DATA2001: Data

W5: Image Processing

Presented by
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School of IT

Book: Programming Computer Vision by Python by Jan Erik Solem

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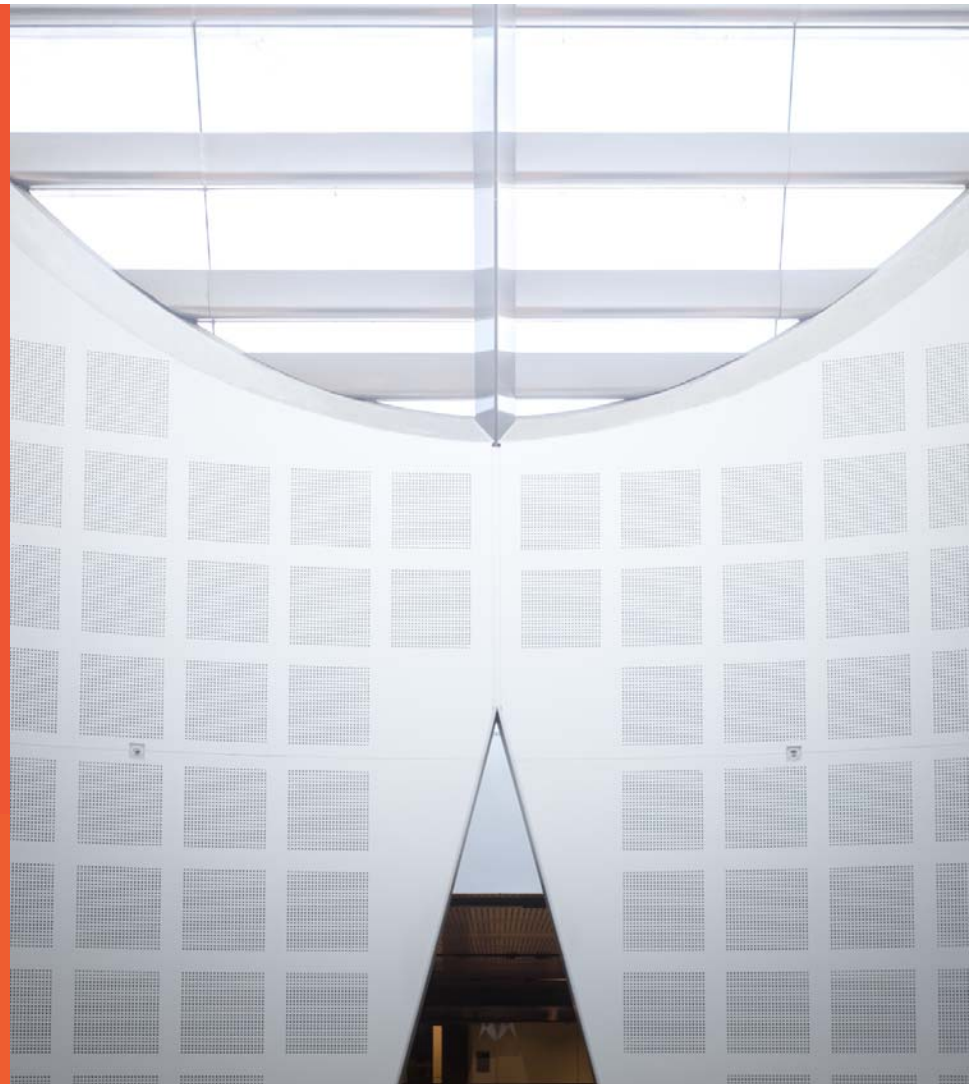


Image Data Processing / Analysis

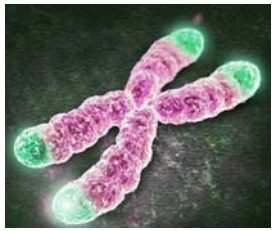
Image analysis is the extraction of meaningful information

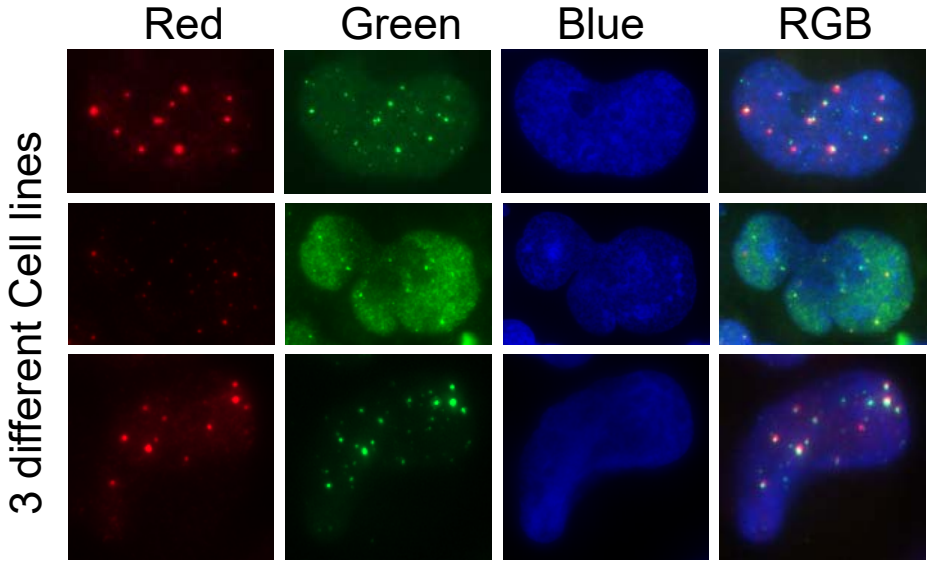
from images; mainly from digital images by means of digital image

processing techniques.

