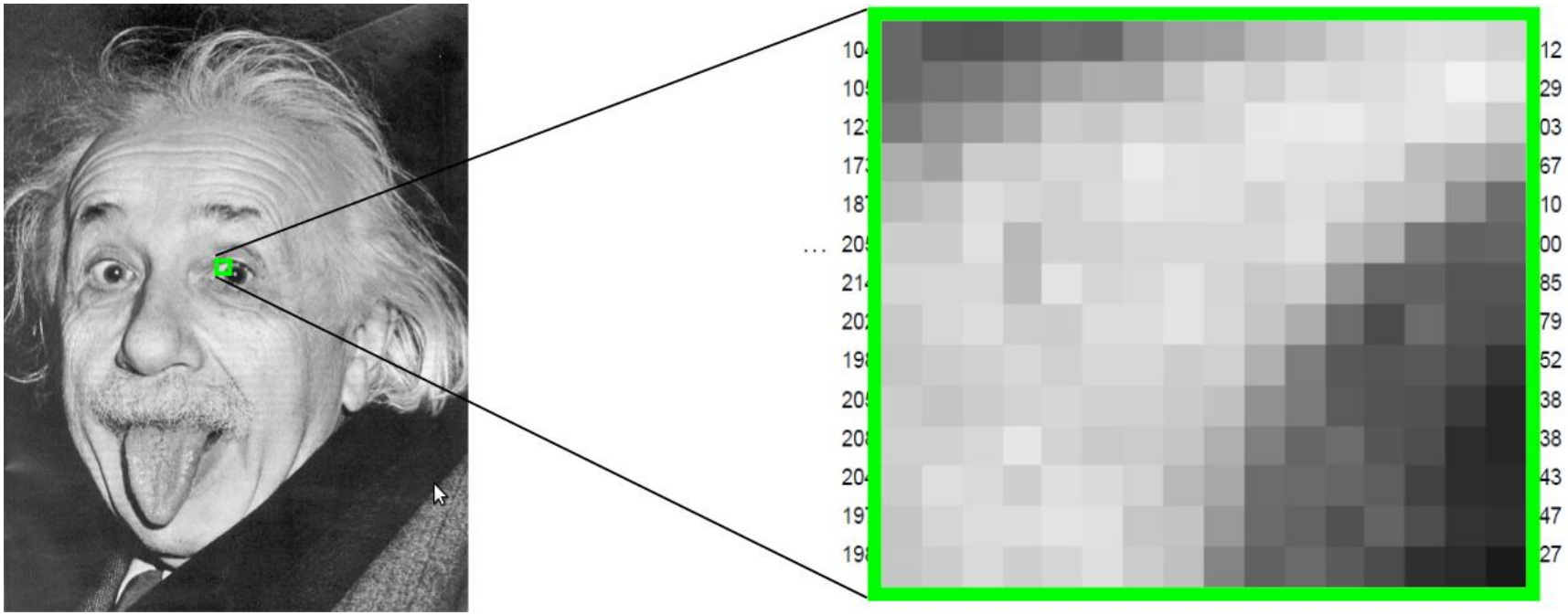
Image Processing

Introduction

What are Images?

