Technical University of Lodz
Institute of Electronics

Piotr M. Szczypiński

Image Processing and Computer Graphics
1. ENHANCEMENT

Przetwarzanie obrazów i grafika komputerowa
1. POPRAWA JAKOŚCI

Abstract

Image enhancement methods are to improve the quality and the information content of original data before viewing or processing. Here we focus on software methods applicable to digitally stored images.

The lecture covers issues related to pixel-wise contrast enhancement, selected linear and nonlinear filtration methods and methods based on mathematical morphology.

Image resampling methods, including down- and up-sampling are presented. In downsampling we focus on the aliasing problems and understanding of sampling theorem and its application. In upsampling we apply and compare several interpolation algorithms.

Streszczenie

Metody poprawy jakości obrazu mają na celu poprawę jakości i zawartości informacji w oryginalnych danych przed ich wizualizacją lub dalszymi etapami przetwarzania. Skupiamy się na metodach komputerowych mających zastosowanie do obrazów cyfrowych.

Wykład obejmuje zagadnienia związane z poprawą kontrastu, wybranymi liniowymi i nieliniowymi metodami filtracji oraz metodami opartymi na morfologii matematycznej.

Przedstawiono metody skalowania obrazów cyfrowych, w tym decymacji i interpolacji. W pierwszym przypadku skupiamy się na problemach aliasingu i zrozumieniu twierdzenia o próbkowaniu. W drugim porównujemy sposób i wyniki działania wybranych algorytmów interpolacji.

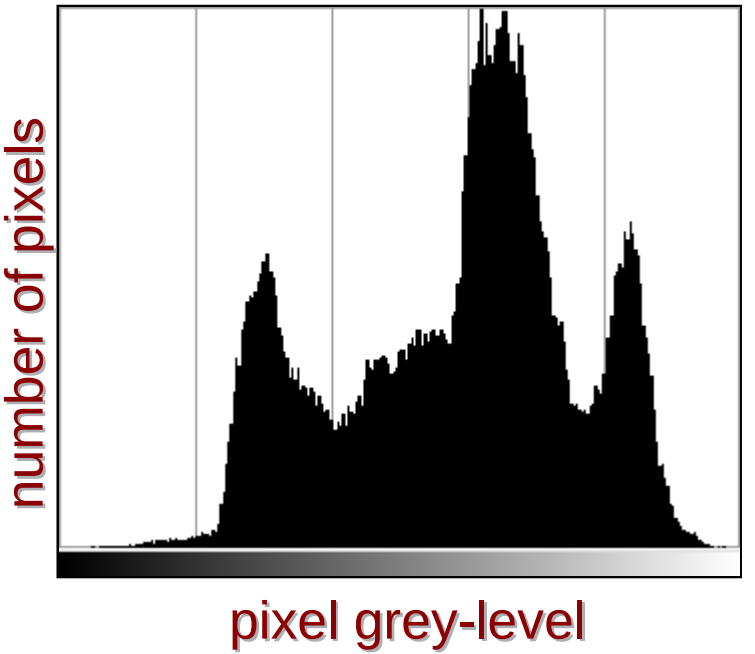
Problem

Image enhancement belongs to image preprocessing methods. Its goal is to process the image so that it is better suited for viewing, further processing or analysis.

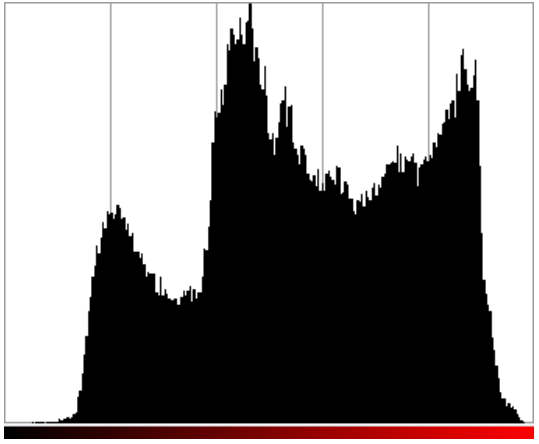
In viewing image enhancement methods are applied to increase some subjective image quality criteria. Applied for processing and analysis they form image data to better suit the requirements of the following computer algorithms.

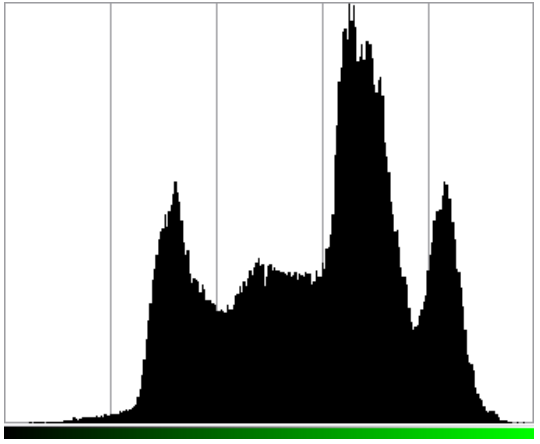
Pixel-wise and histogram
Punkowe, histogramowe

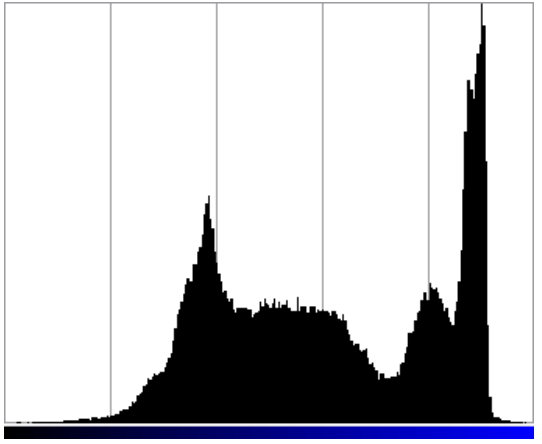
Image histogram – count of...



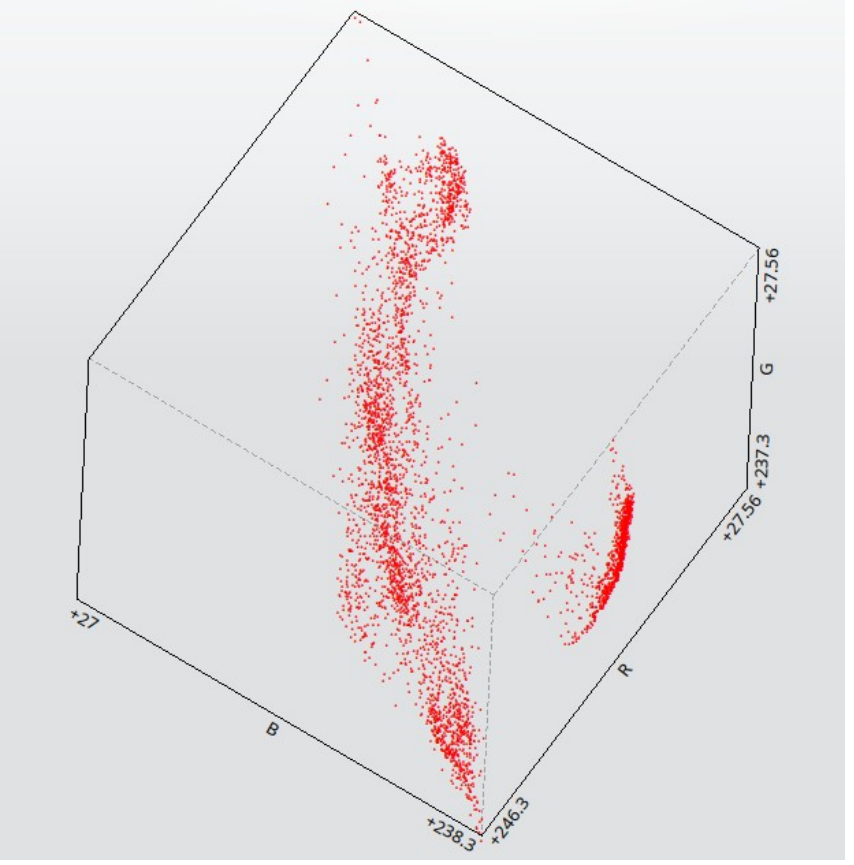
?



