Lecture 2, Point Processing
GW 3.1-3.4, Ida-Maria

Last Lecture
Digitization
- sampling in space \((x,y)\)
- sampling in amplitude (intensity)

Sample in space twice as often as the smallest detail you want to see

Image Processing

\[ f(x,y) \xrightarrow{T} g(x,y) \]

Original image \( f(x,y) \)
New image \( g(x,y) \)

- We want to create an image which is "better" in some sense.
- For example
  - Image restoration (reduce noise)
  - Image enhancement (enhance edges, lines etc.)
  - Make the image more suitable for visual interpretation
- Image enhancement does NOT increase image information

Image processing can be performed in the
- Spatial domain (lectures 2 and 3)
  - brightness transforms, works per pixel \(\rightarrow\) point processing
  - spatial filters, local transforms, works on small neighborhood.
- Frequency domain (lectures 4, 11 and 12)

greylevel transform

\[ r = T(s) = \text{greylevel out} \]

\[ s = \text{greylevel in} \]

\( r > 45^\circ \rightarrow \text{increased contrast} \)
\( r < 45^\circ \rightarrow \text{decreased contrast} \)
\( \text{up} \rightarrow \text{increased brightness} \)
\( \text{down} \rightarrow \text{decreased brightness} \)

- change the greylevel for each individual pixel
- compare to TV:
  - brightness: addition
  - contrast: multiplication

brightness: subtract
add

\[ \text{grey level} \]
\[ \text{white level} \]
\[ \text{black level} \]
contrast: multiply

Image histograms
- A grey scale histogram shows how many pixels there are at each intensity level.

Gray-level transformations

Log transformation to visualize patterns in the dark regions of an image
**Histogram Equalization**

Idea: create an image with evenly distributed greylevels, for visual contrast enhancement

- the normalized grey-level histogram gives the probability for a pixel to have a certain greylevel
- Transform the image using the cumulative normalized histogram
- The histogram for the output image is uniform (THEORETICALLY! continuous case), why not in our case with digital images?

**More Examples of Histogram Equalization**

Transformations for image 1-4. Note that the transform for figure 4 (dashed) is close to the neutral transform (thin line).

**Histogram Equalization is not always “optimal” for visual quality**

Original image | Image after histogram equalization | Image after manual choice of transform

(image from GW, the Mars moon Phobos)

**Local Histogram Equalization**

**Arithmetic/Logical Operations**

- Information from two different images with the same size can be combined by adding, subtracting, multiplying or comparing the pixel values, pixel by pixel.
- For enhancement, segmentation, change detection
Reduction of noise by averaging

Noise can be reduced by observing the same scene over a long period of time, and averaging the images.

Image from GW, averaging 8, 16, 64 and 128 times.