrammetry and Geoinformatics
barsi.arpad@epito.bme.hu

- Part 1: (5/12/2018) „Theory” of image processing
- Part 2: (12/12/2018) Practice with software examples

Main content

Content

- Basic terms
- Image descriptions
- Image acquisition
- Resolutions
- Storage & software
- Manipulations: LUT, morphology, histogram operations
- Image filterings
- Color models
- Geometric manipulations
- Basic measurements

- Photography
- Mathematics
- Physics, optics
- Signal processing, electronics
- IT
- …
- Application fields

Is it interdisciplinary?

- Photography, documentation (from holiday to events)
- Cinema
- Design, marketing, advertisements
- Medicine, biology
- Industrial applications: robots, QA/QC, transportation…
- Physics, astronomy, measurement technologies
- Military applications
- Remote sensing, GIS
- And many more…

Application fields

Goals of image processing

- Detection and recognition of known objects
- Obtaining geometric models of unknown objects
- Computing position and orientation of objects
- Measurement of spatial properties of objects (distances, sizes, etc.)
- Measurement of object motion
- Measurement of surface texture and color

- Image processing
  - E.g. image enhancement
- Image analysis
  - E.g. feature extraction
- Image understanding
  - E.g. semantics

Levels

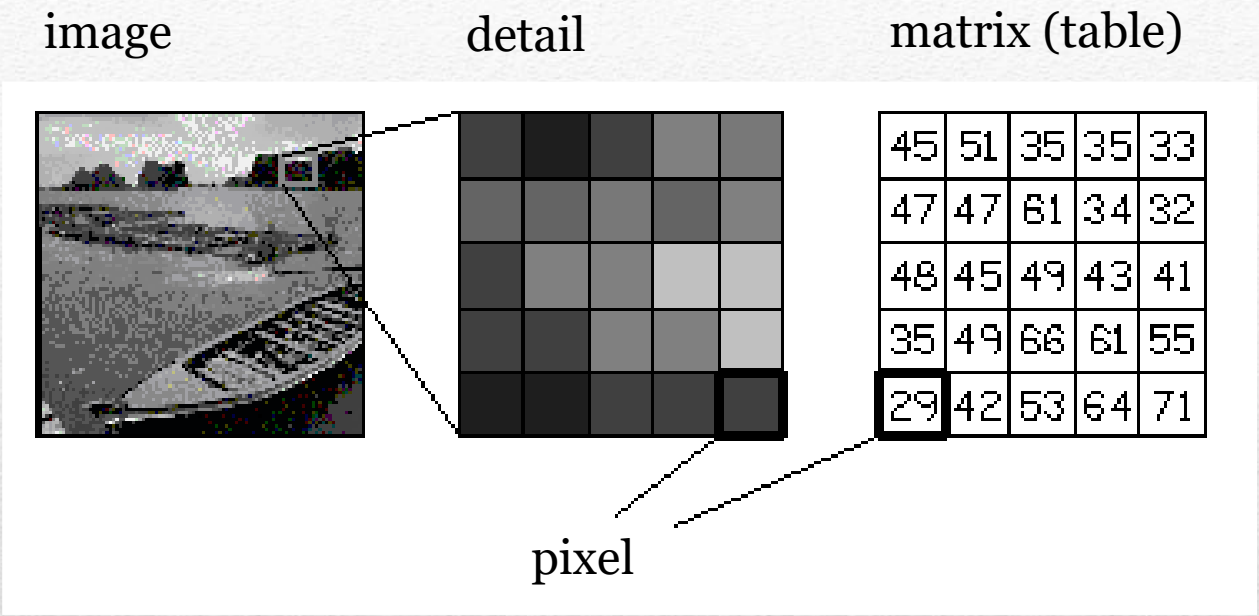
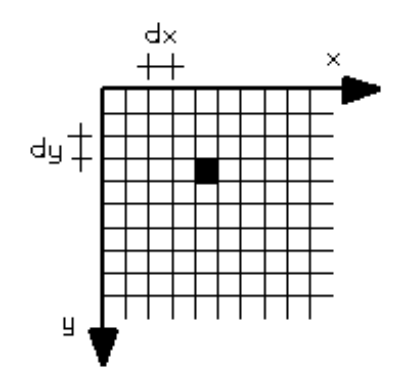


Image and pixel



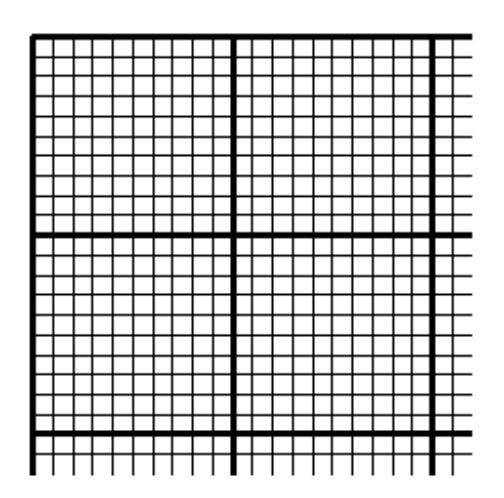


Image coordinate systems

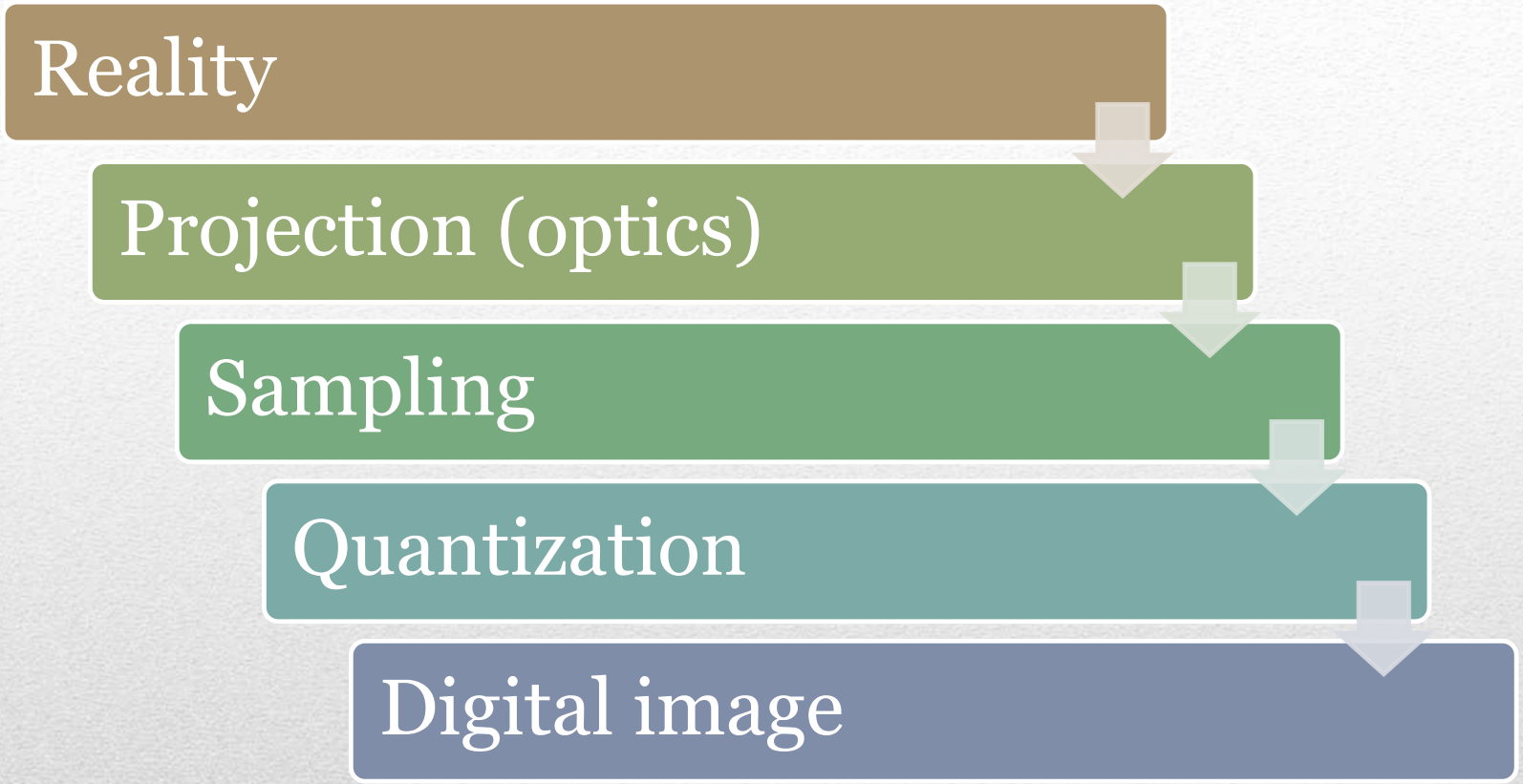
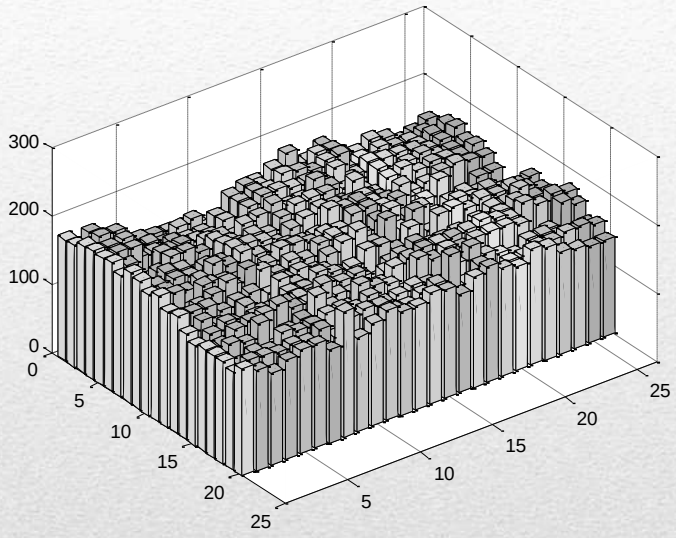


Image acquisition procedure



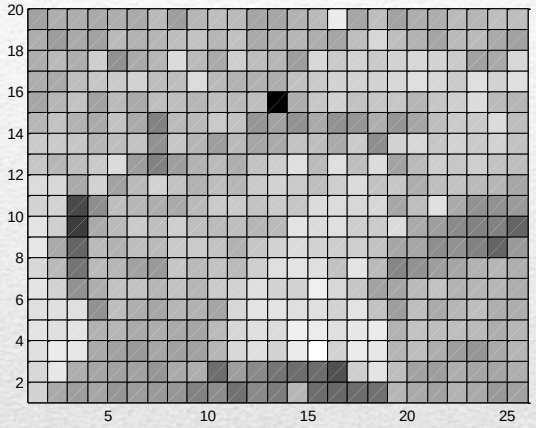
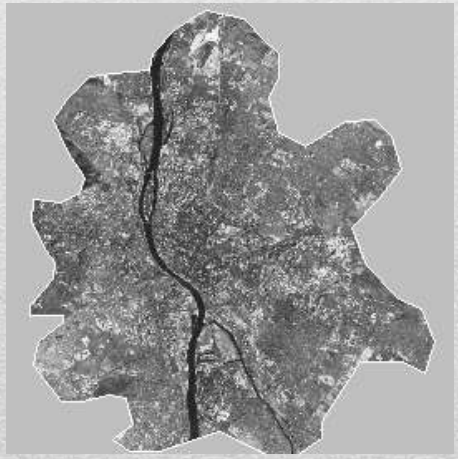