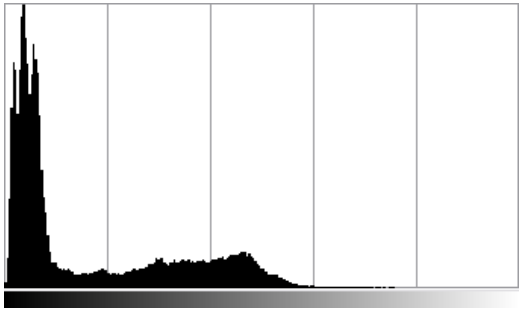


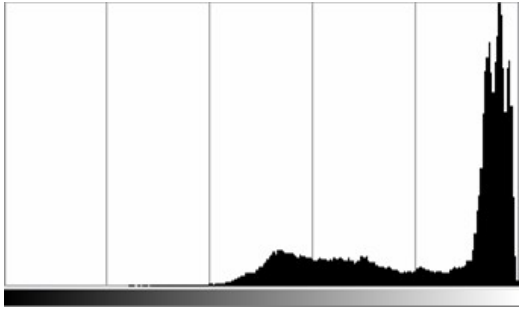


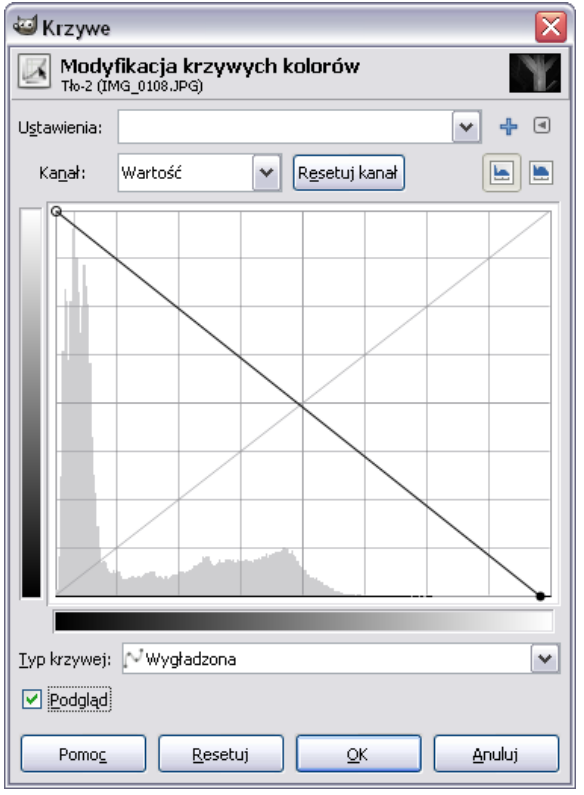
Where is a blue sky?



Inversion (negative) and transfer function

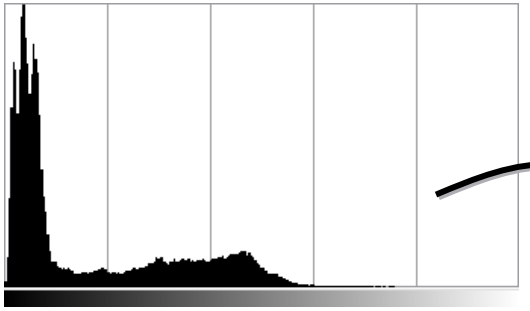


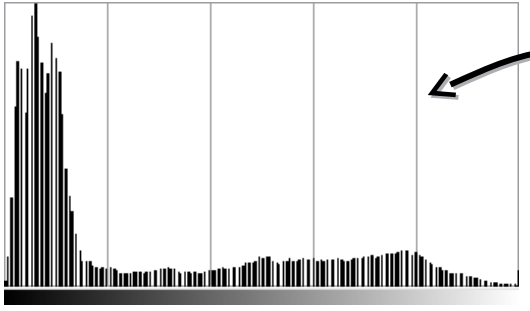


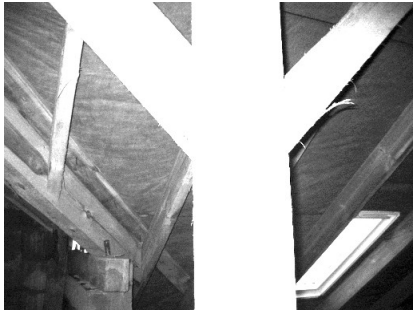


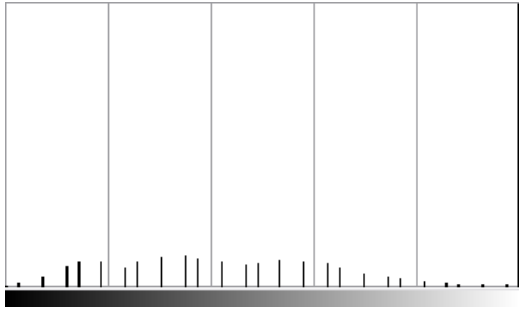
```
#! /usr/bin/python

import cv2
img = cv2.imread('./image.jpg', cv2.IMREAD_GRAYSCALE)
height, width = img.shape

for y in range(0, height-1):
    for x in range(0, width-1):
        img[y][x] = 255 - img[y][x]

cv2.imshow('window', img)
cv2.waitKey(2000)
cv2.destroyAllWindows()
```