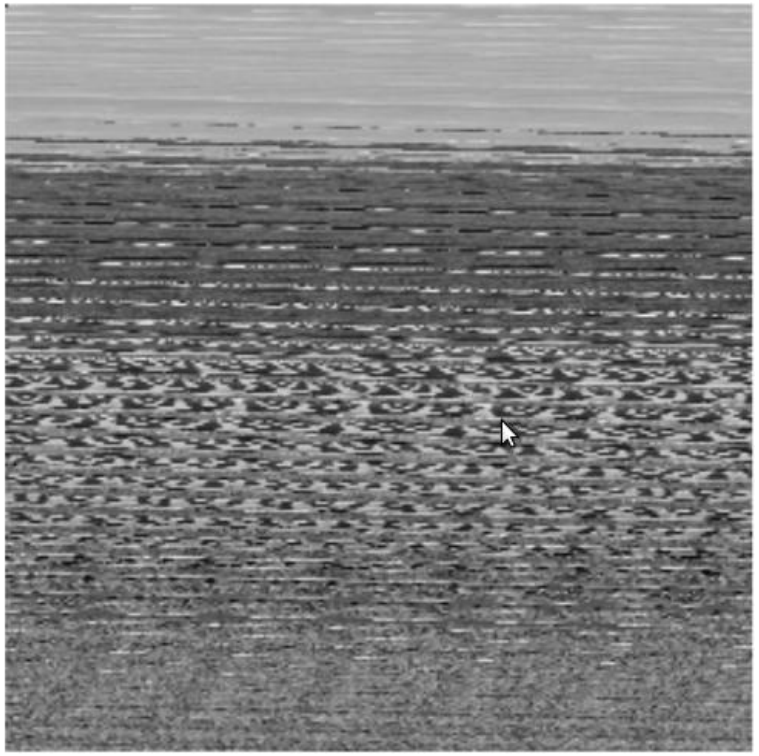
How computers see Einstein…



What are Images?

Images are Vectors:

Zebra image



Same image with a different row length

"Similar" vectors do not correspond to "similar" images

What are Images?

Images are Vectors:

"Similar" images need not to correspond to "similar" vectors (example: translation)

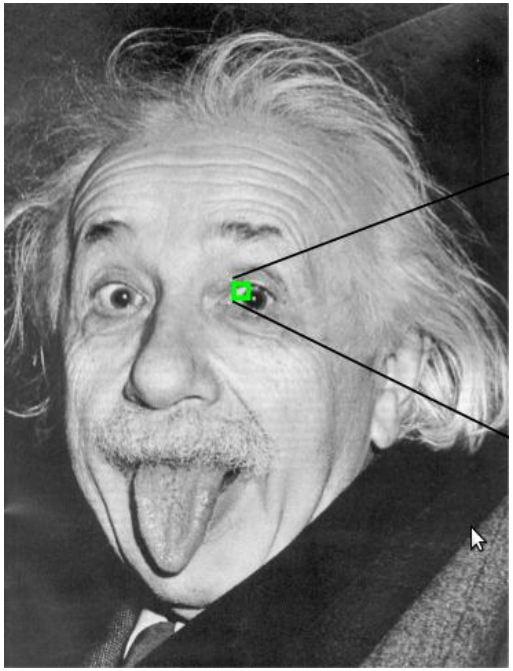
Spatial relations are extremely important

are lost in vector representation ☹

What are Images?

Images are Matrices:

Is it possible to multiply images as matrices?



X

= ?

Determinant, eigenvalues, semidefinite images …

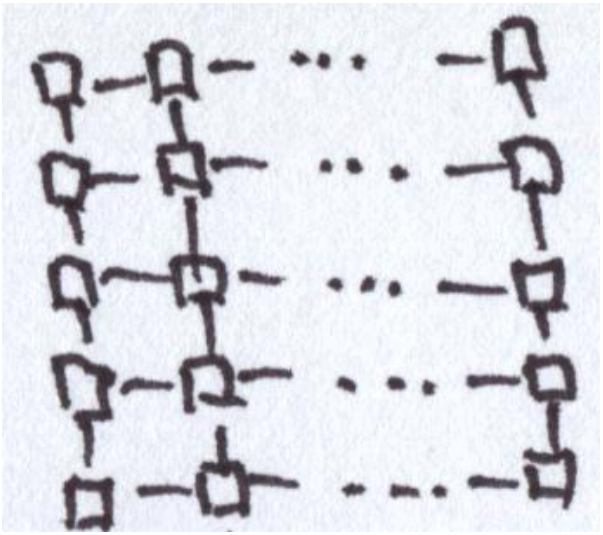
Does it have sense?