Image acquisition procedure

Image basics

- An image is a function f(x,y,b,t)
- Resolution: geometric, radiometric, spectral, temporal
- Cut-off/mask: regular, arbitrary (ROI, AOI)
- Storage formats (color and BW; lossy and lossless)
- Features: descriptive data, statistics, histogram, sections



Original resolution

1/4 of original

1/8 of original

1/16 of original

Geometric resolution

64 gray levels

16 gray levels

8 gray levels

4 gray levels

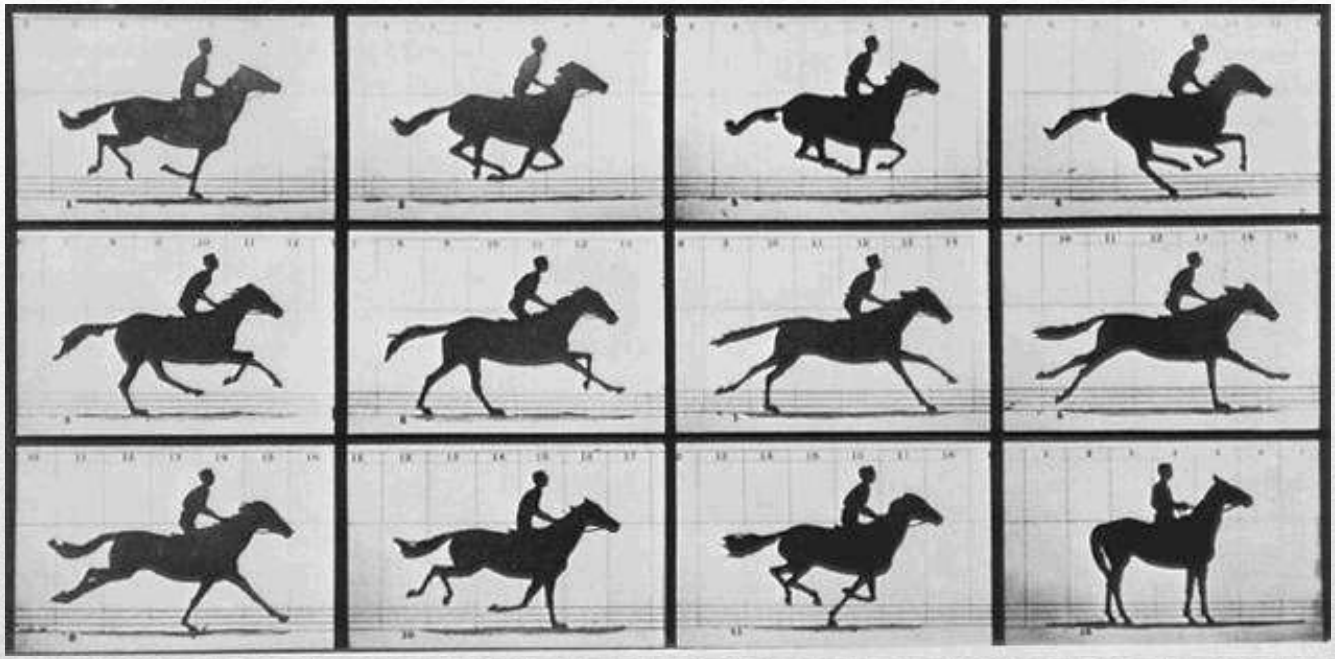
Radiometric resolution

R

G

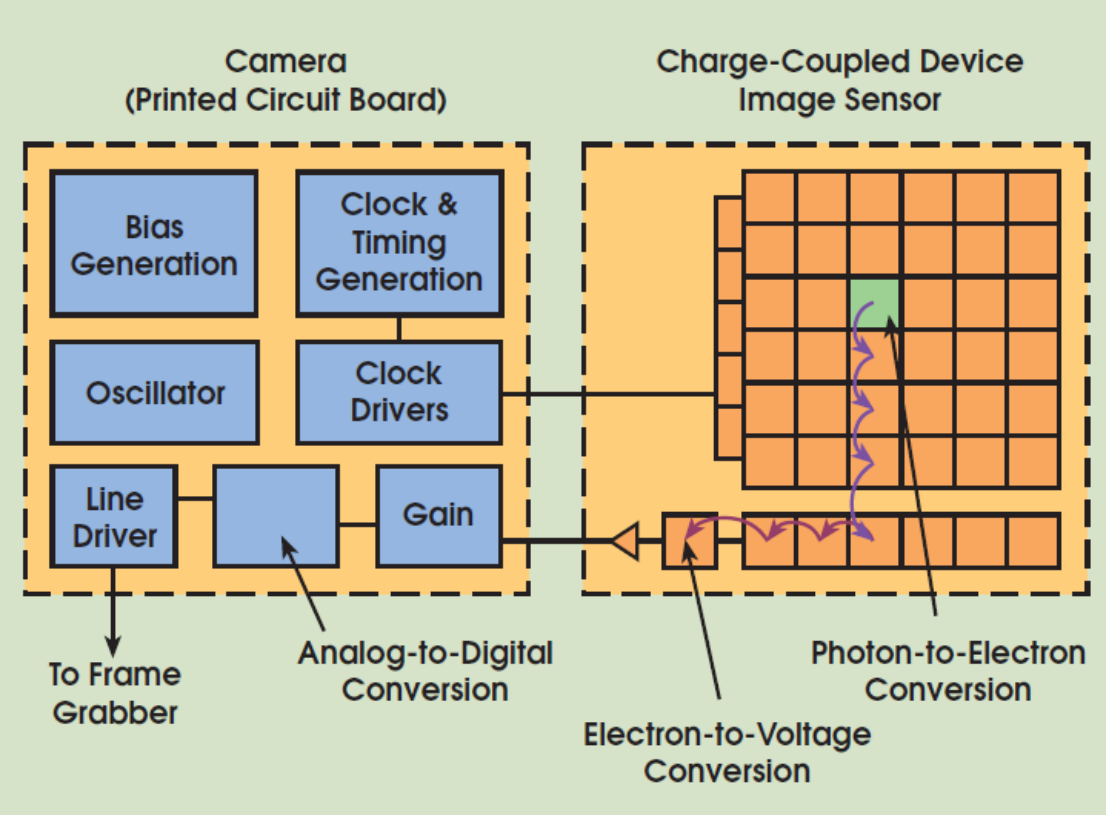
B

Spectral resolution

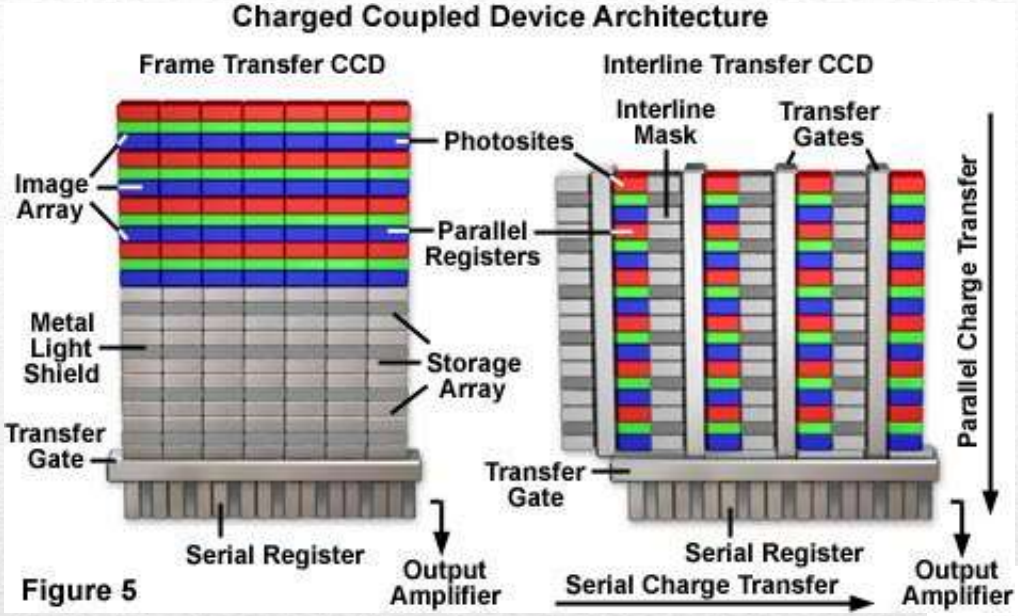


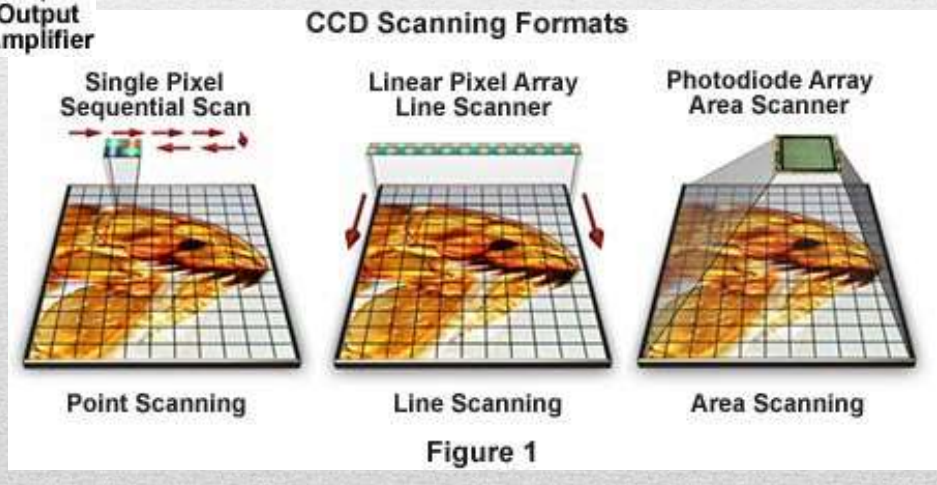
Temporal resolution

Special resolution terms



Charge Coupled Device (CCD)





CCD „versions”

Image storage

- Paper of A4 with 600 dpi
  - 210 × 297 mm
  - 4961 × 7016 pixel = 34 806 376 pixel
  - à 24 bit (1 byte) = 99.6 MB !
- Aerial image with 7 µm pixel size
  - 230 × 230 mm
  - 32 857 × 32 857 pixel = 1 079 582 449 pixel
  - à 24 bit = 3.02 GB !!!
- Efficient algorithms to store information
  - Lossy or lossless methods