Use Case Scenarios

Use Case 1: Measurement of Proteins and Telomeres Colocalisation



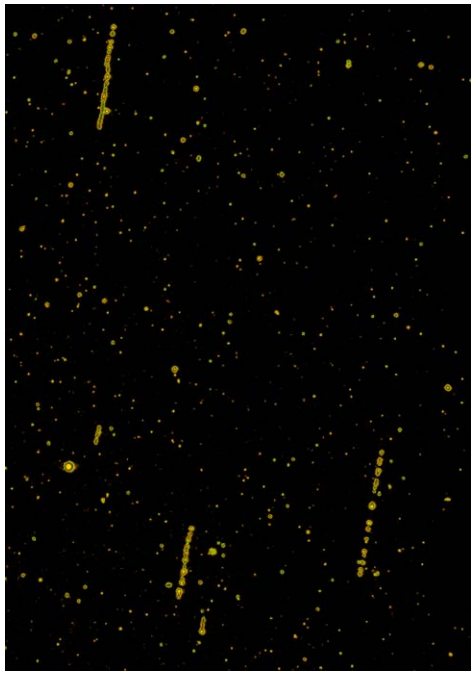


Khushi M. et. al. Sci Rep. 2017; 7: 8879

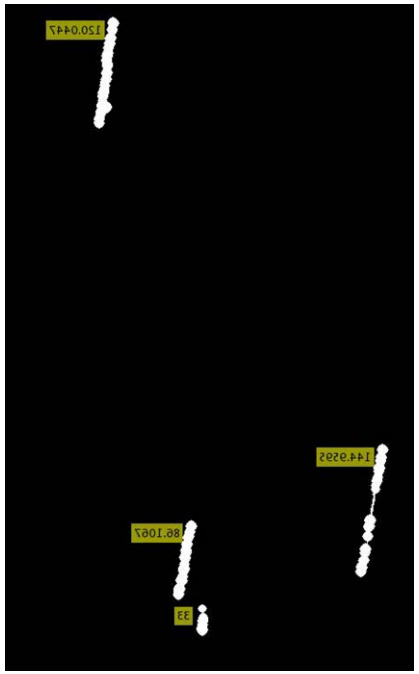
Use Case 2: Measurement of telomere lengths

- Broken telomeres within a specified range are automatically joined to address experimental artefacts.

Original image

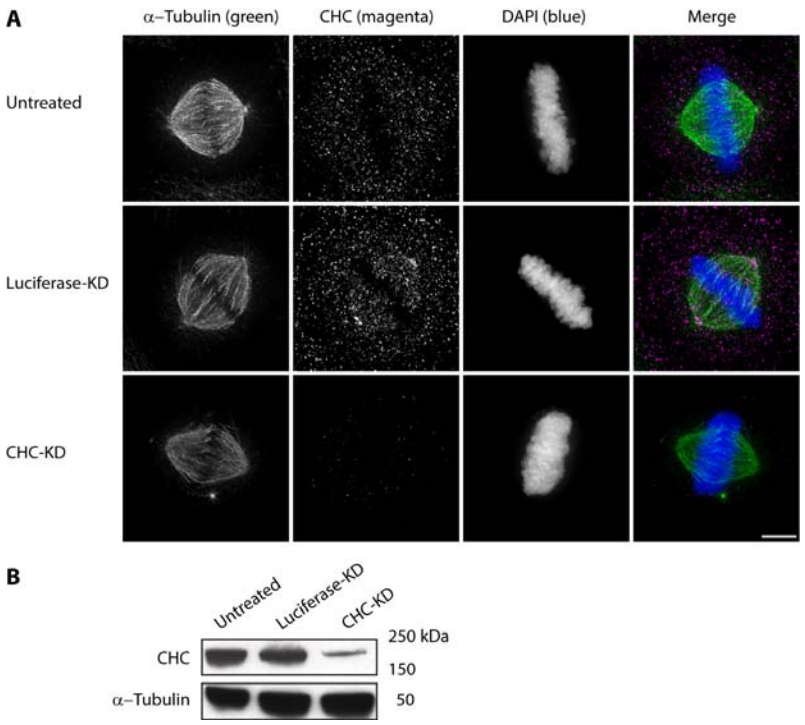


Segmented telomeres



Use Case 3: Quantification of DNA and Mitotic Spindles

- Untreated sample (control)
- Luciferase knockdown (-ve control)
- Clathrin heavy chain knockdown (CHC KD)



Khushi M. et al. BMC Bioinformatics. 2017; 18(Suppl 16): 566.