➡ Typical operations are senseless ☹

What are Images?

Images are Graphs:

Pixels are vertices, edges connect neighboring pixels (4-connectivity)

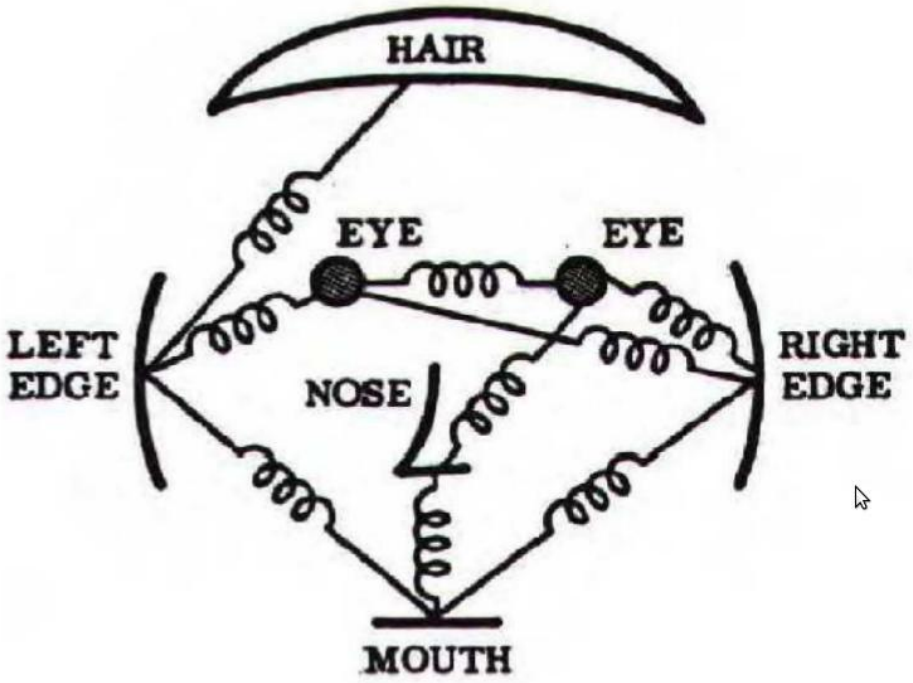


Without further components to restricted: grids only ☹

attributed graphs, labeled graphs etc. are necessary

What are Images?

Scenes are Graphs:



(Fischler, Elschlager 1973)

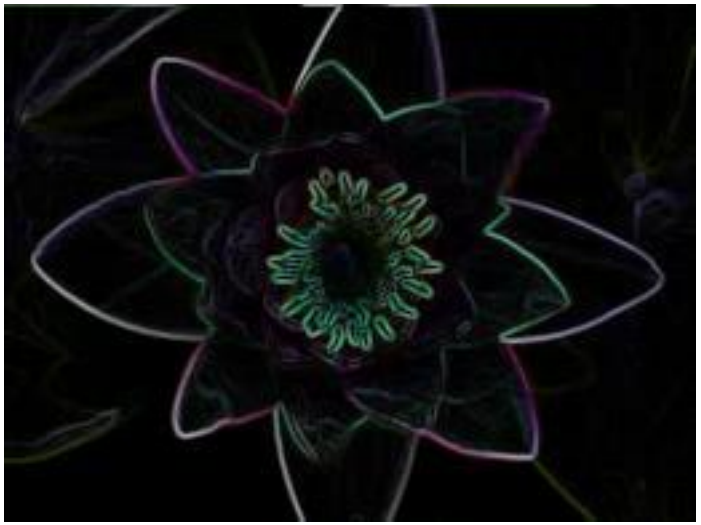
Graphs are mainly used in higher processing levels

Problem: Connection **„Image ↔ Graph“**

What are Images?