Image processing software

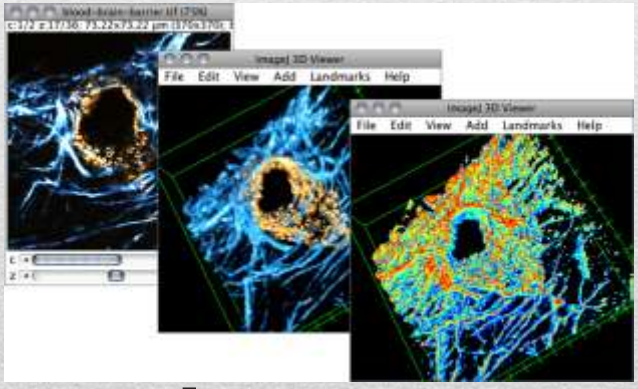
- Graphics software:
  - PhotoShop, PhotoPaint, PaintShopPro, Kai, Photo DeLuxe, Gimp, ImageJ…
- General purpose development environments:
  - Khoros, **Matlab Image Processing Toolbox**, AVS, Image Vision Library, Halcon, ImageMagick, Rapidminer…
- Special application software:
  - ImageStation Imager, Erdas Imagine, GRASS, ImagePro Plus, Ilwis, **ImageJ, Fiji**, SNAP…

PhotoShop

Kai's Power Tools

ILWIS

GIMP

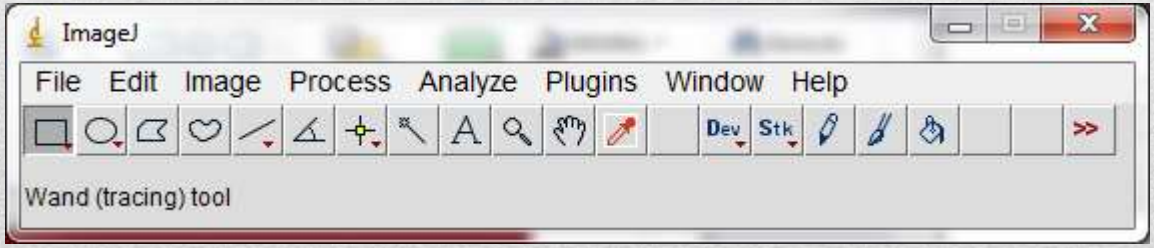


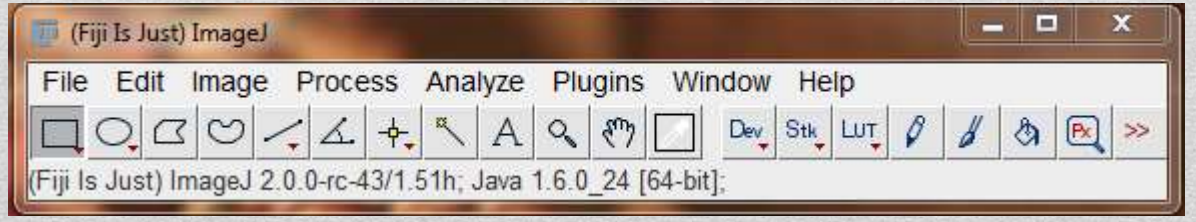
ImageJ

Software examples

- Free Java based image processing software
- Download from: http://imagej.nih.gov/ij/
- Clear menu structure
- Numerous medical/biologic function
- Add-on possibility (plug-in)
- Well-documented (help, tutorials, videos)

ImageJ and FIJI





- DICOM – Digital Imaging and Communication in Medicine
- Copyright at NEMA – National Electrical Manufacturers Association
- First standard: NEMA + Americal College of Radiology (1985)
- DICOM Standard Committee
- Providers: e.g. Agfa, Philips, Siemens, Zeiss…
- Users: e.g. American Academy of Ophthalmology, European Society of Cardiology, Deutsche Roentgengesellschaft…
- Other members: e.g. IT companies, health industry companies…