Image Data

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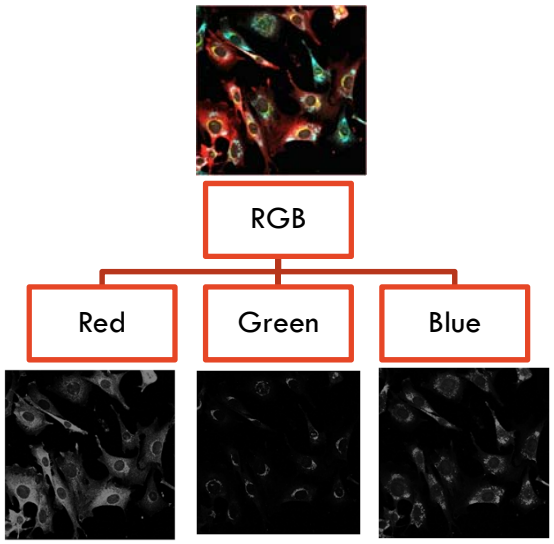
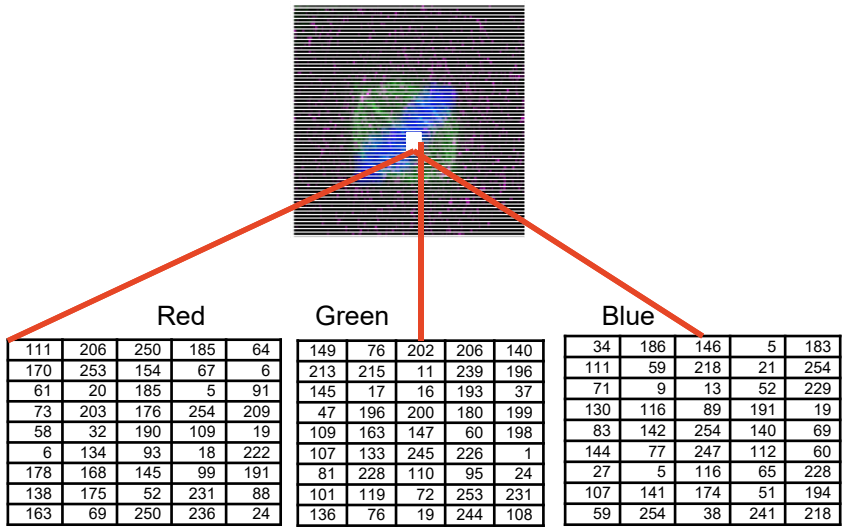
Types of Images

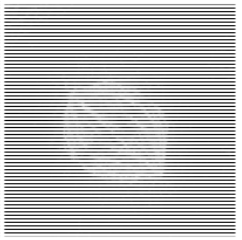
- **True Colour or RGB Image:** Each pixel has a particular color; that color is described by the amount of pixels in RGB channel (red, green and blue)





Types of Images

- **Gray-scale image**
  - Single channel
  - Each pixel is a shade of gray.



Types of Images

- **Binary image**
  - Each pixel is just black (0) or white (1)
  - Single channel
  - Referred as ‘mask’ in the image processing domain

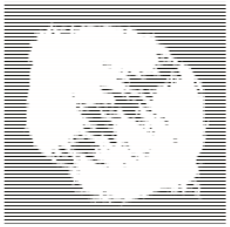


Image File Formats

- JPEG
- GIF
- PNG
- TIFF
- BMP
- Others…

Convert images to Another Format

```
from PIL import Image
import os

for infile in filelist:
  outfile = os.path.splitext(infile)[0] + ".jpg"
  if infile != outfile:
    try:
      Image.open(infile).save(outfile)
    except IOError:
      print "cannot convert", infile
```

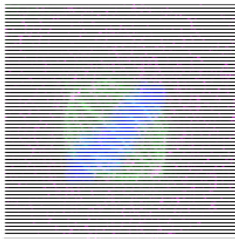
Aspects of Image Processing

- **Image Enhancement:** Processing an image so that the result is more suitable for a particular application. (sharpening or deblurring an out of focus image, highlighting edges, improving image contrast, or brightening an image, removing noise)
- **Image Restoration:** This may be considered as reversing the damage done to an image by a known cause. (removing of blur caused by linear motion, removal of optical distortions)
- **Image Segmentation:** This involves subdividing an image into constituent parts, or isolating certain aspects of an image. (finding lines, circles, or particular shapes in an image, in an aerial photograph, identifying cars, trees, buildings, or roads.