Images are functions: $f : \mathbb{R}^2 \rightarrow \mathbb{R}$

For example: image edges are location of high gradient values



Are they convex, differentiable, continuous … ?

How to specify ?

Image families → function spaces → infinite dimensional !!!

Many things become much more difficult.

What are Images?

Images are both … and …

Images are neither … nor …

Images are **Images** ☺

Image processing – how to deal with?

Topics.

1. Human Vision (today – rather for fun)
2. Linear Filtering, Morphologic Operations (2 DS)
   efficient algorithms (program assignments)
3. Fourier-Transform (classic, 1 DS)
4. Diffusion Filters: „Images are Functions“ (1 DS)
5. Continuous and Discrete Energy Minimization (2 DS)
   example: denoising
6. Interest Points, Image Features (2 DS)
   with regard to recognition (Computer Vision)
7. Camera models, 3D-Geometry (2 DS)
8. RANSAC (1 DS)
9. Application: Stereo (1 DS)
   2, 5, 7 und 8 together in one Application

Linear Filtering

Image generation

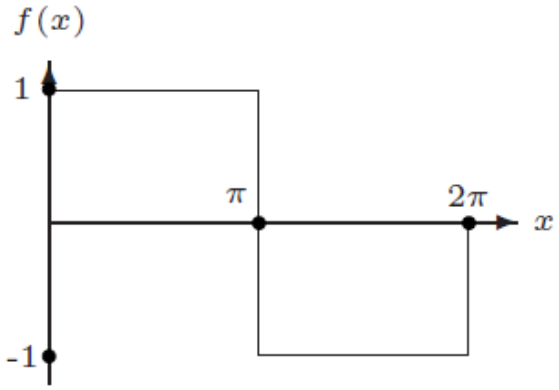
Original

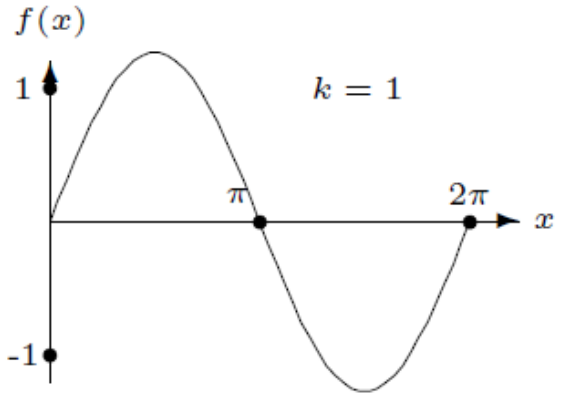
Noise

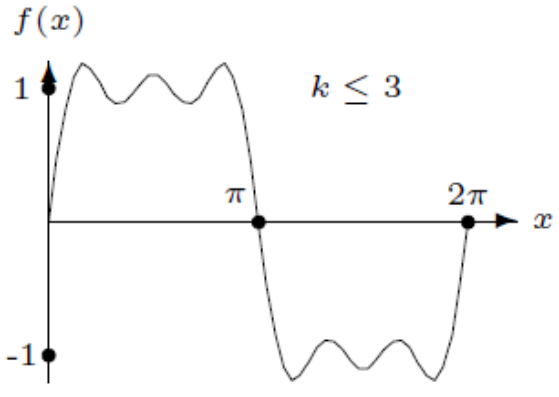
Result

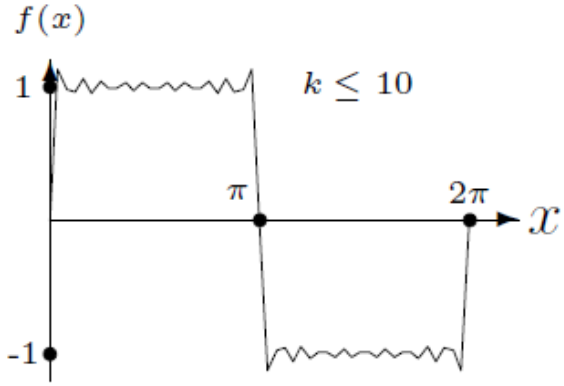
Image restoration

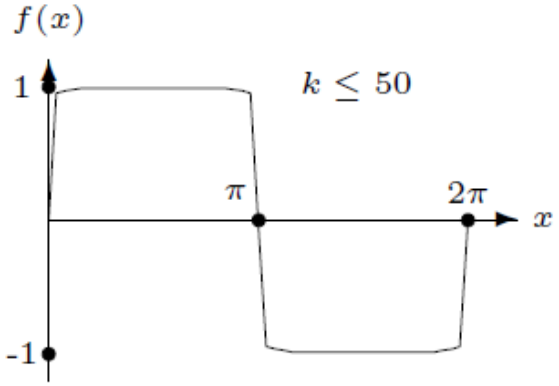
Fourier Transform











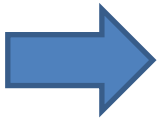
Diffusion Filters

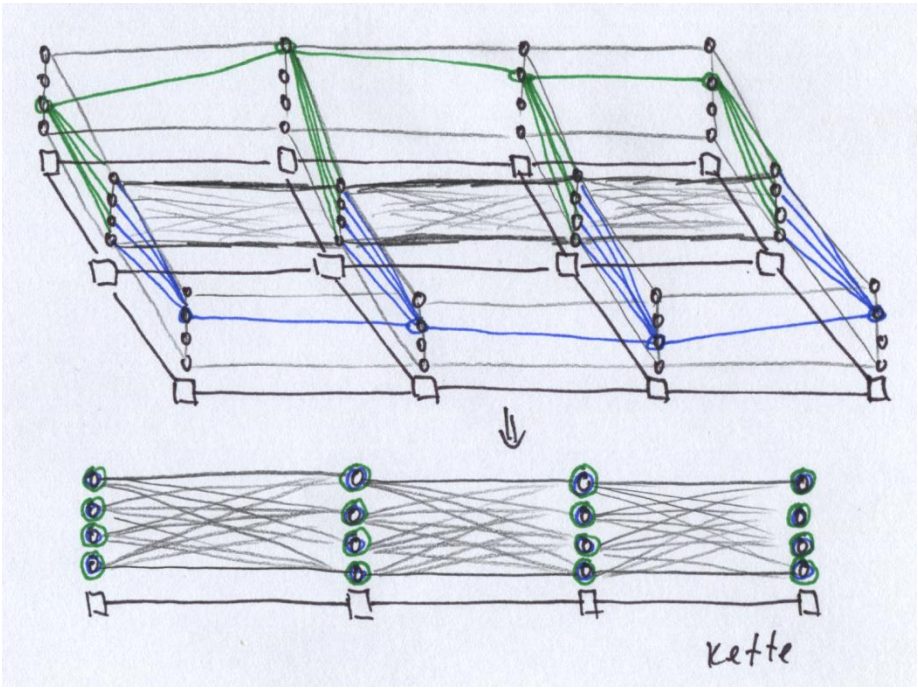
"Images are functions"