DICOM

DICOM support

Info for 4762B7A0.DCM

File Edit Font

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0020,0012  Acquisition Number: 7
0020,0013  Image Number: 4
0020,0032  Image Position (Patient): -121.91341535875\-109.93346959850\-32.537737485952
0020,0037  Image Orientation (Patient): 0.99996411800384\-6.167521496E-05\0.00847145821899\-
0020,0052  Frame of Reference UID: 1.3.46.670589.11.17162.5.0.5772.2007121414034121028
0020,0100  Temporal Position Identifier: 1
0020,0105  Number of Temporal Positions: 1
0020,1040  Position Reference Indicator:
0020,1041  Slice Location: 0
0028,0002  Samples per Pixel: 1
0028,0004  Photometric Interpretation: MONOCHROME2
0028,0010  Rows: 256
0028,0011  Columns: 256
0028,0030  Pixel Spacing: 0.8984375\0.8984375
0028,0034  Pixel Aspect Ratio: 1\1
0028,0100  Bits Allocated: 16
0028,0101  Bits Stored: 12
0028,0102  High Bit: 11
0028,0103  Pixel Representation: 0
0028,1050  Window Center: 4116.68686868686
0028,1051  Window Width: 8233.37373737373
0028,2110  Lossy Image Compression: 00
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0040,0244  Performed Procedure Step Start Date: 20071214
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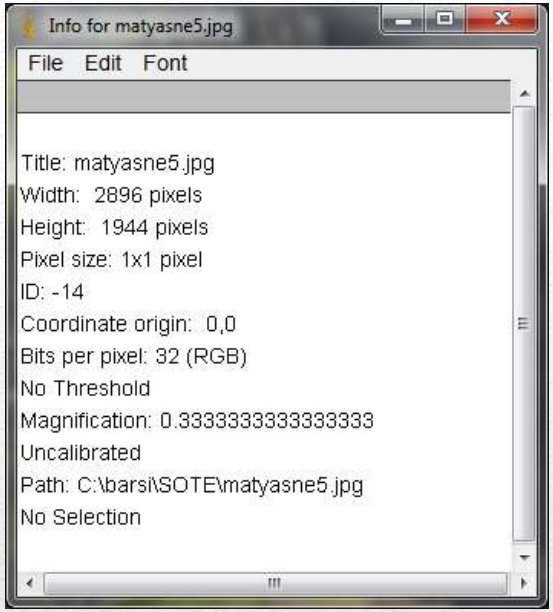
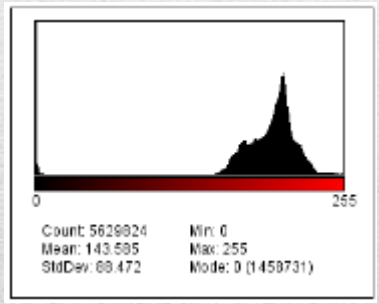
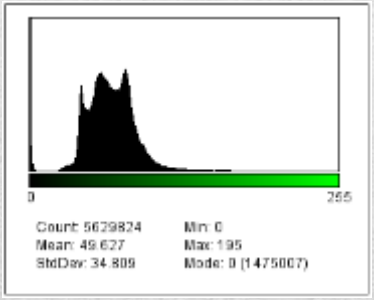
0040,0321  Film Consumption Sequence:
0040,9224  >---:
0040,9225  >---:      dÎ?
2001,0010  ---: Philips Imaging DD 001
2001,100B  ---: TRANSVERSAL
2005,0010  ---: Philips MR Imaging DD 001
```

DICOM example

- Descriptive data
  - #rows, #columns, capture date, exposition time…