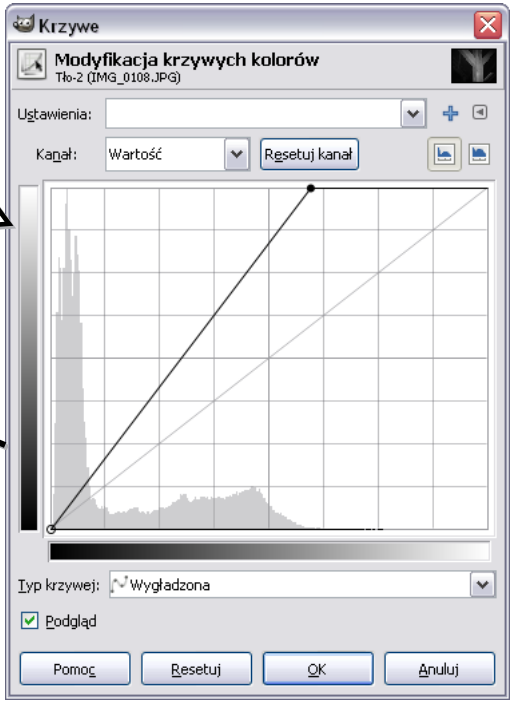
cv2.CV_LOAD_IMAGE_GRAYSCALE









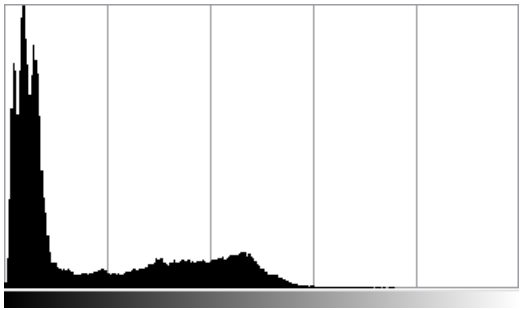


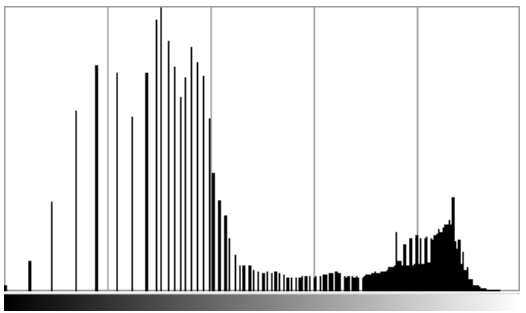
Made with GIMP

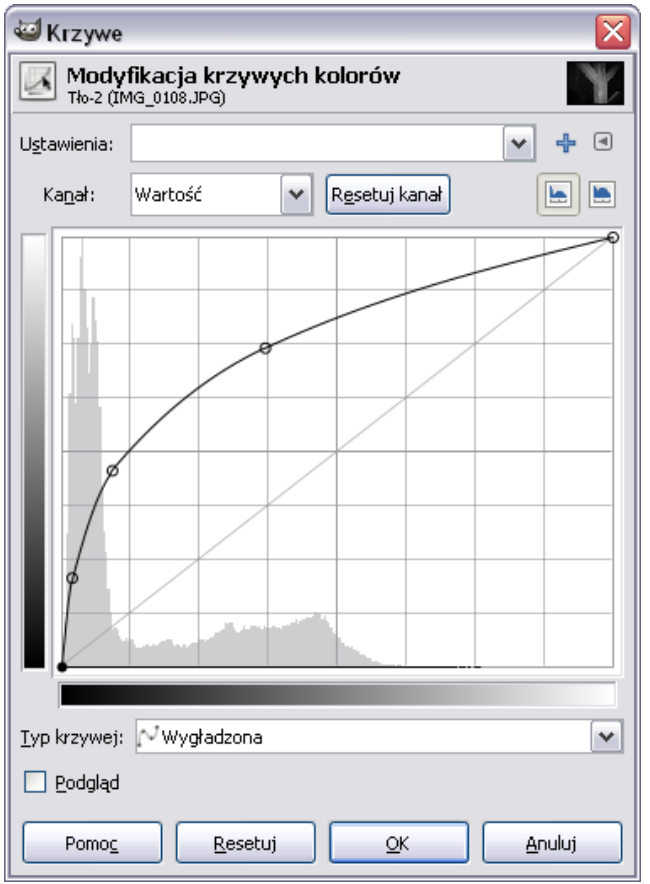
Is it linear or nonlinear?

Is it pixel-wise?

Background or foreground?







Gamma correction:

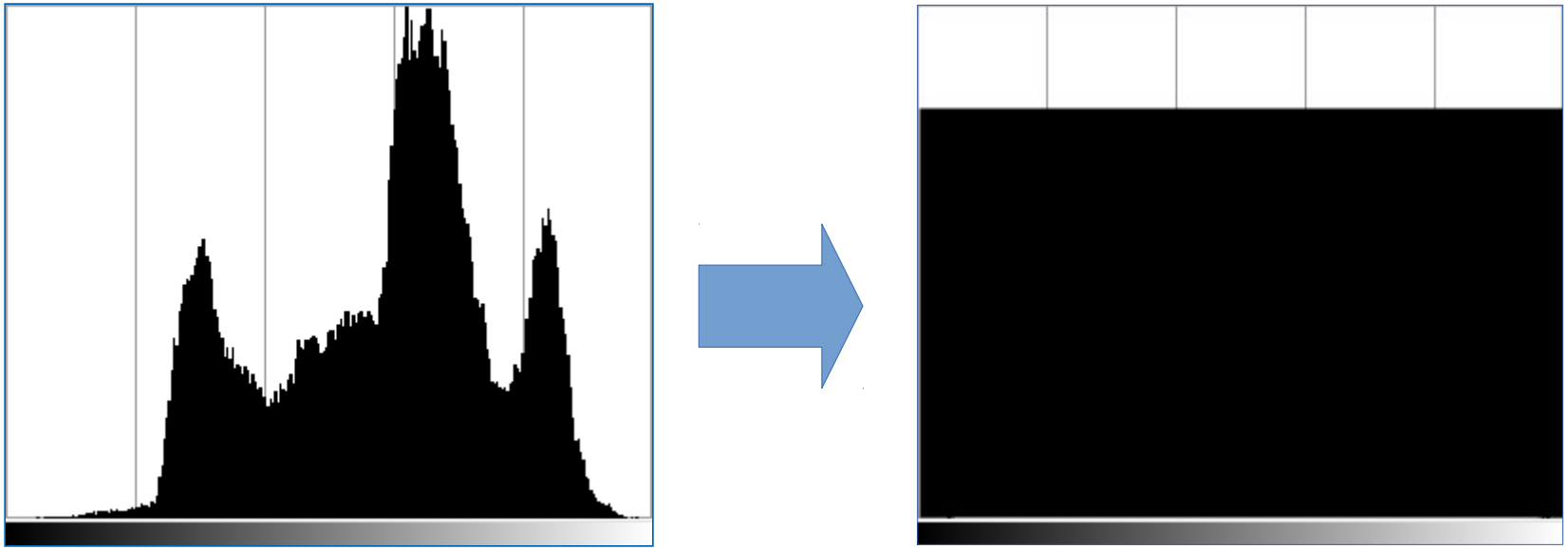
$$I_{OUT}(i, j) = I_{IN}^{\gamma}(i, j)$$

$$I_{IN} \in \langle 0, 1 \rangle$$

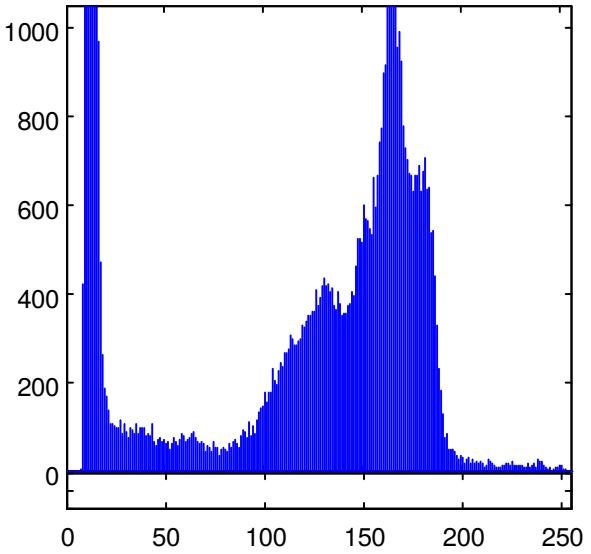
Linear or nonlinear?

https://en.wikipedia.org/wiki/Gamma_correction

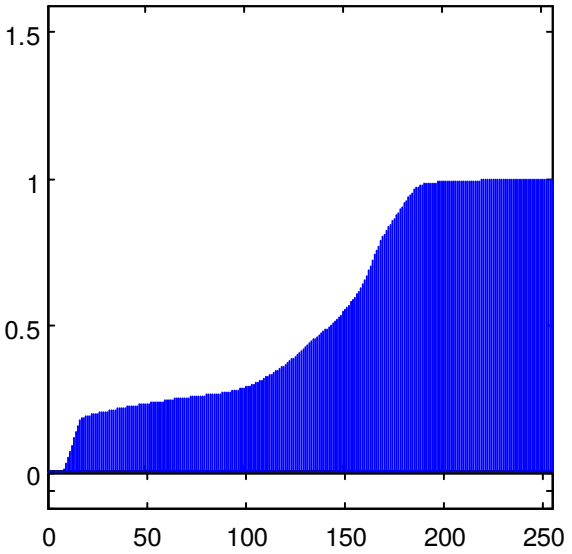
Histogram equalization



Histogram equalization aims at obtaining uniform statistical distribution of image gray levels (uniform probability density function)