Do not smooth uniformly everywhere,
take into account **local** image properties

Energy Minimization

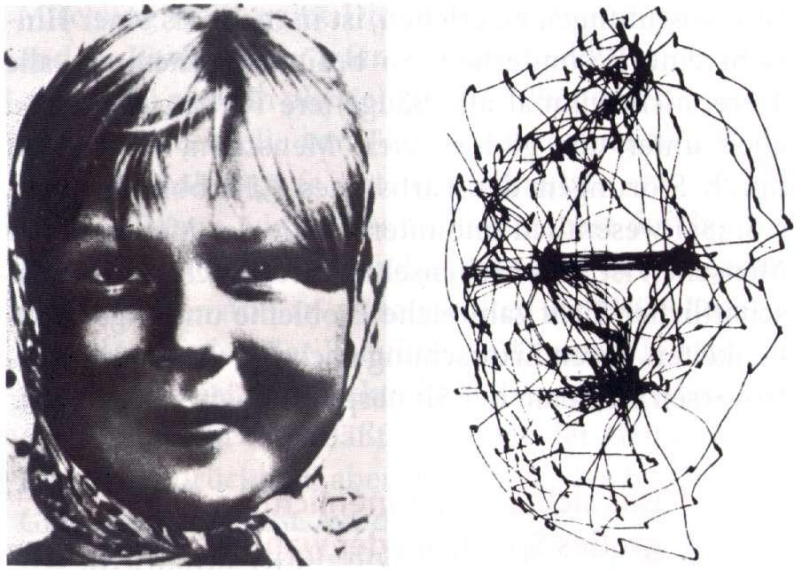
Images are functions (continuous), images are graphs (discrete)