- Statistics
  - Max, min, mean, median…
- Histogram
- Sections







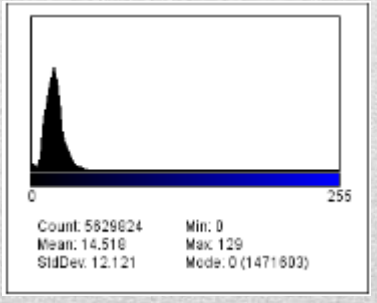
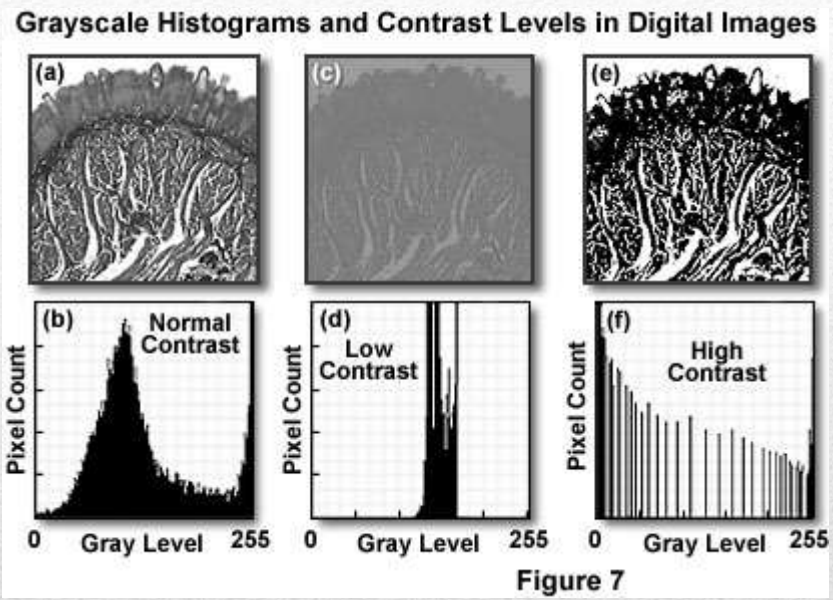
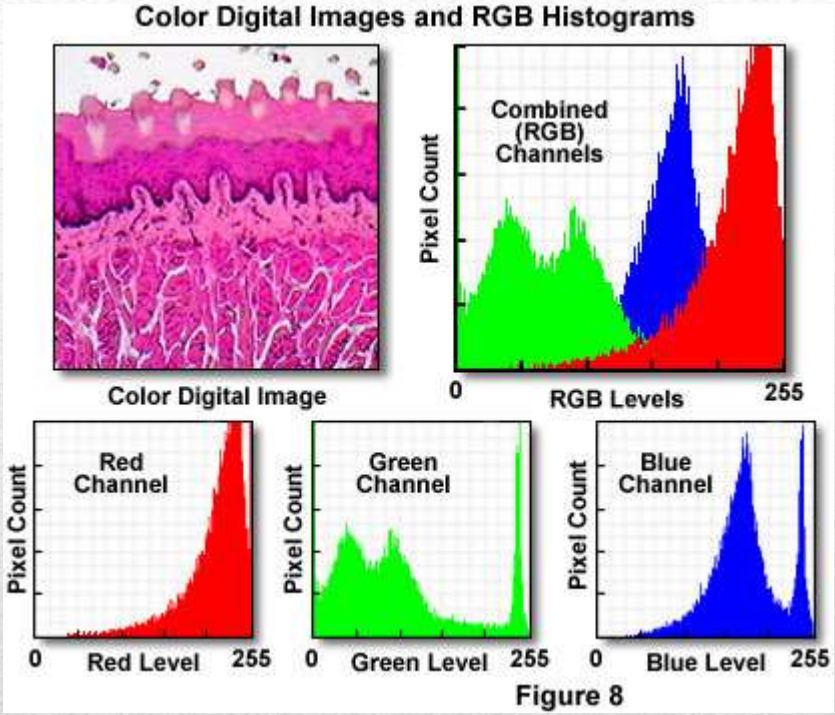
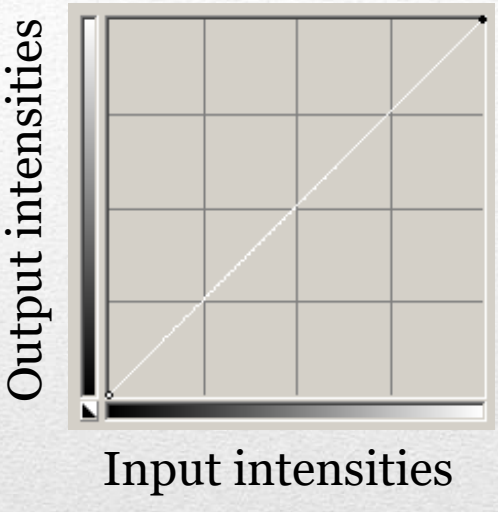


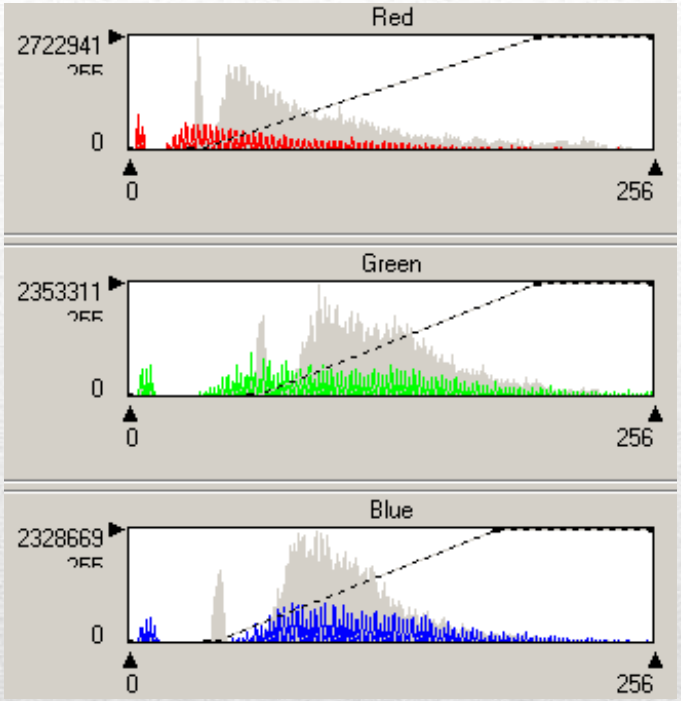
Image features



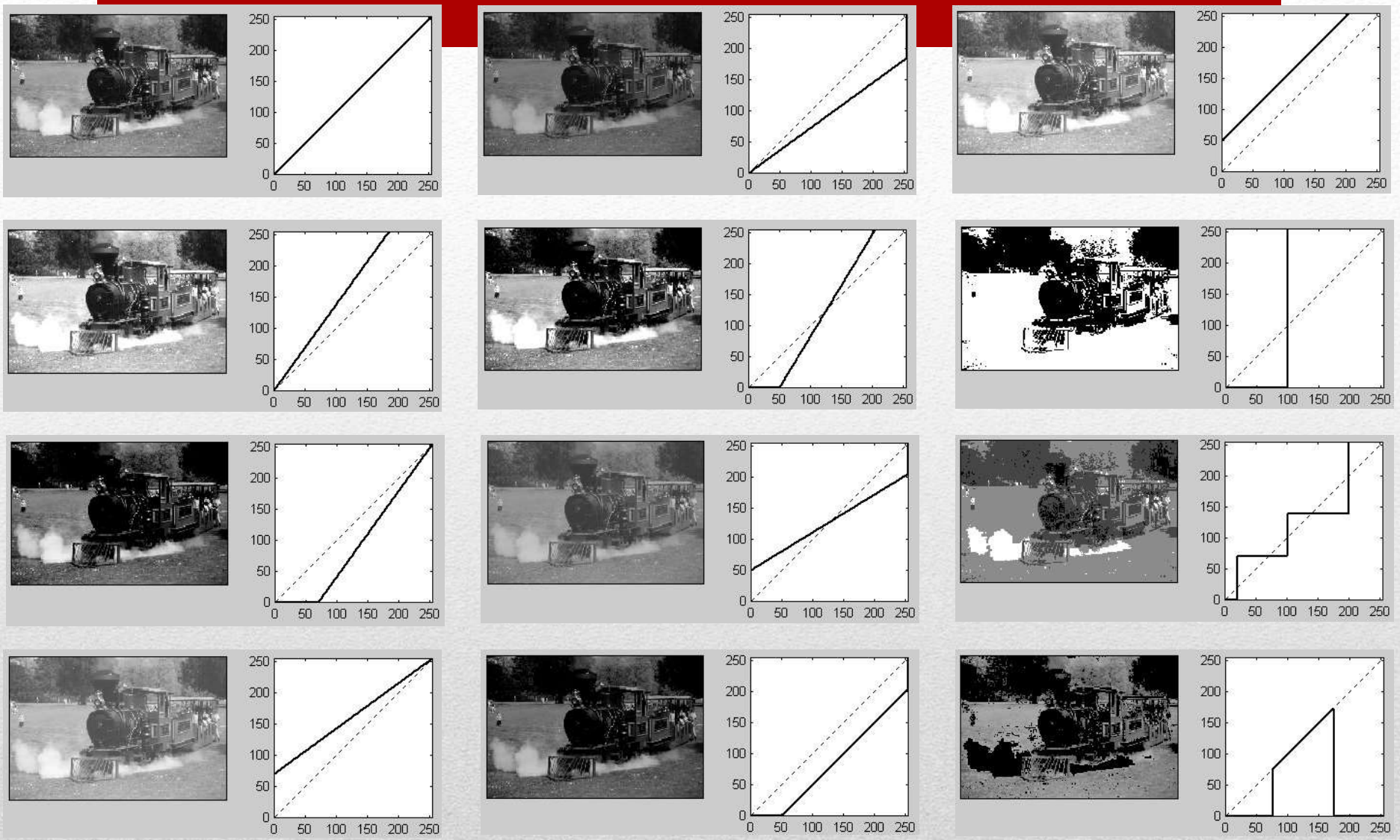


Once more about histograms

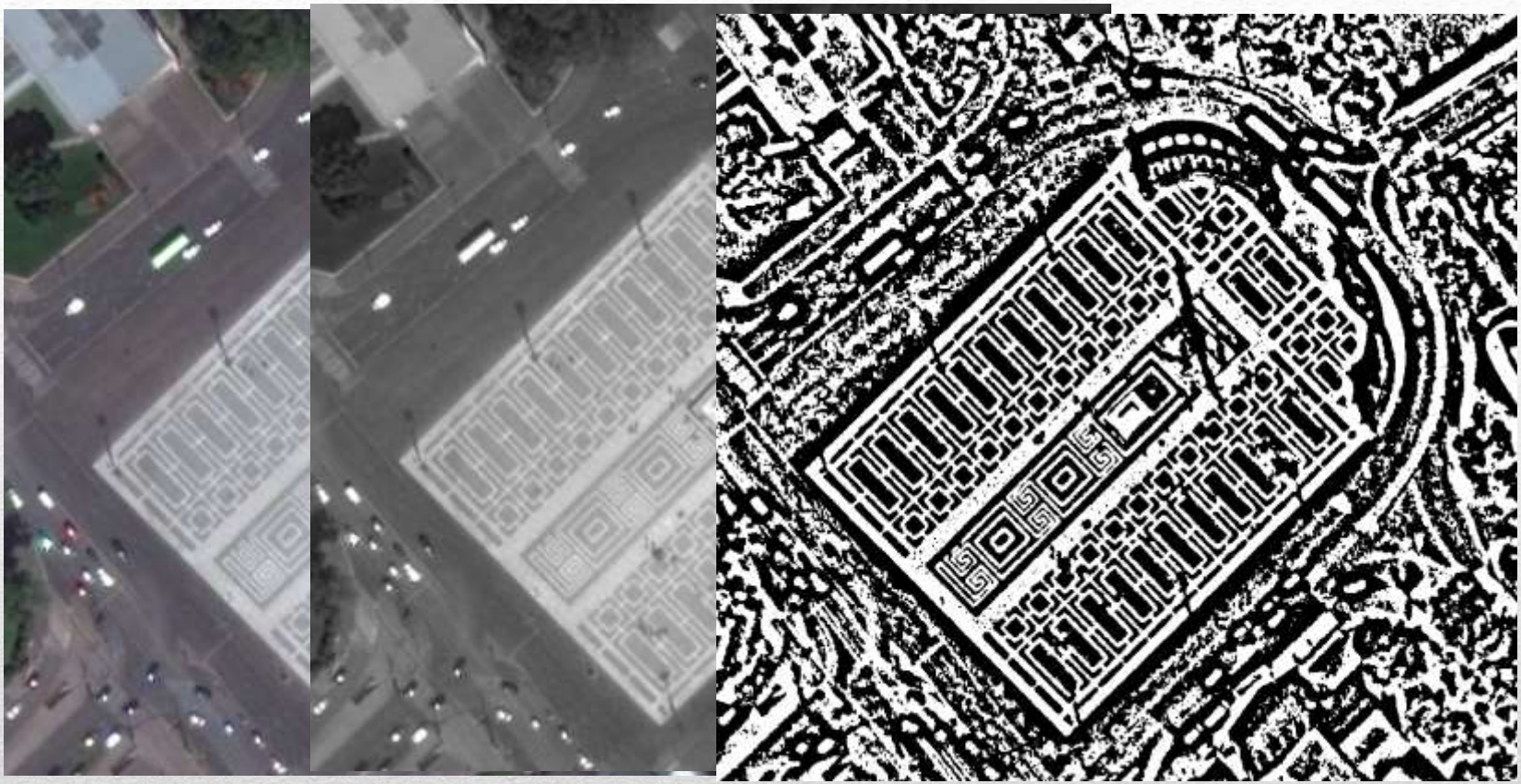




Look-Up Table (LUT)



LUT cases

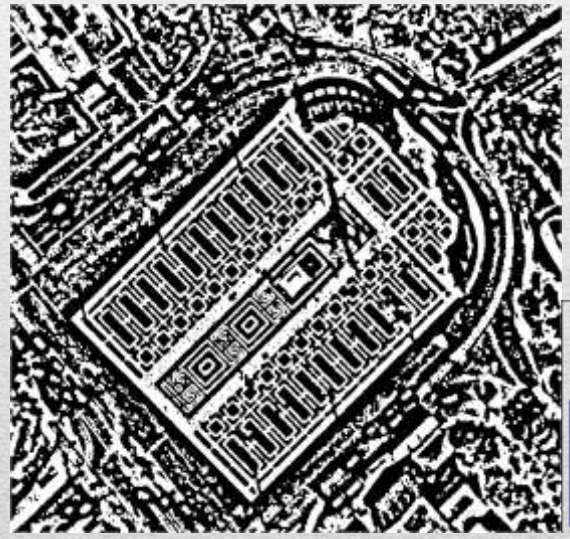


Binarization

Erosion

Dilatation

Opening



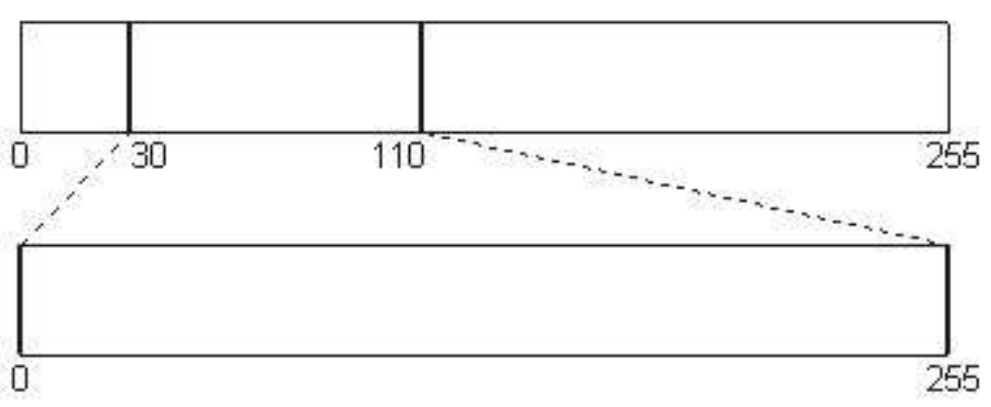
Closing

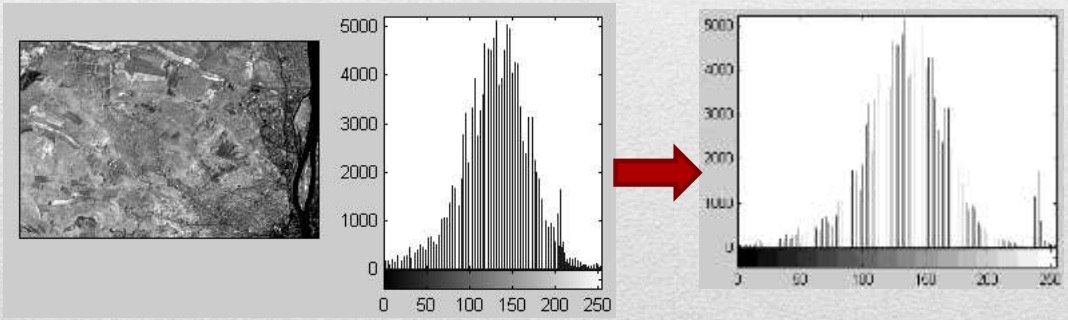
Morphology

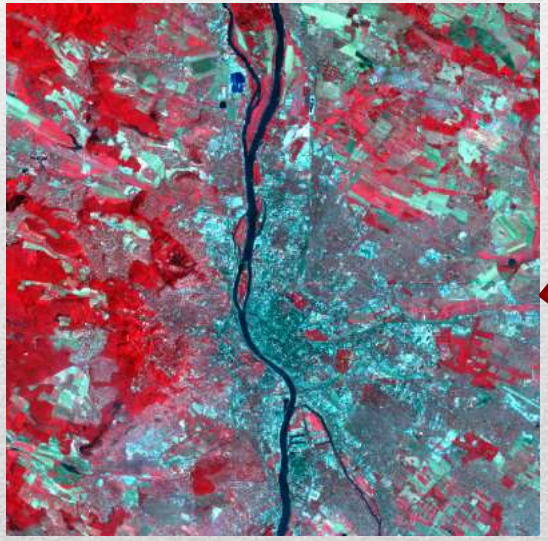
Skeletonize

Opening & closing with 5 pixel radius STREL

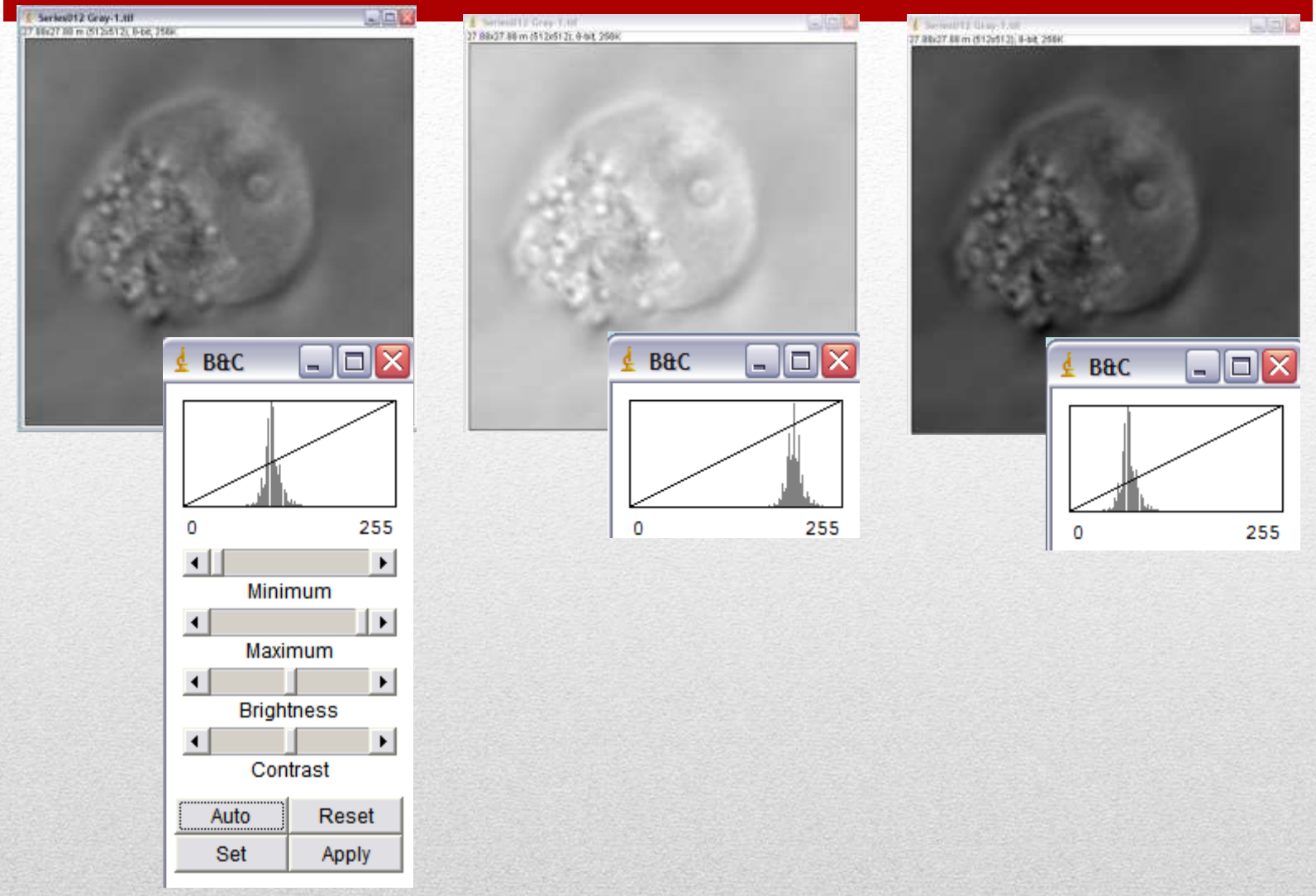