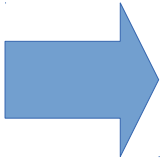


Histogram



Cumulative histogram

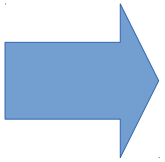
https://en.wikipedia.org/wiki/Cumulative_distribution_function
https://www.youtube.com/watch?v=4W7Z-QkGz2Q

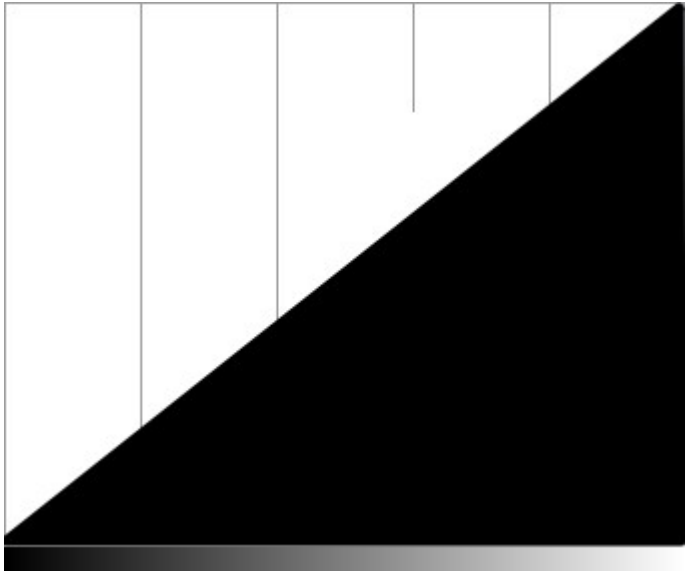


?

Histogram

Cumulative histogram

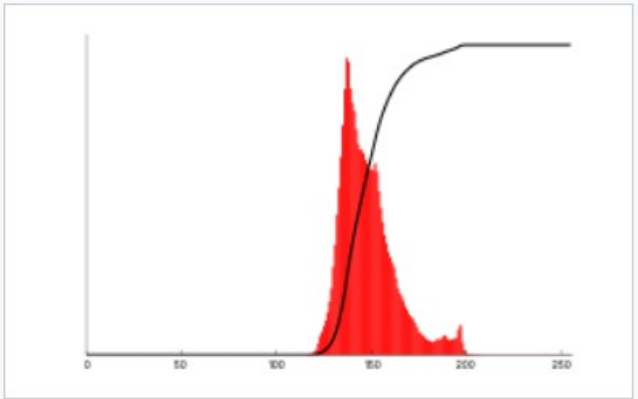




Histogram

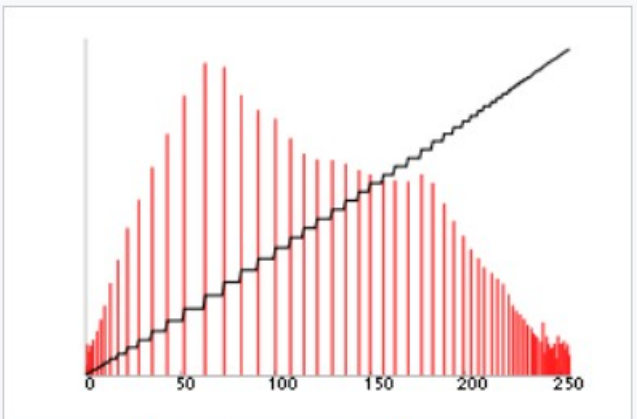
Cumulative histogram

Before Histogram Equalization



Corresponding histogram (red) and cumulative histogram (black)

After Histogram Equalization



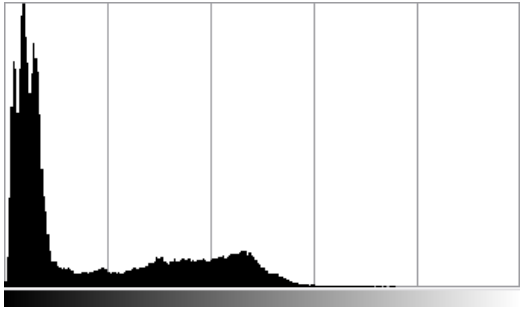
Corresponding histogram (red) and cumulative histogram (black)

What is a transfer function?
Is it pixel-wise?
Is it linear or nonlinear?

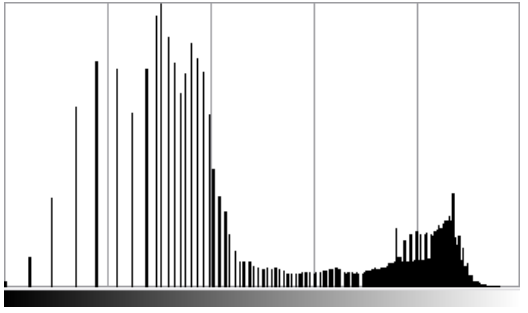
https://en.wikipedia.org/wiki/Histogram_equalization

```
#! /usr/bin/python

import cv2
img = cv2.imread('./image.jpg', cv2.IMREAD_GRAYSCALE)
cv2.namedWindow('original')
cv2.namedWindow('equalized')
cv2.imshow('original', img)

equ = cv2.equalizeHist(img)

cv2.imshow('equalized', equ)
cv2.waitKey(2000)
cv2.destroyAllWindows()
```