Data Analysis Using Images

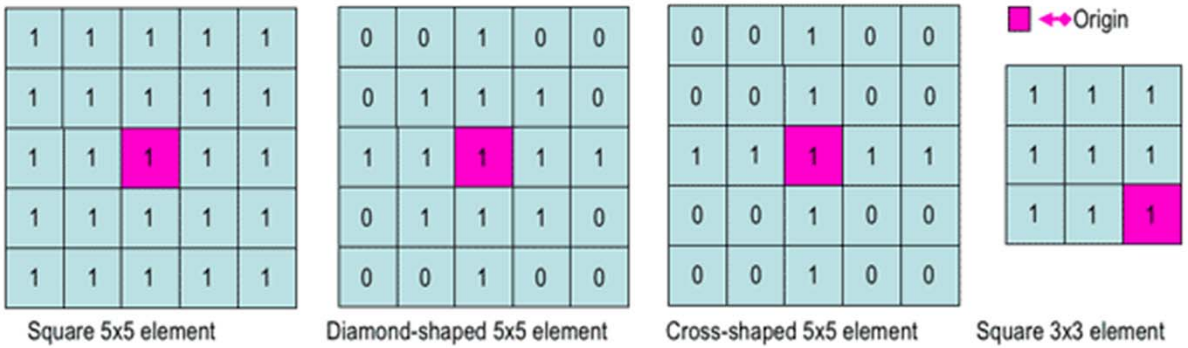
Usually image data analysis involve the following steps

- Removal of noise
- Extraction of region of interest (ROI) using binary mask
  - Image enhancement
    - Okay to extract ROI or shape features
    - Not-Okay for intensities-based analysis
- Measurements
  - Binary image
  - Greyscale intensities



Morphological Image Processing

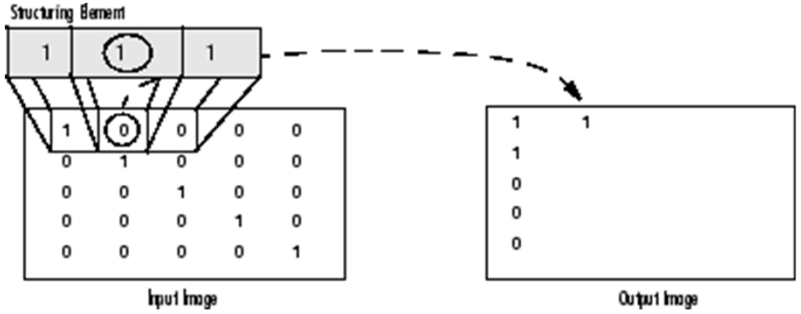
- Morphological techniques probe an image with a small shape or template called a **structuring element.**
- The **structuring element** is a small binary image, i.e. a small matrix of pixels, each with a value of zero or one



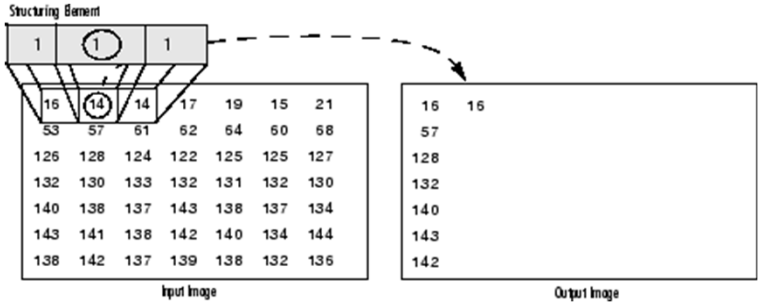
https://www.cs.auckland.ac.nz/courses/compsci773s1c/lectures/ImageProcessing-html/topic4.htm

Morphological Dilation

– The value of the output pixel is the maximum value of all the pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to the value 1, the output pixel is set to 1.



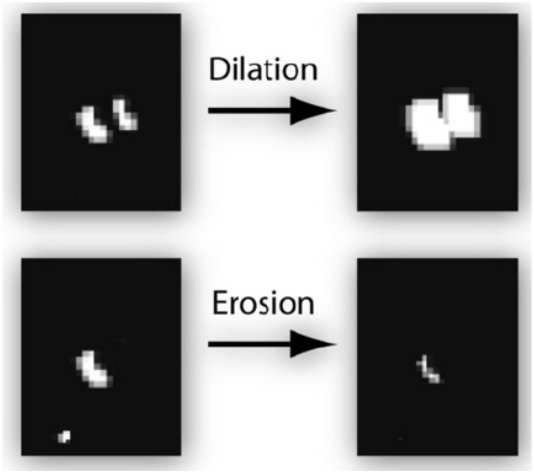
Dilation of a Binary Image



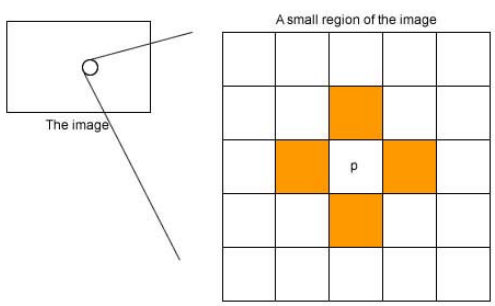
Dilation of a Grayscale Image

Morphological Erosion

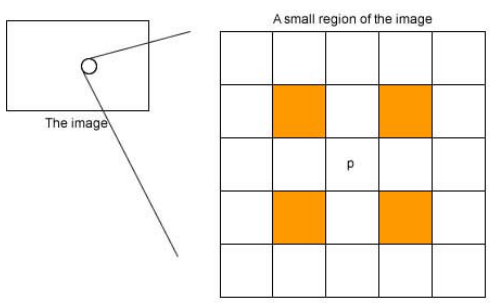
- The value of the output pixel is the *minimum* value of all the pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to 0, the output pixel is set to 0.