Grayscale morphology



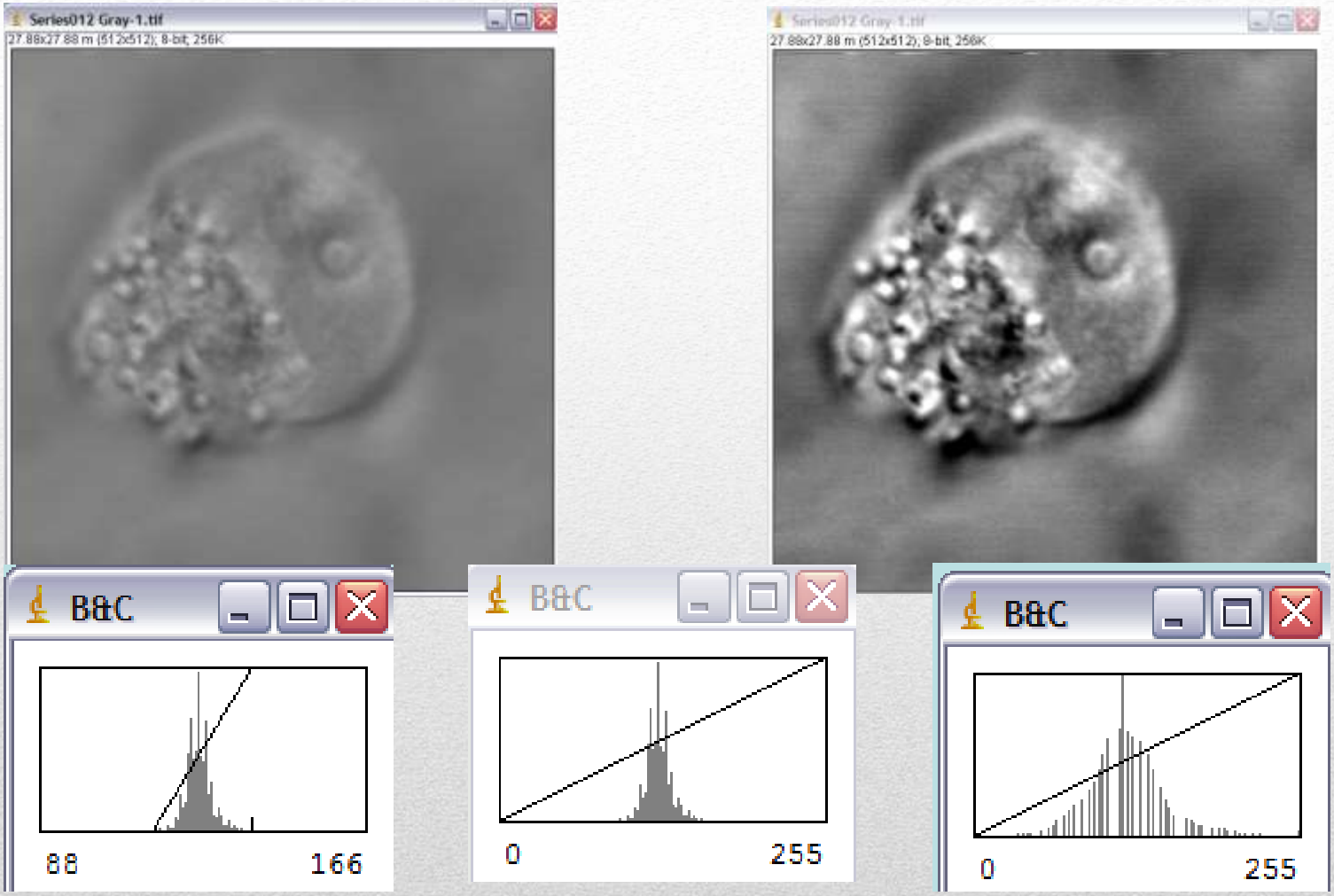




Histogram stretch

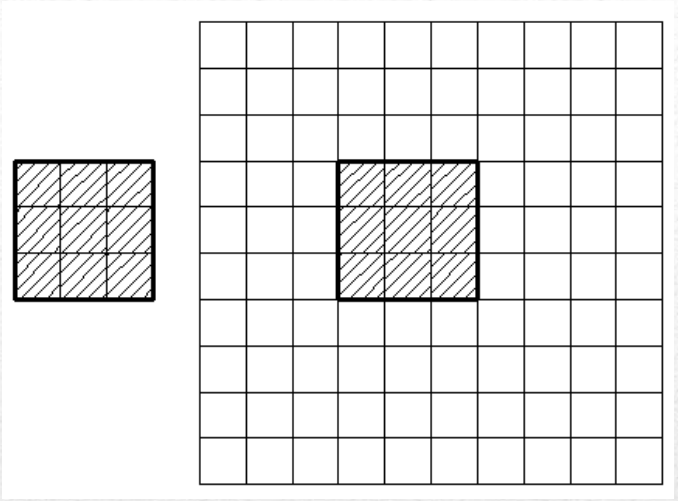


Brightness functions



Contrast function

- Convolution
  - Smoothing
  - Edge detection
- Non-convolution
  - Special effects
- Filtering in frequency domain
  - Periodic noise removal



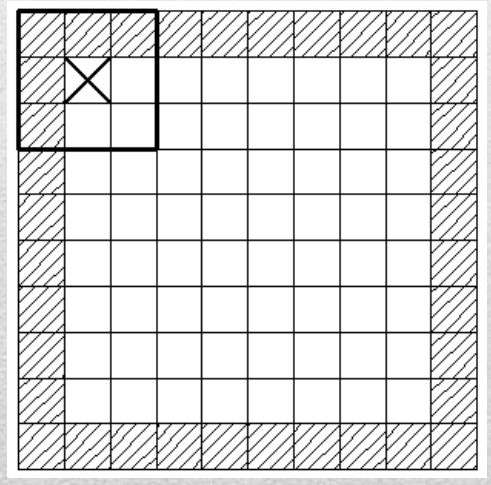
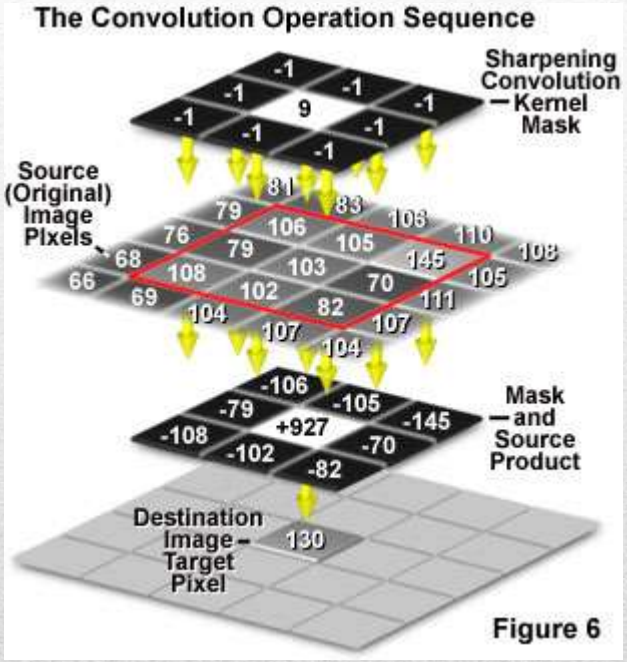
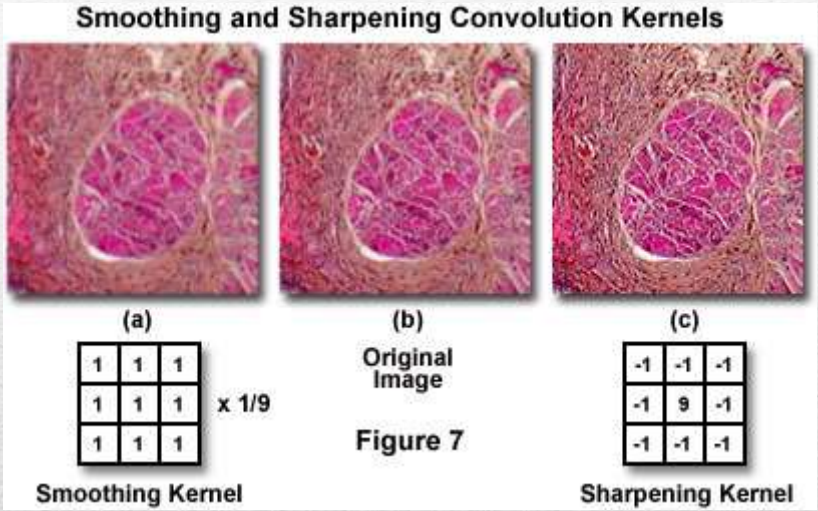
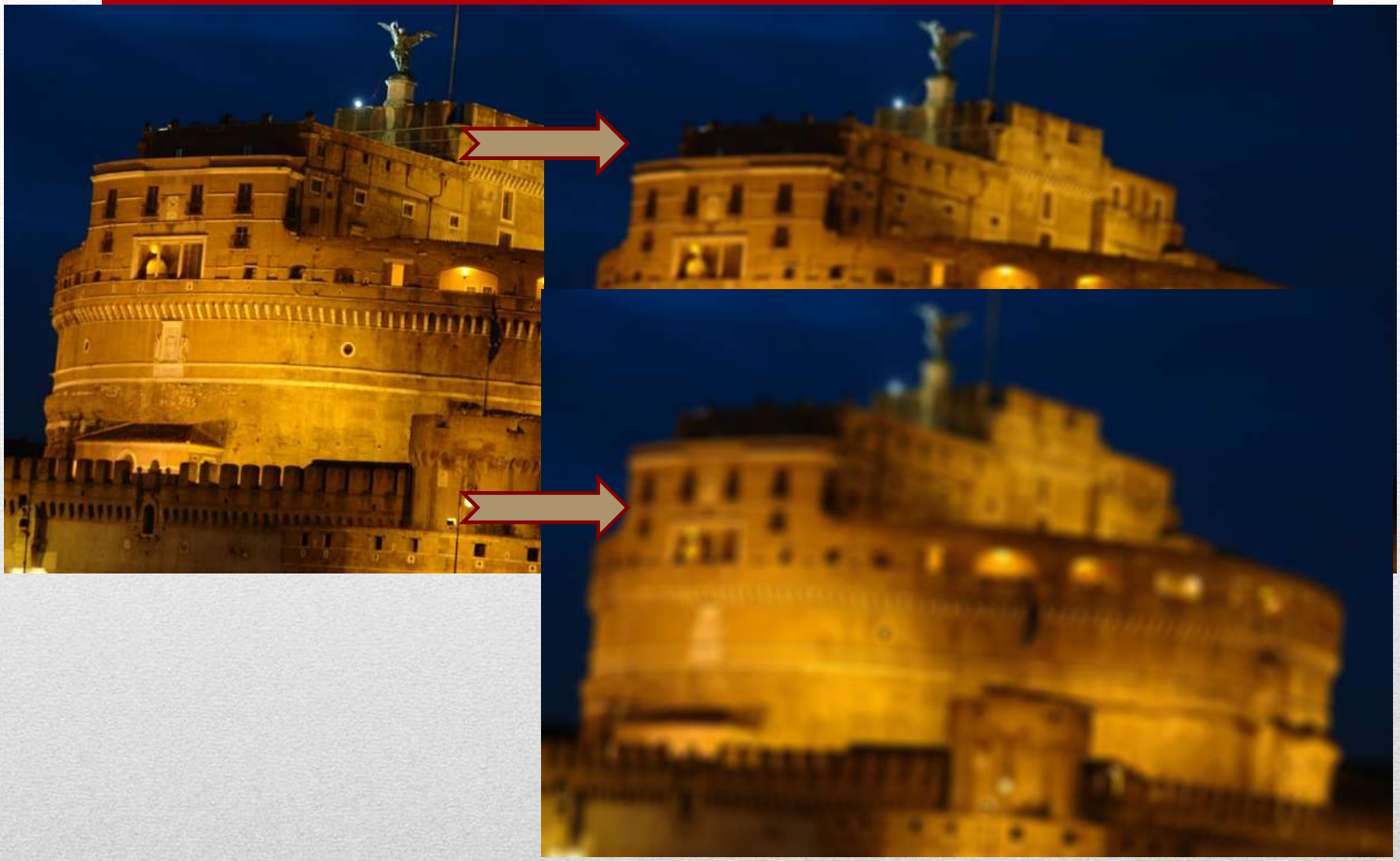


Image filtering

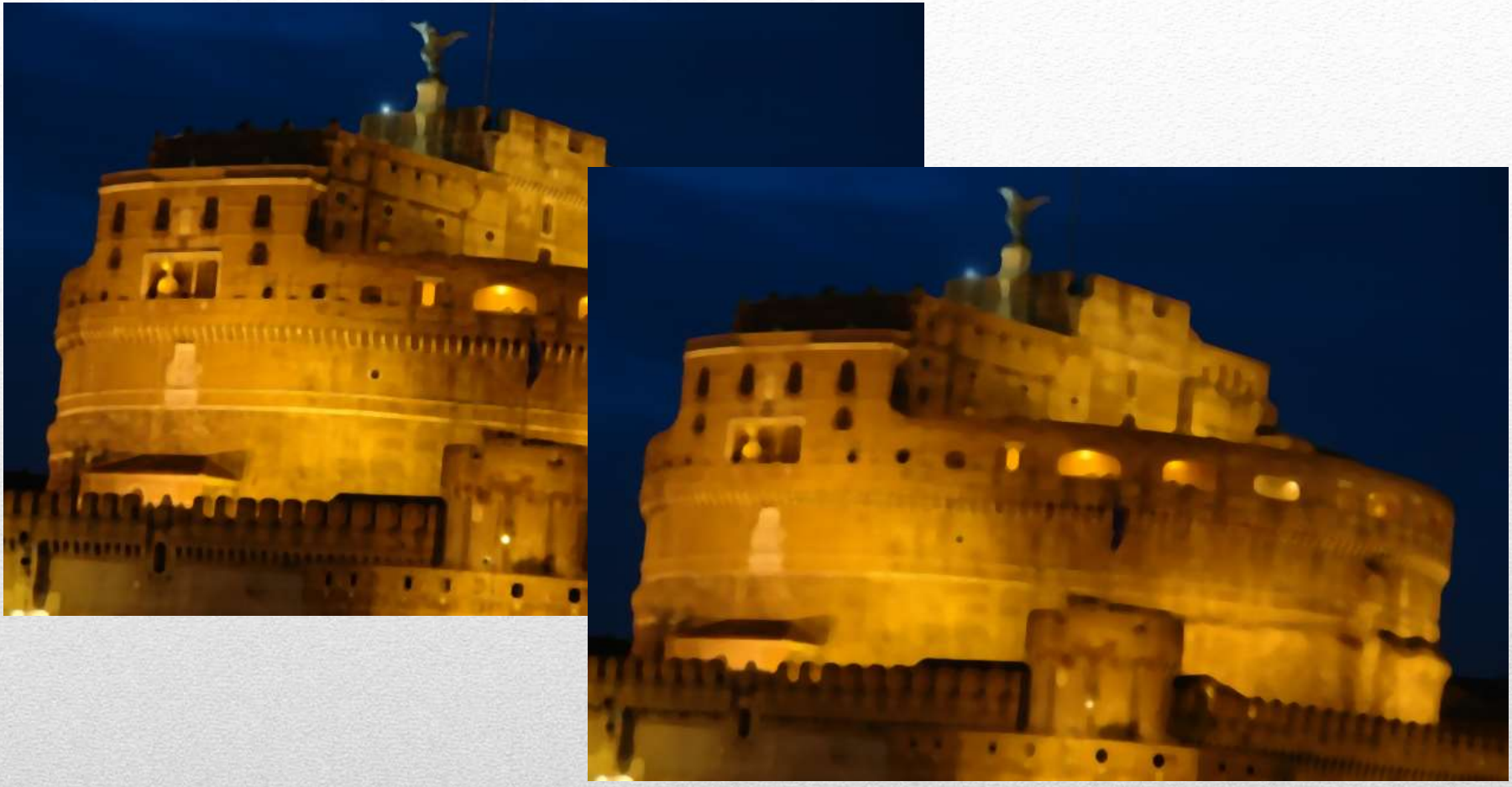




Convolution



Smoothing filter (mean)



Median-filter

Mean vs median filter

N=4,n=4

N=4,n=5

N=8,n=8

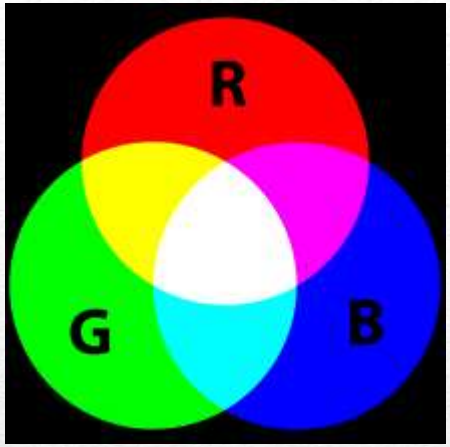
N=8,n=9

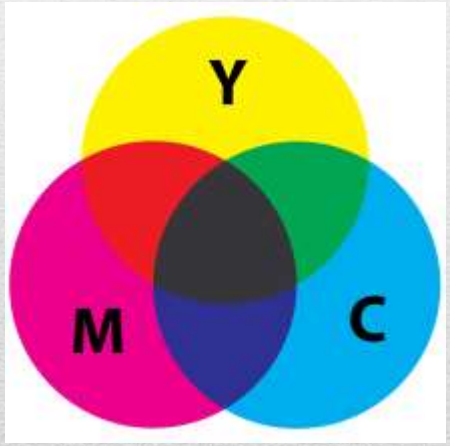
Laplace filtering

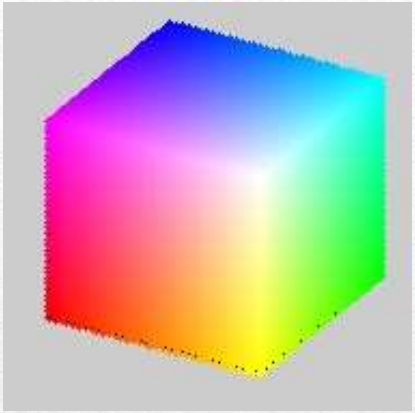