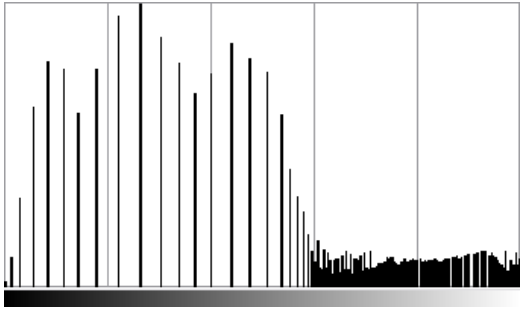
Original image



Gamma corrected

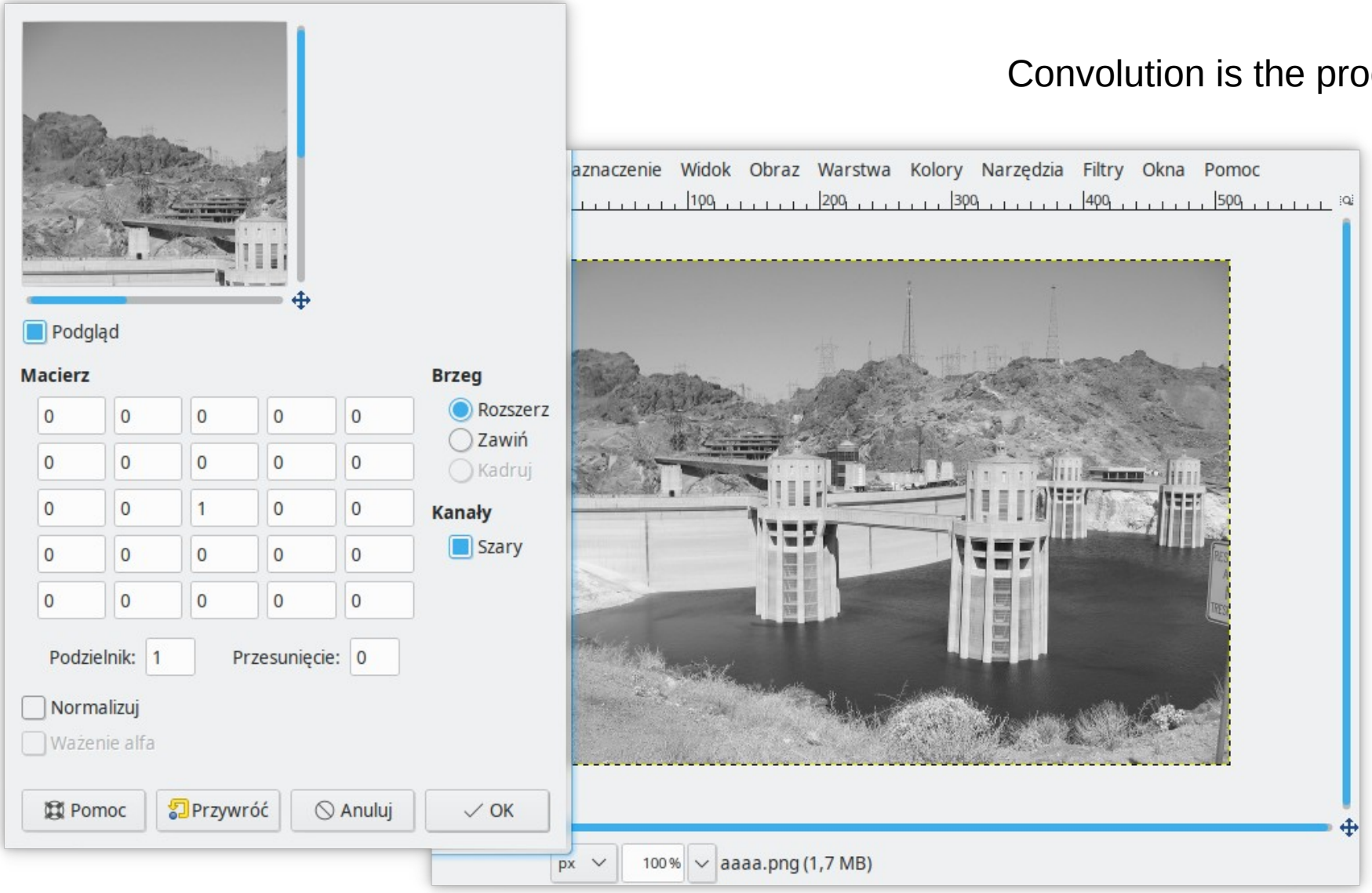


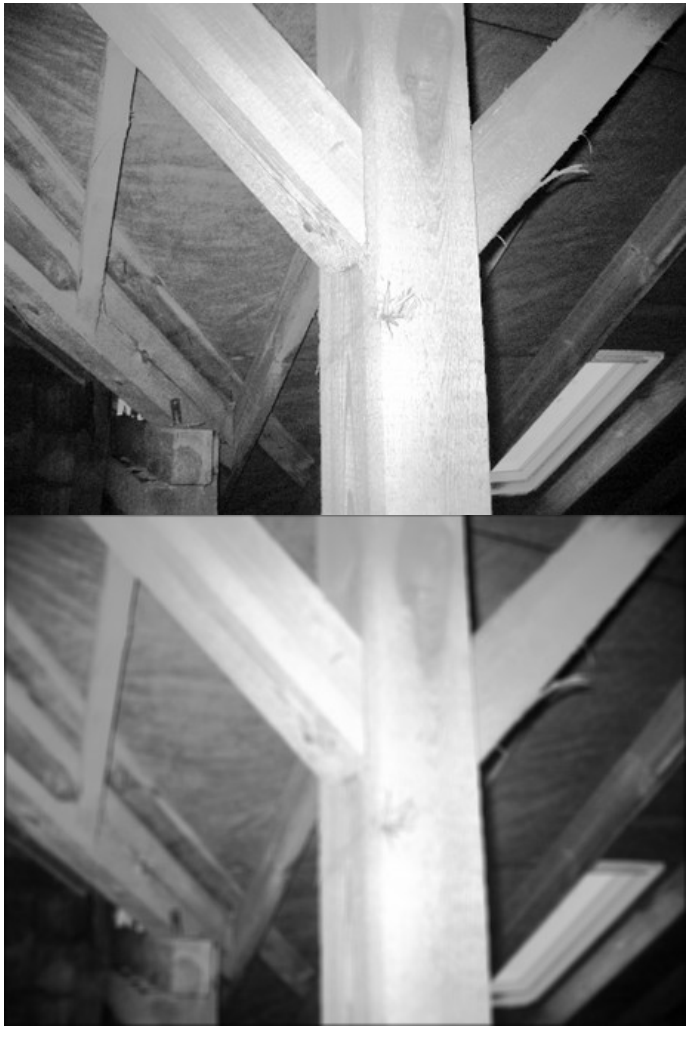
Histogram equalized

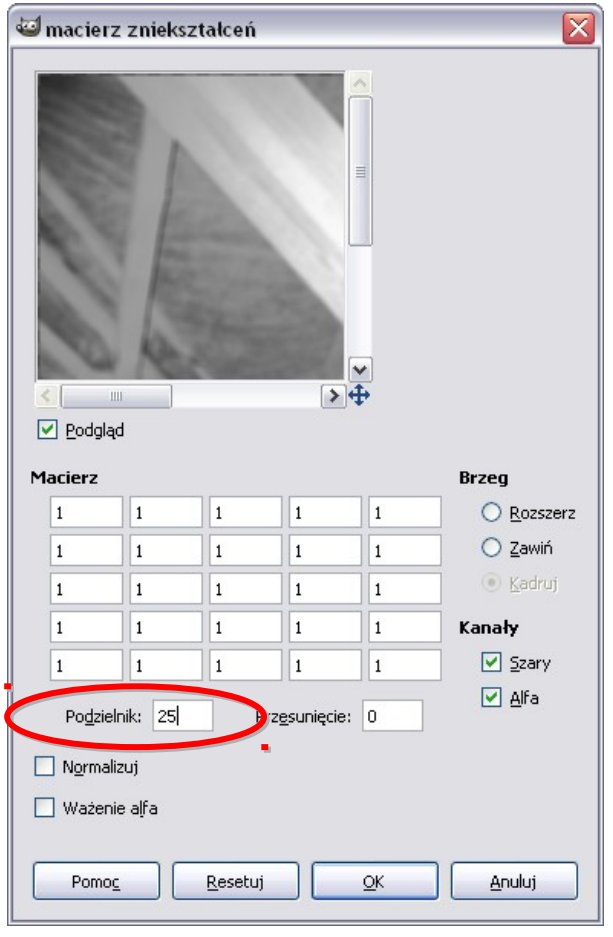


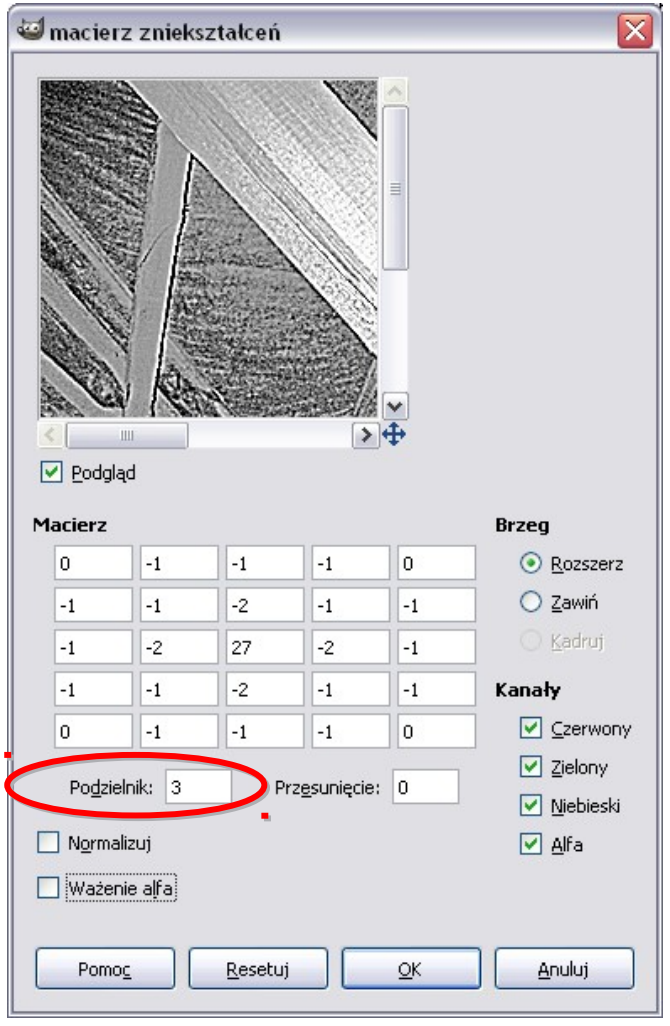
Convolution filter
Filtr splotowy

Convolution is the process of...