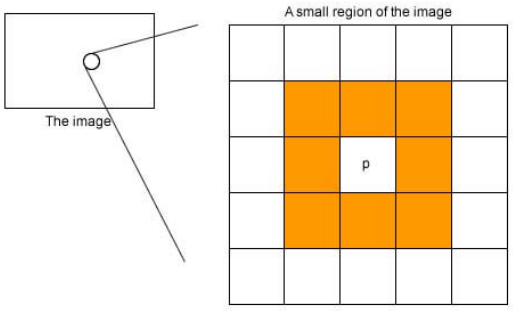
Neighbourhood of connected component



4-neighbourhood



d-neighbourhood



8-neighbourhood

Object Connectivity

– All the coloured pixels are "connected" to 'p'... or, they are 8-connected to p. However, only the green ones are '4-connected to p. And the orange ones are d-connected to p.

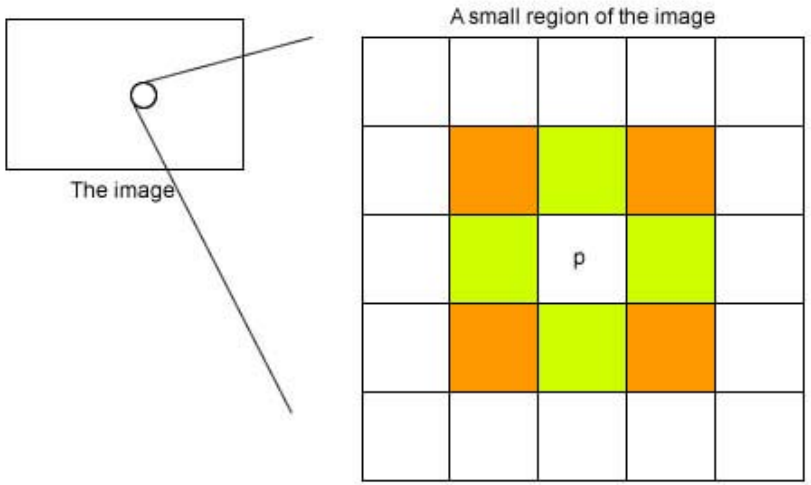
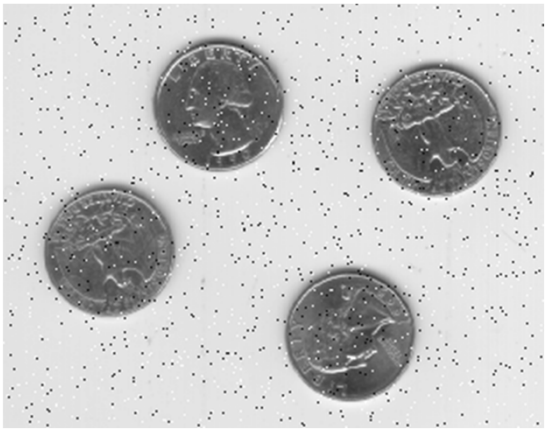
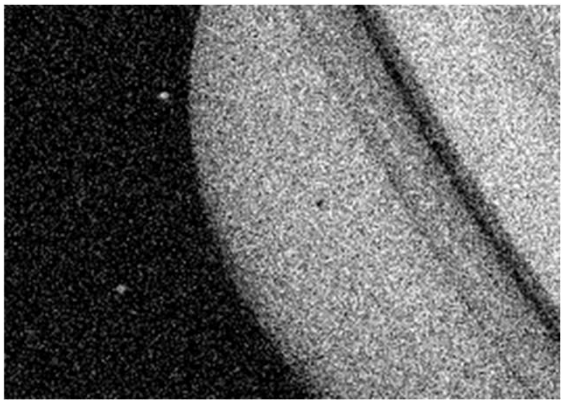


Image Enhancement

- Image denoising
- Point spread function (PSF)
- Gussain blurr



Salt & Pepper Noise
(median filter)



Gaussain Noise
(Adaptive Filtering, Wiener filter)

Digital filters

- In image processing filters are mainly used to suppress either the high frequencies in the image, *i*.e. smoothing the image, or the low frequencies, *i*.e. enhancing or detecting edges in the image.
  - Median filter
  - Average filter
  - Weiner filter
  - Spatial filter

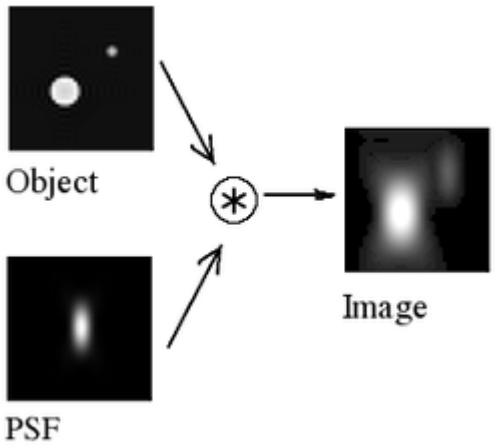
Dynamic Range

– The range of values spanned by the gray scale is called dynamic range of an image. Image will have high contrast, if the dynamic range is high and image will have dull washed out gray look if the dynamic range is low.