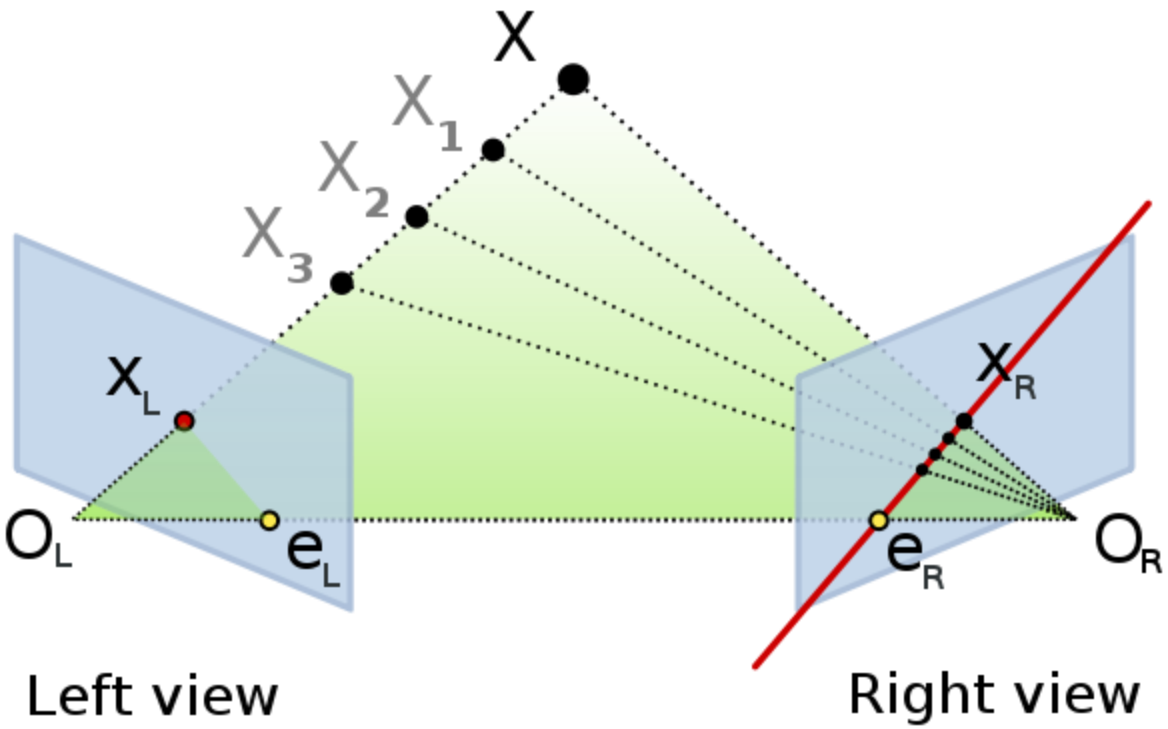
Interest Points, Image Features

Motivation: saccades

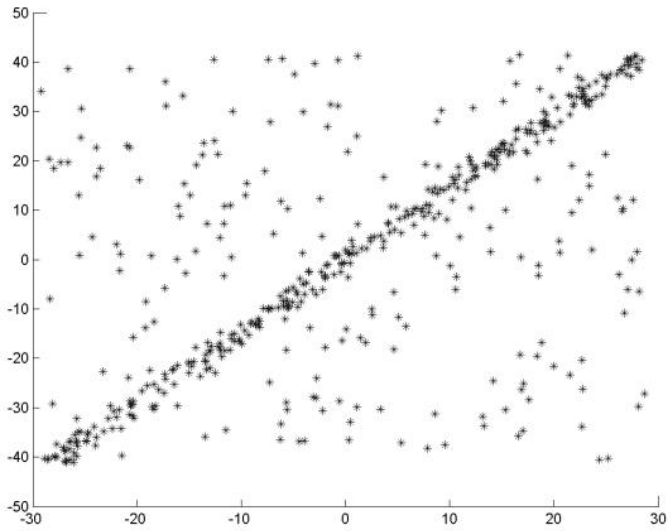


Interest points detection

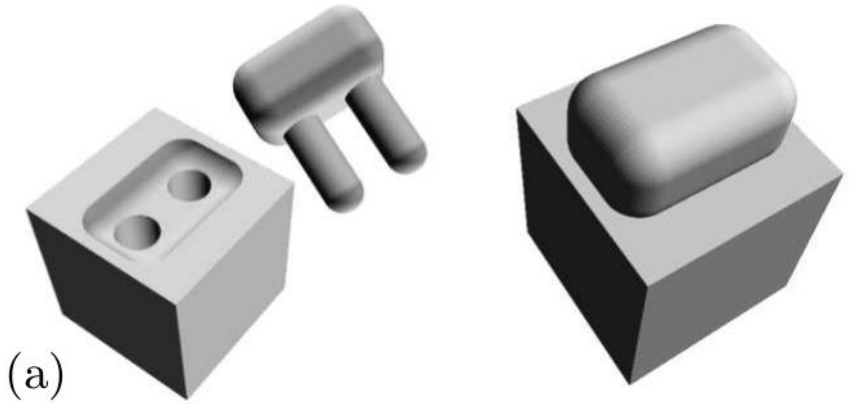
3D-Geometry



RANSAC

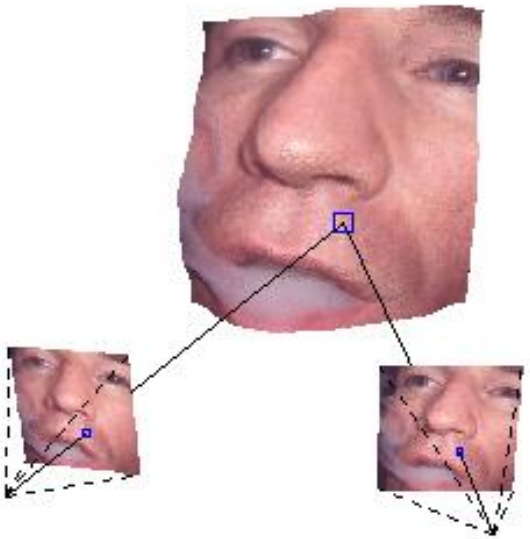


Model fitting

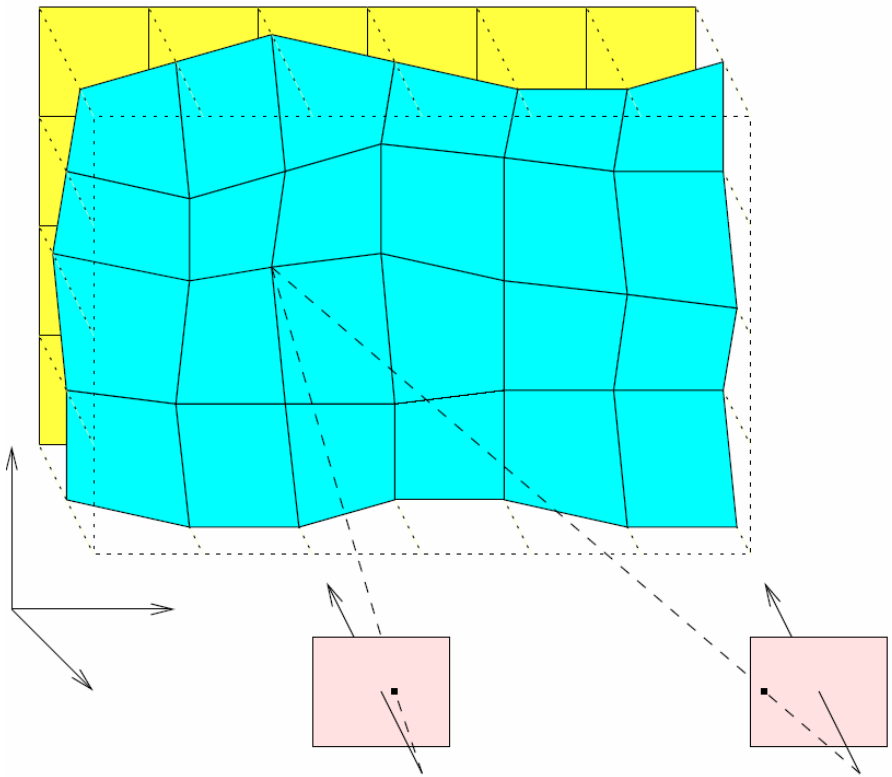


Stereo

Reality



Model



Prerequisites:
epipolar geometry, dissimilarity measures, (discrete) optimization …

Prerequisites: Math

What does it mean?

Examples – one should be able at least to guess, what does it mean:

$$\ln \prod_i f(x_i) = \sum_i \ln f(x_i)$$

$$\min_x f(x) = -\max_x \big(-f(x)\big)$$

$$\arg\min_x f(x) = \arg\min_x \ln f(x)$$

$$\min_x \sum_y f(x,y) \geq \sum_y \min_x f(x,y)$$

$$\sum_{i=1}^{n} a_i \ln x_i \to \max_x$$

$$\text{s.t. } x_i \geq 0, \sum_i x_i = 1$$

$$x_i \sim a_i$$

In particular: geometry (sin, cos), linear algebra (vectors, matrices, SVD), functions (derivative, gradients, integrals, series), a bit optimization, a bit probability theory …

Program assignments

- Free attendance (consultations)
- Tasks: all having something in common with image processing (pattern recognition as well), see catalog, own tasks are welcome
- Point system (1 to 3 per assignment), 4 in overall, groups (up to 3 people) possible
- Environments: Linux (Windows), C/C++, QT, OpenCV (see examples on the page)
- Tutors: Andre Steinborn, Denis Kirmizigül
- Delivery: commented sources, documentation or /and evaluation, advises for compilation, call, input/output etc. (if applicable)
- No GUI
- Per E-Mail to Andre/Denis

Miscellaneous

- Scripts, slides (quite chaotic at the moment), info etc.

  http://www1.inf.tu-dresden.de/~ds24/lehre/bvme_ss_2013/bvme_ss_2013.html

- Exam: oral (graded), with assignments – 4SWS, without – 2SWS

- Literature:
  - David A. Forsyth, Jean Ponce: ”Computer vision – A modern approach”
  - Klaus D. Tönnies: ”Grundlagen der Bildverarbeitung”
  - Internet, Google, Wikipedia ...
  - Papers ...

- Comments, requests, questions, criticism are welcome (anonym via mail-form as well).