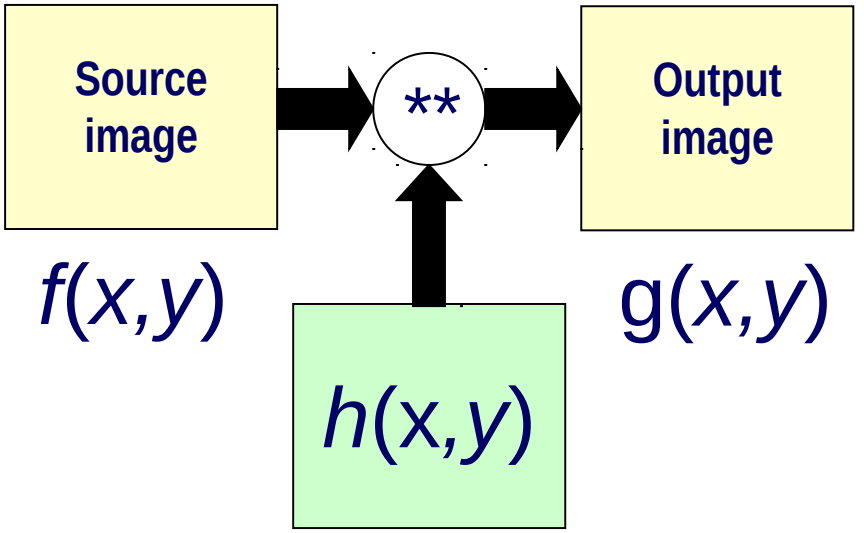



macierz zniekształceń
Podgląd
Macierz
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
1 1 1 1 1
Brzeg
Rozszerz
Zawiń
Kadruj
Kanały
Szary
Alfa
Podzielnik: 25
Przesunięcie: 0
Normalizuj
Ważenie alfa
Pomoc
Resetuj
OK
Anuluj


macierz zniekształceń
Podgląd
Macierz
0 -1 -1 -1 0
-1 -1 -2 -1 -1
-1 -2 27 -2 -1
-1 -1 -2 -1 -1
0 -1 -1 -1 0
Podzielnik: 3
Przesunięcie: 0
Normalizuj
Ważenie alfa
Brzeg
Rozszerz
Zawiń
Kadruj
Kanały
Czerwony
Zielony
Niebieski
Alfa
Pomoc
Resetuj
OK
Anuluj

What is a convolution filtration?
Is it linear or nonlinear?
How to blure and sharpen?
How to preserve local brightness?
Are they low-pass or high-pass?

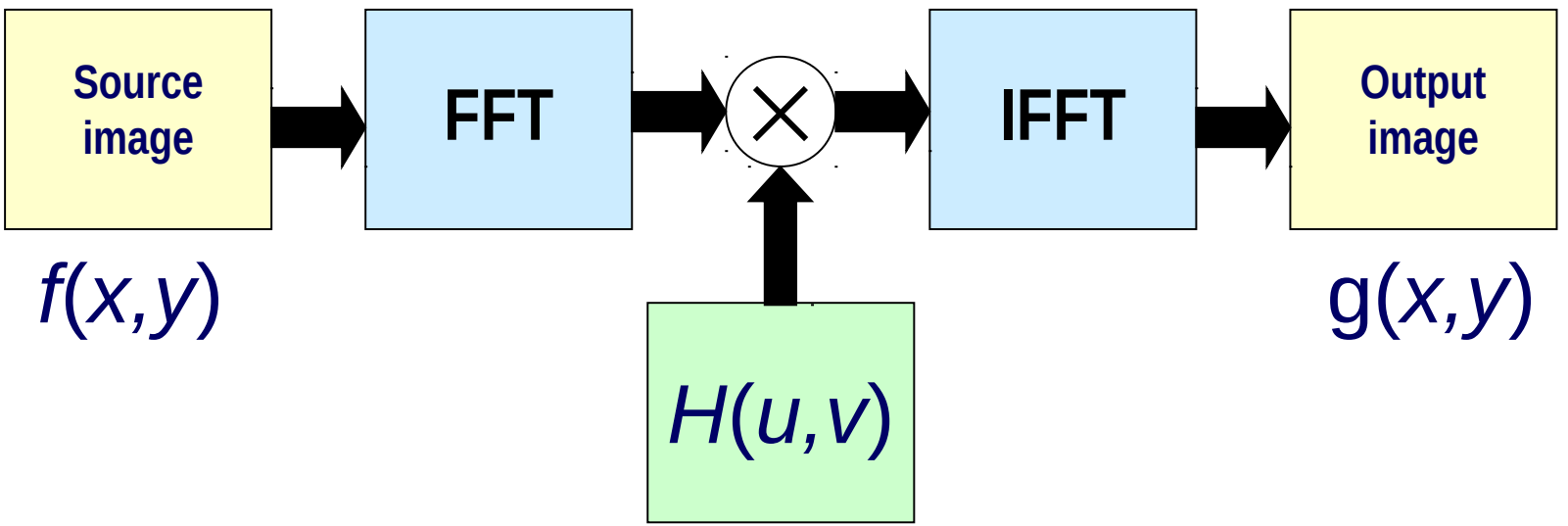
By the definition – may be slow



$$g(x,y) = h(x,y)**f(x,y)$$

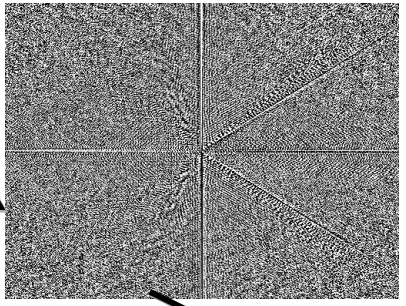
The other way – sometimes faster

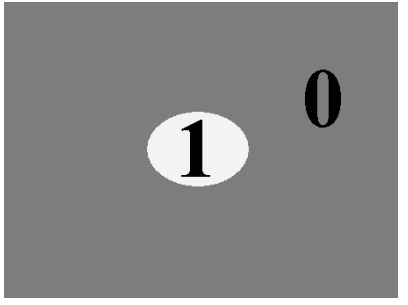
$$g(x,y) = IFFT\{ H(u,v)\, FFT\{f(x,y)\} \}$$



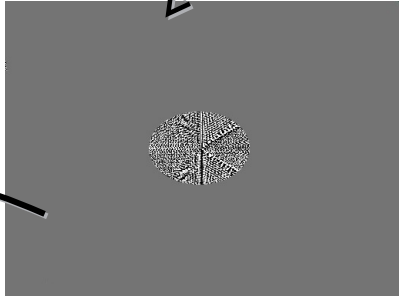
https://en.wikipedia.org/wiki/Fast_Fourier_transform