The first three images represent a high dynamic range scene. The fourth image is the result of a range compression.

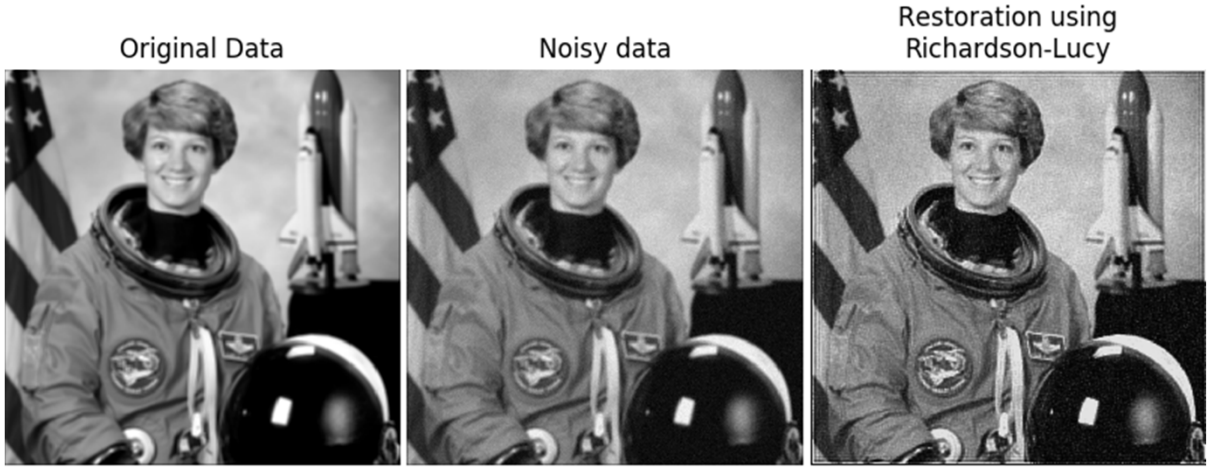
Point Spread Function (PSF) / Convolution

- PSF is described as the impulse response of the optical system. E.g. Diffraction of light, which determines the microscope's resolution limit, blurs out any point-like object to a certain minimal size and shape called the Point Spread Function (PSF).
- The captured image become convoluted.



Deconvolution

– Deconvolution is an algorithm-based process used to reverse the effects of convolution on an image.



ROI Segmentation by Thresholding and Histogram

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Thresholding

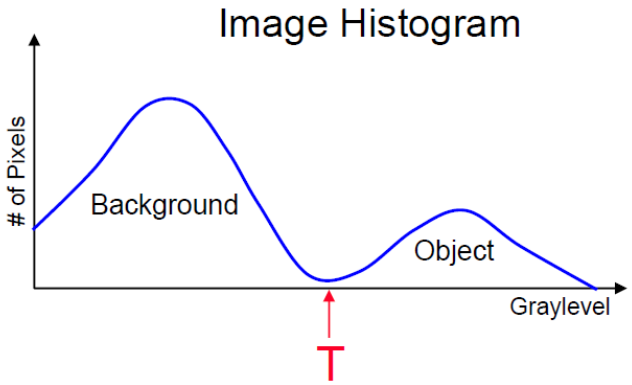
- Thresholding creates binary images from grey-level ones by turning all pixels below some threshold to zero and all pixels about that threshold to one.
- the separation of light and dark regions

If $g(x, y)$ is a thresholded version of $f(x, y)$ at some global threshold T,

$$g(x, y) = \begin{cases} 1 \text{ if } f(x, y) \geq T \\ 0 \text{ otherwise} \end{cases}$$

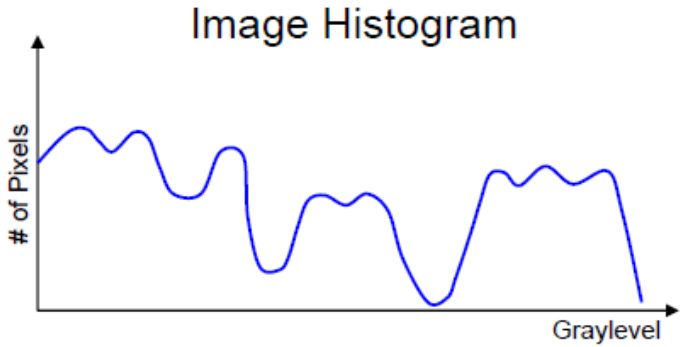
Thresholding Algorithms

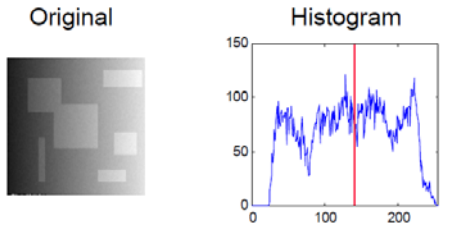
– Global thresholding choose threshold T that separates object from background