Find edges = Sobel filtering

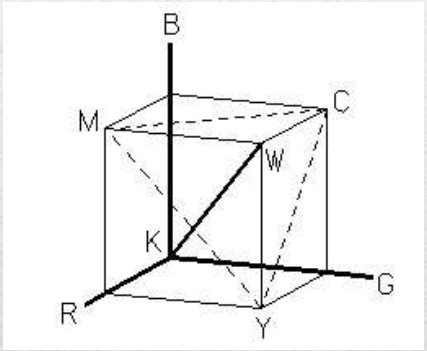
Color models

- Additive models
  - E.g. RGB
- Substractive models
  - E.g. CMY

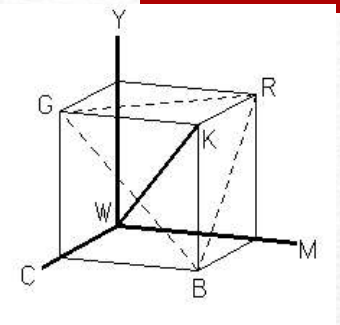




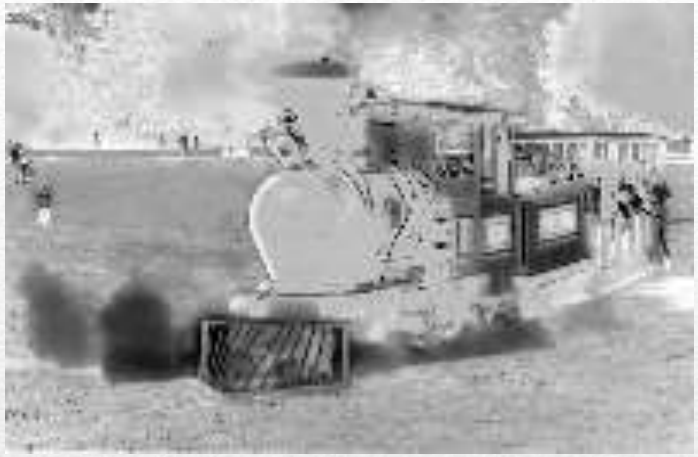




RGB model

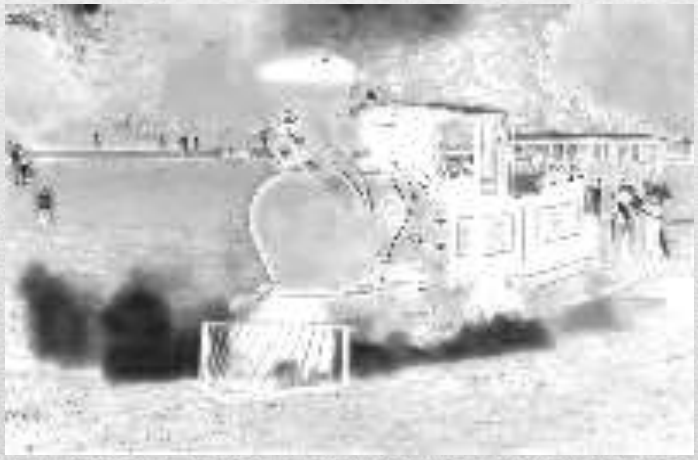


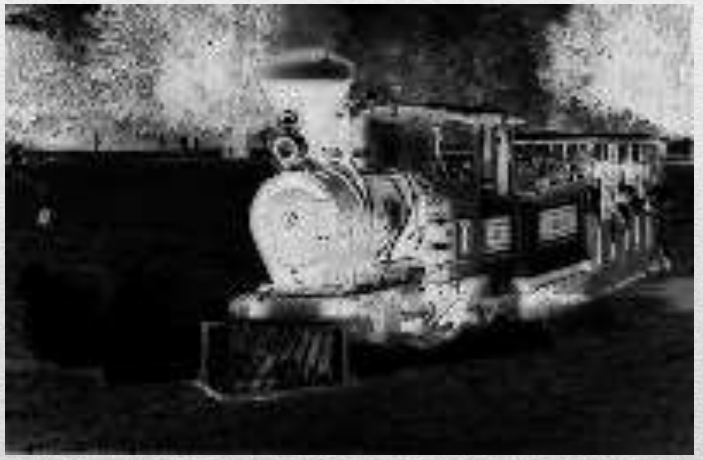
C



M

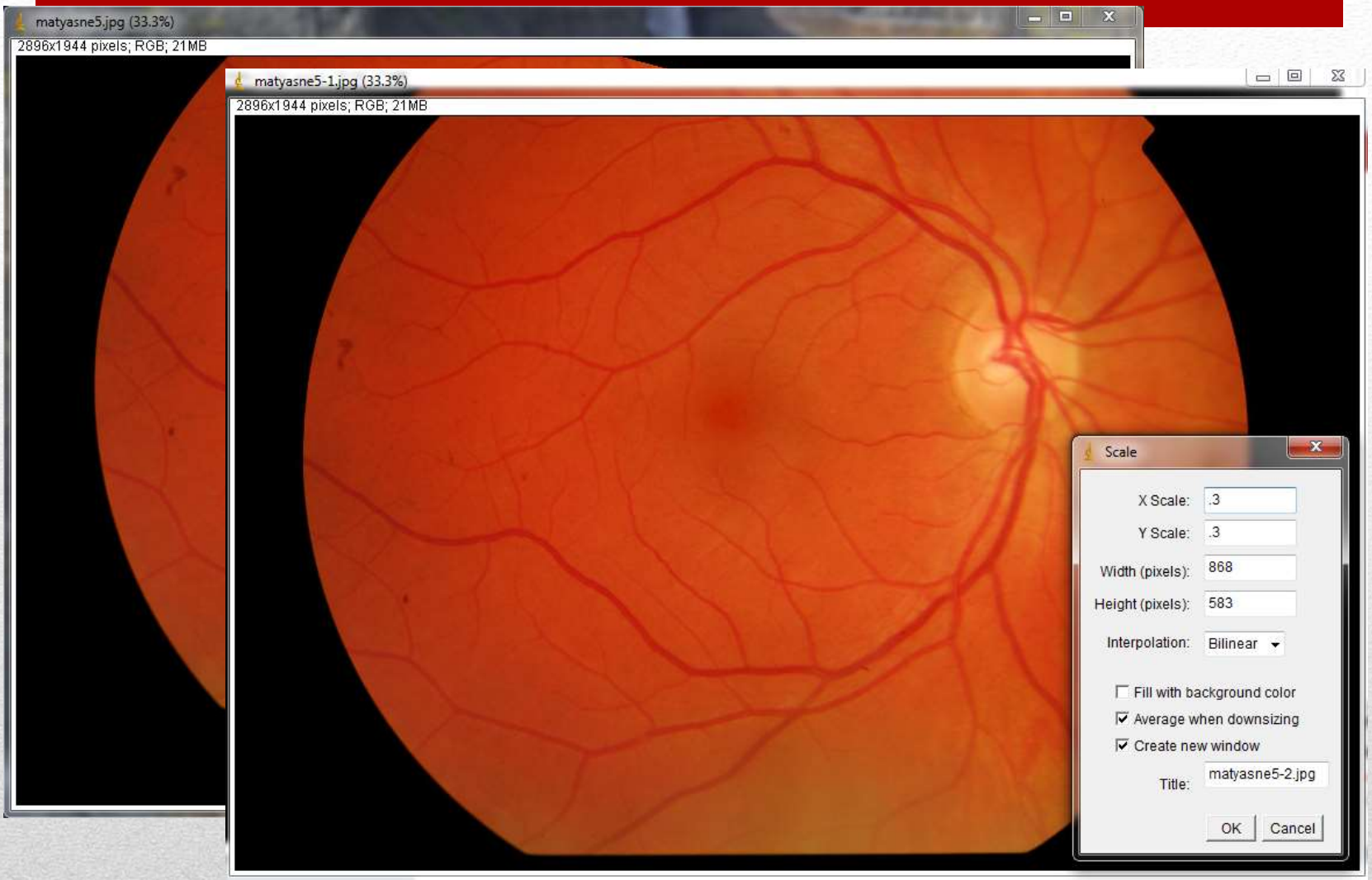
Y



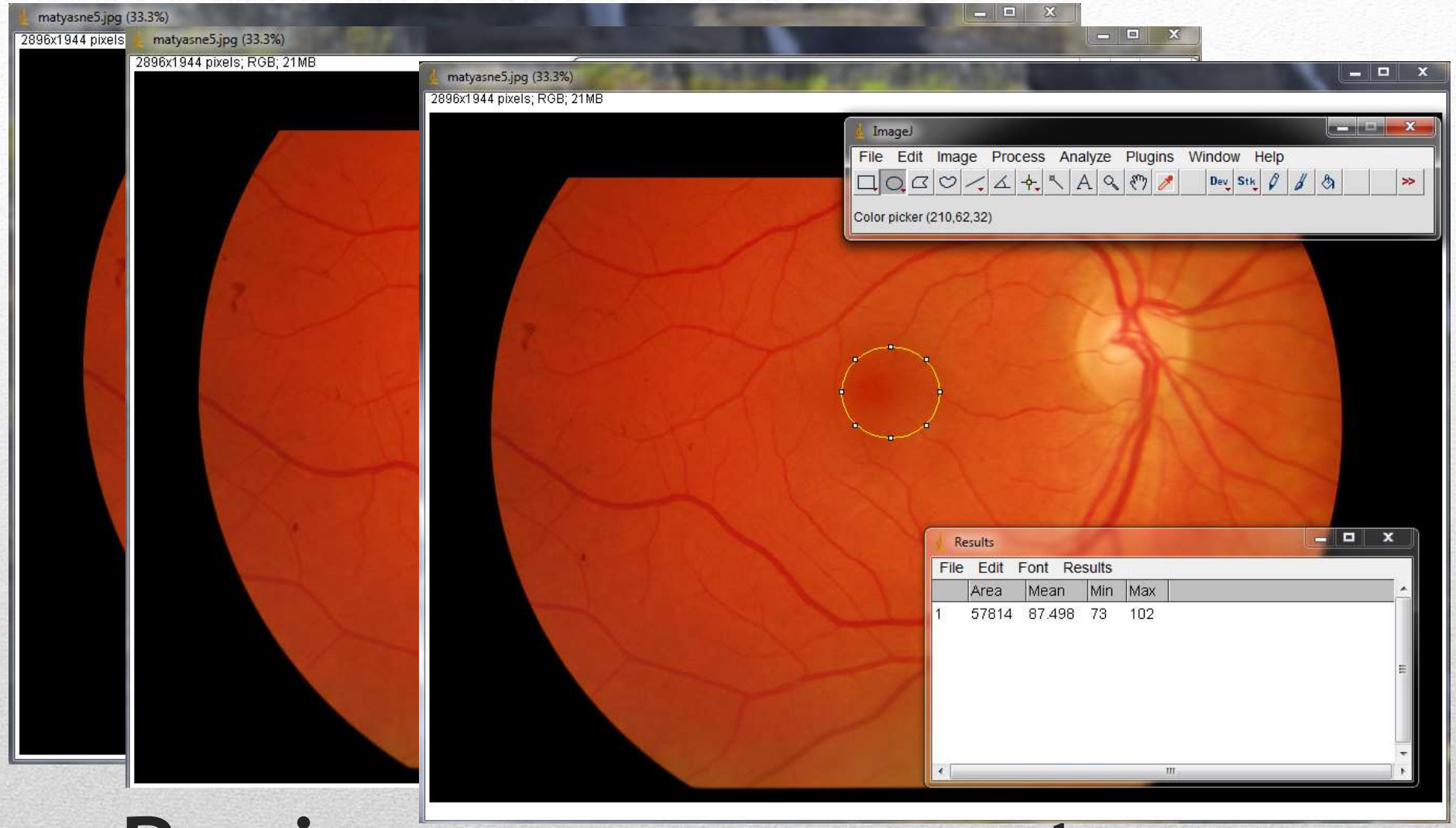


K

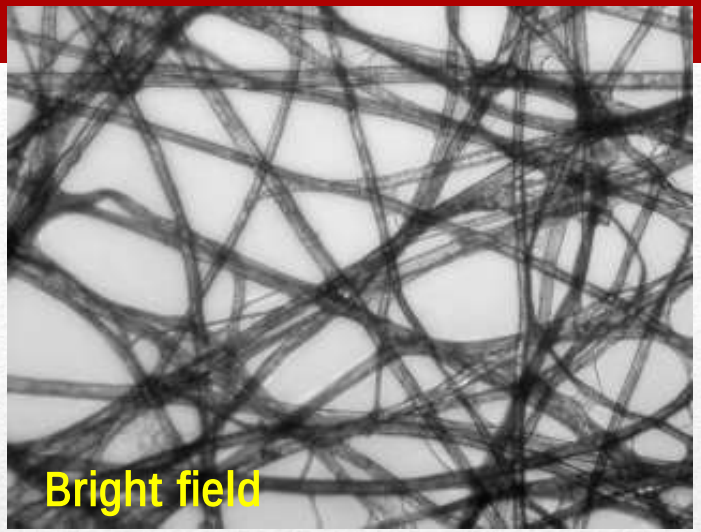
CMYK model

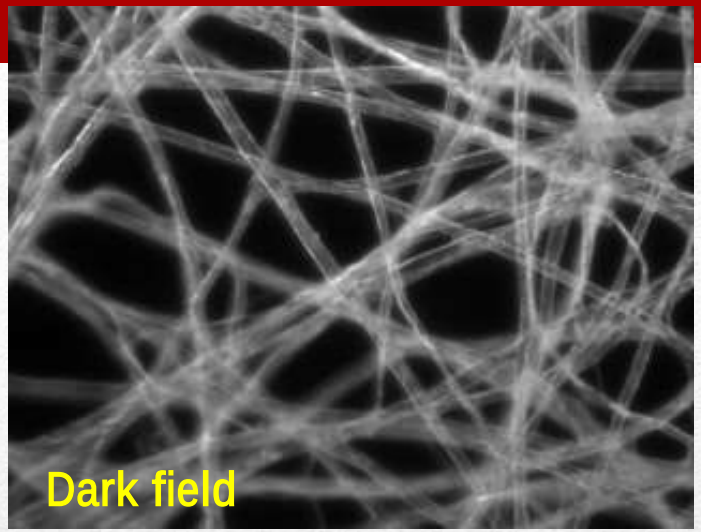


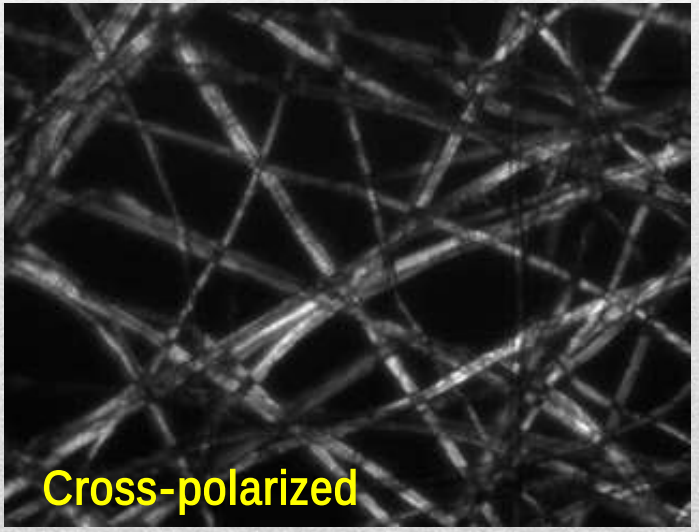
Geometric manipulations

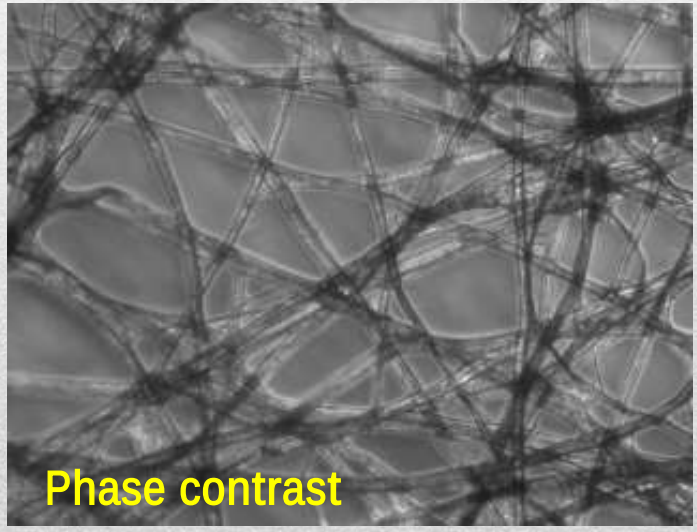


Basic measurements









Illumination techniques

To be continued…

Thanks for your attention!

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