FFT



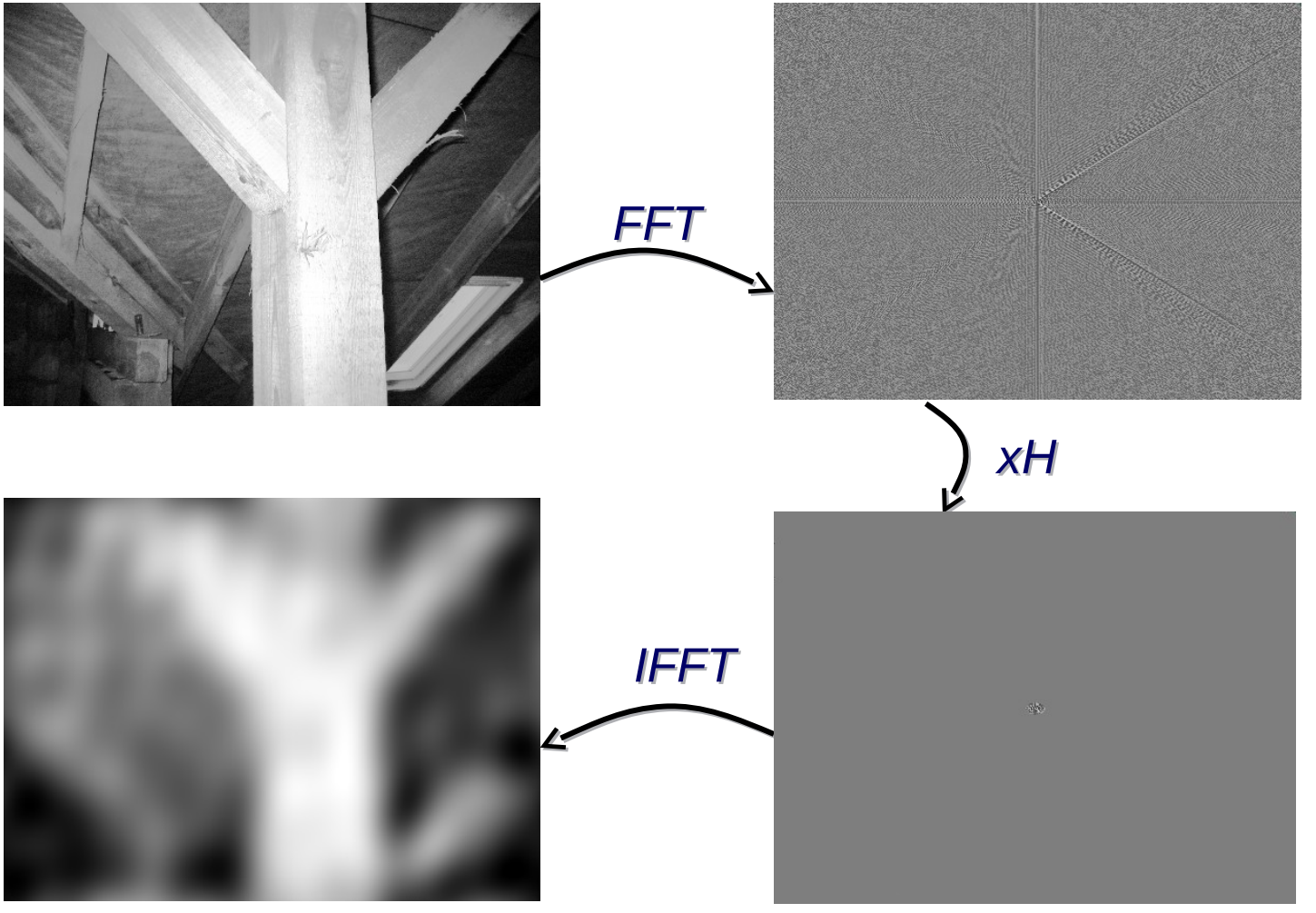


xH

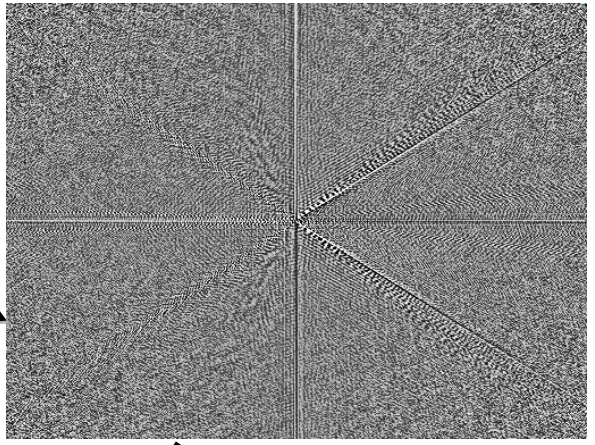


IFFT

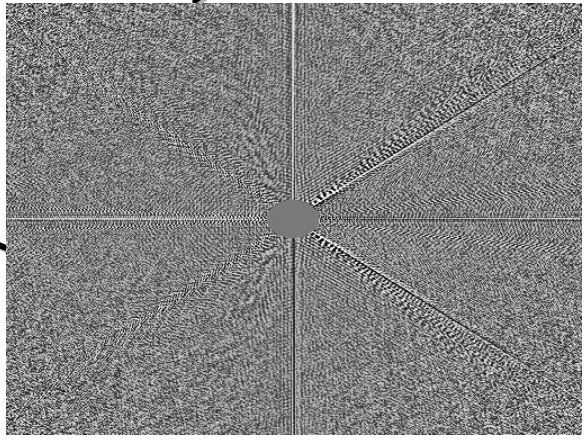
Examples created with GIMP
and FFT plugin by Remi Peyronnet