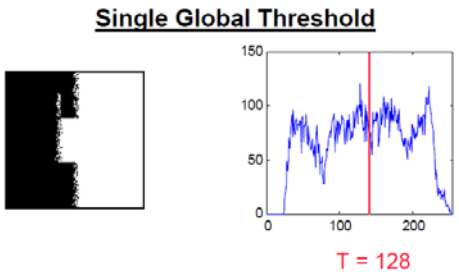


Thresholding issues

- Many objects at different gray levels
- Variations in background gray level
- Noise in image.

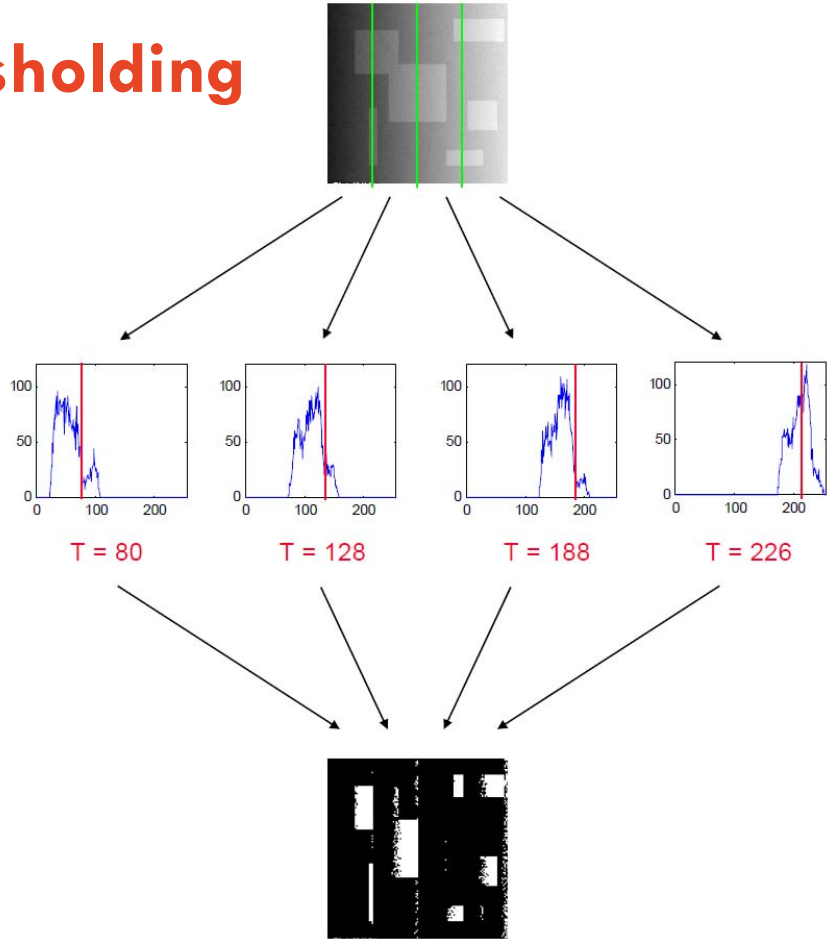






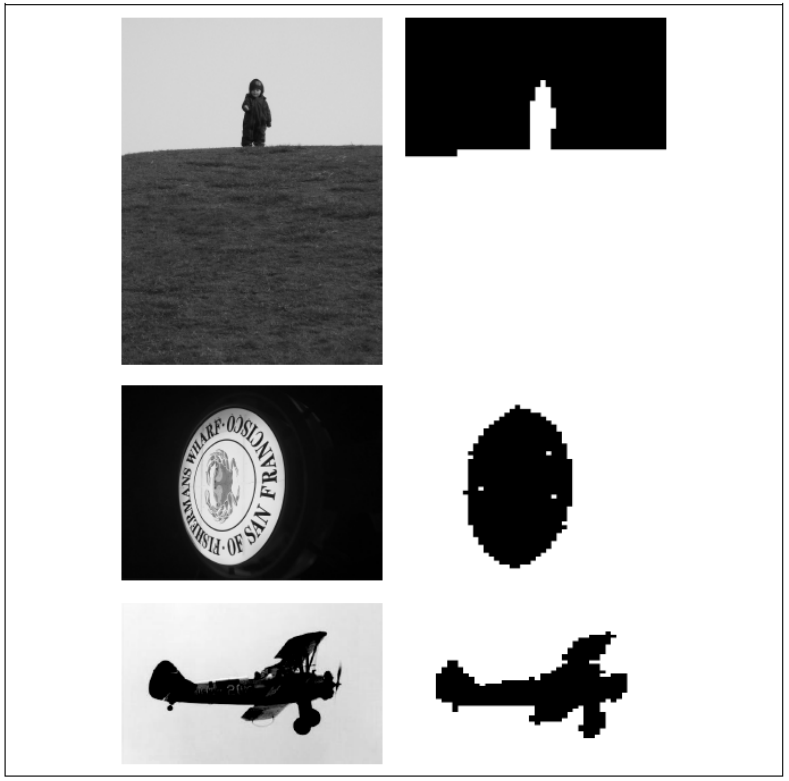
Global vs Adaptive/local thresholding

- Local threshold T(x, y) is calculated for each pixel, based on some local statistics such as range, variance, or surface-fitting parameters of the neighborhood pixels within a local block of size *wxw*.