FFT
xH
IFFT

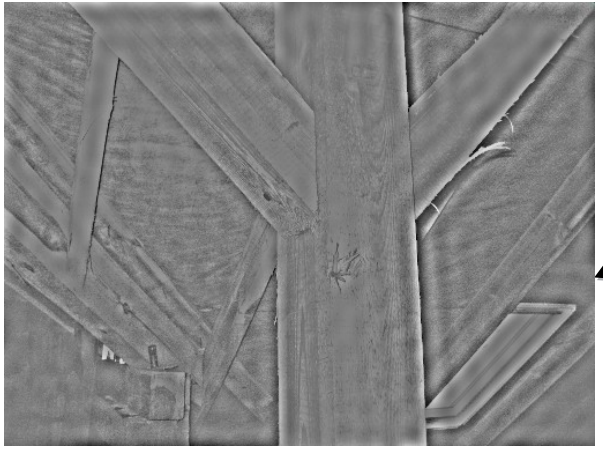
FFT



xH



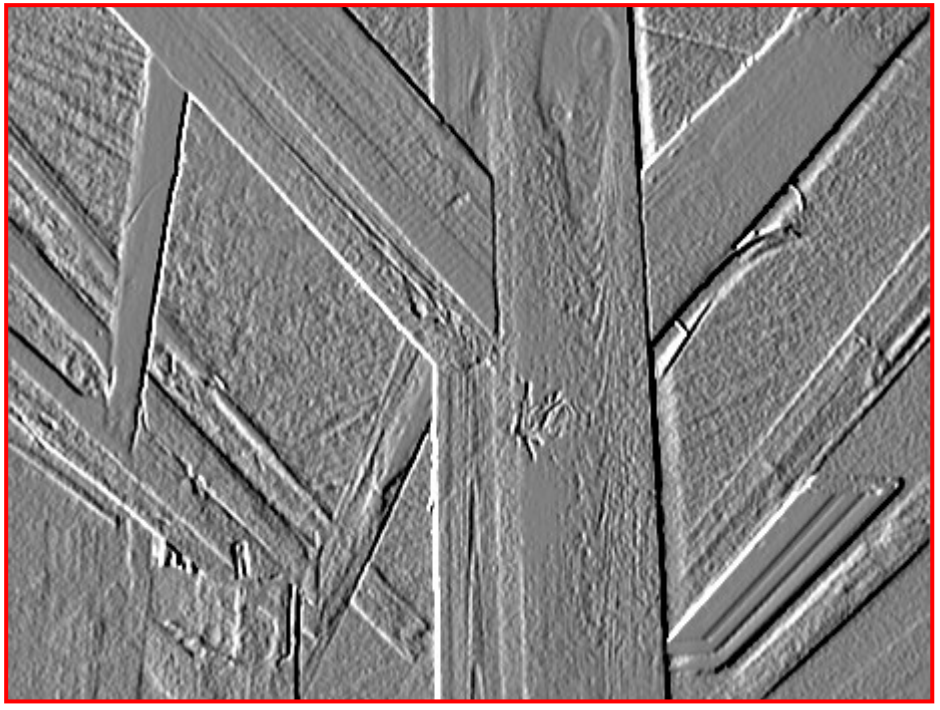
IFFT

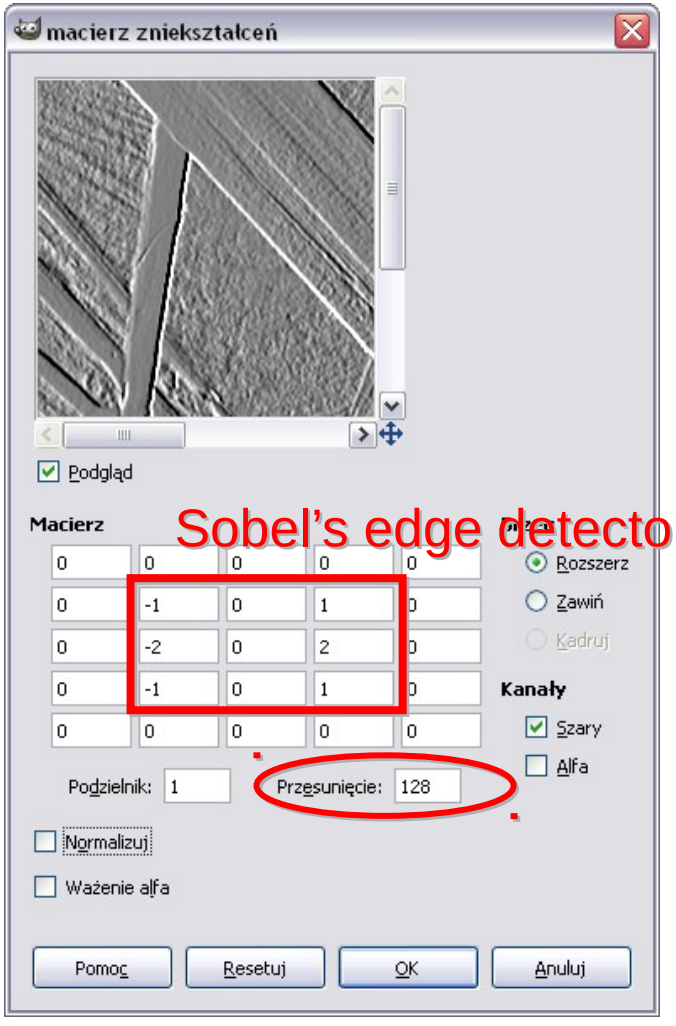


Is it linear or nonlinear?

```
#! /usr/bin/python

import cv2
img = cv2.imread('./image.jpg', cv2.IMREAD_GRAYSCALE)
cv2.imshow('original', img)

kernel = np.array([[-1.0, -1.0, -1.0],
                   [-1.0,  9.0, -1.0],
                   [-1.0, -1.0, -1.0]])
conv = cv2.filter2D(img, -1, kernel)

cv2.imshow('convolved', conv)
cv2.waitKey(2000)
cv2.destroyAllWindows()
```

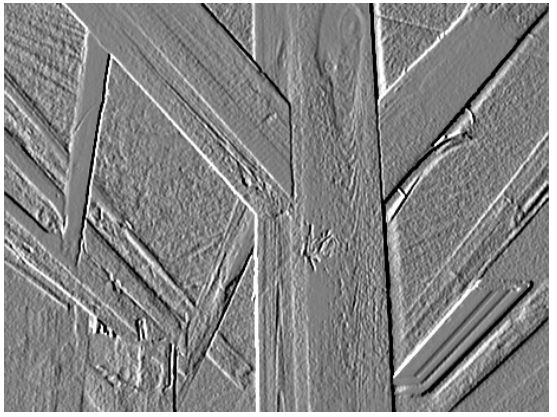
Edge detection
Detekcja krawędzi

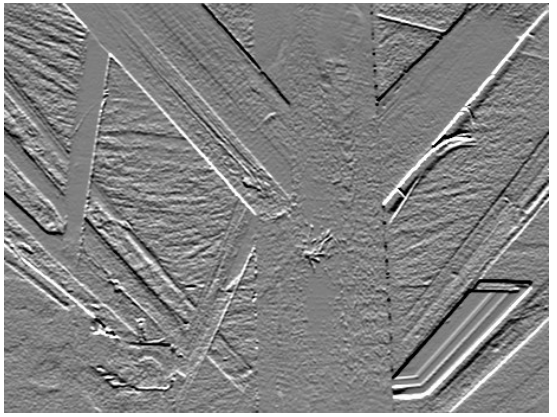




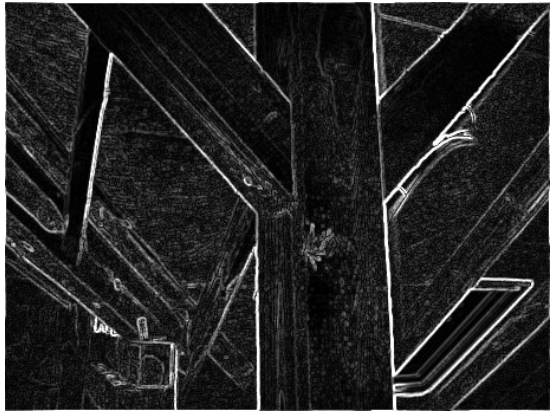
Sobel's edge detector

Nonlinear!





$$I_{edges}(i,j)=\sqrt{I_{H}^{2}(i,j)+I_{V}^{2}(i,j)}$$



```
#! /usr/bin/python

import cv2
img = cv2.imread('./image.jpg', cv2.IMREAD_GRAYSCALE)
cv2.imshow('original', img)

sbl = cv2.Sobel(img, -1, 1, 1)

cv2.namedWindow('edges')
cv2.imshow('edges', sbl)
cv2.waitKey(2000)
cv2.destroyAllWindows()
```

https://en.wikipedia.org/wiki/Edge_detection

Edge enhancement operators:

https://en.wikipedia.org/wiki/Edge_detection
https://en.wikipedia.org/wiki/Sobel_operator
https://en.wikipedia.org/wiki/Prewitt_operator
https://en.wikipedia.org/wiki/Roberts_cross

Thin and binary:

https://en.wikipedia.org/wiki/Canny_edge_detector

Quiz

1. What is a goal of image enhancement procedures?
2. What is a transfer function?
3. How many loops in program we need for pixel-wise algorithms?
4. How many loops in program we need to convolve?
5. Is Sobel operator for horizontal direction linear?
6. How to design a filter kernel to preserve brightness and contrast?