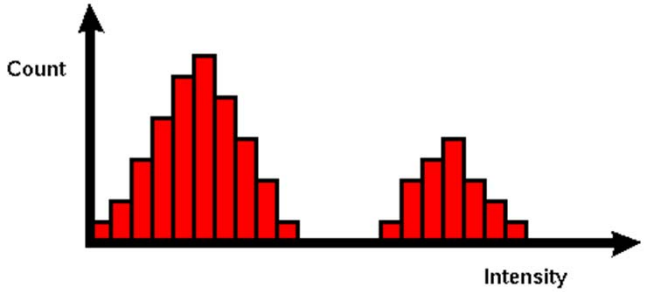
Binary Image Uses

- Object recognition
- Spatial location
- Size measurements
- Surveillance



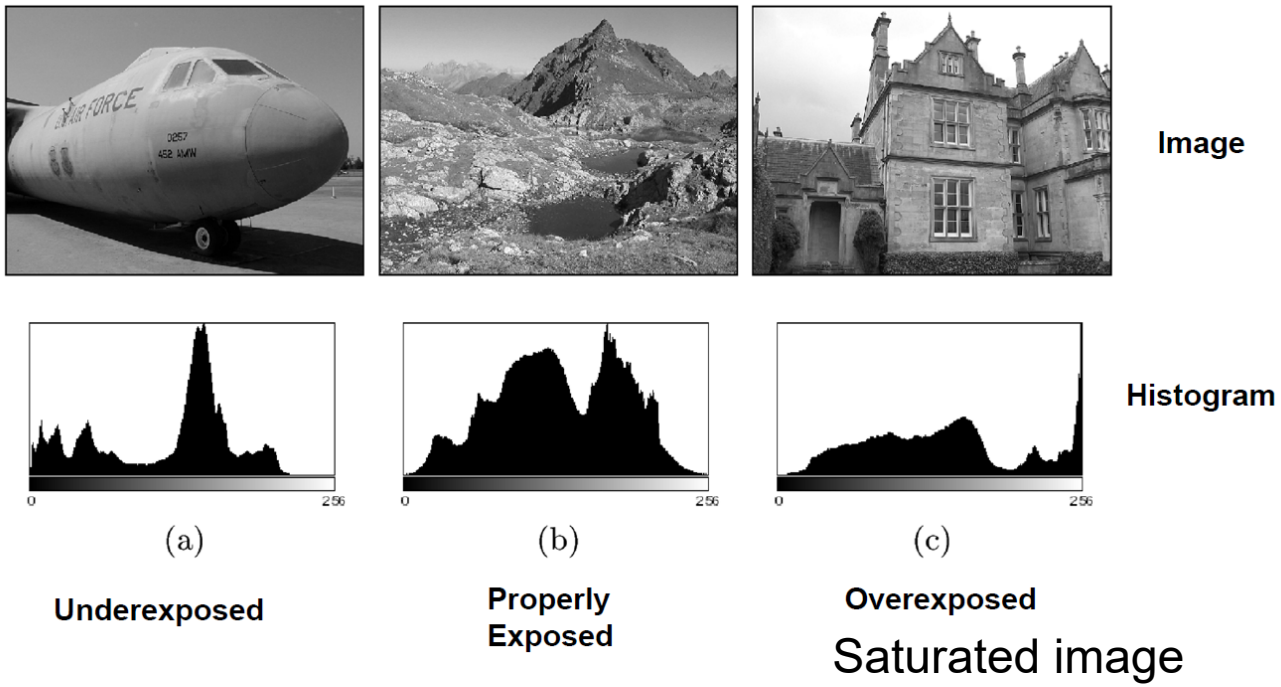
histogram of the pixel intensity values

- Histograms plots how many times (frequency) each intensity value in image occurs
- Different images can have same histogram
- Half of pixels are gray, half are white
  - same histogram = same statistics
- We can't reconstruct image from histogram



Detecting Bad Exposure using Histograms

– Exposure? Are intensity values spread out or saturated (overly bright colors)



References

- http://cs.haifa.ac.il/hagit/courses/ip/Lectures/Ip12_Segmentation.pdf
- http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/MORSE/threshold.pdf
- http://web.cs.wpi.edu/~emmanuel/courses/cs545/S14/slides/lecture02.pdf
- http://aishack.in/tutorials/pixel-neighbourhoods-connectedness/