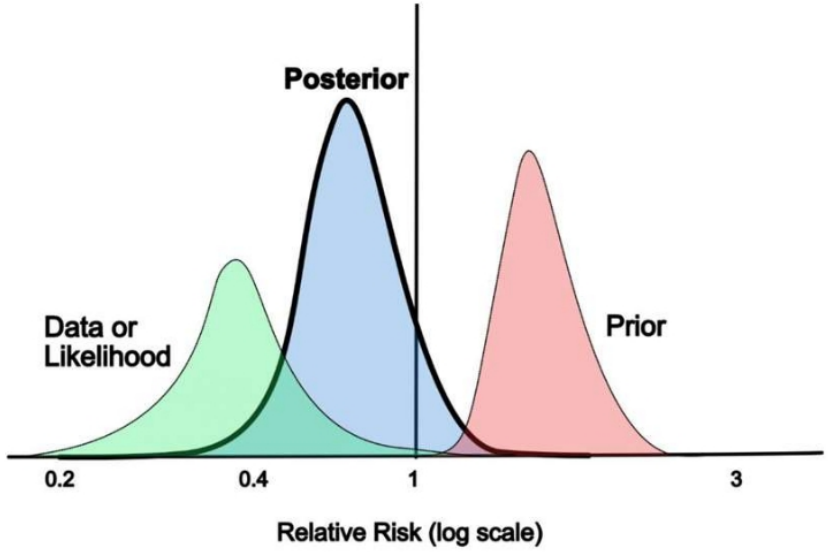
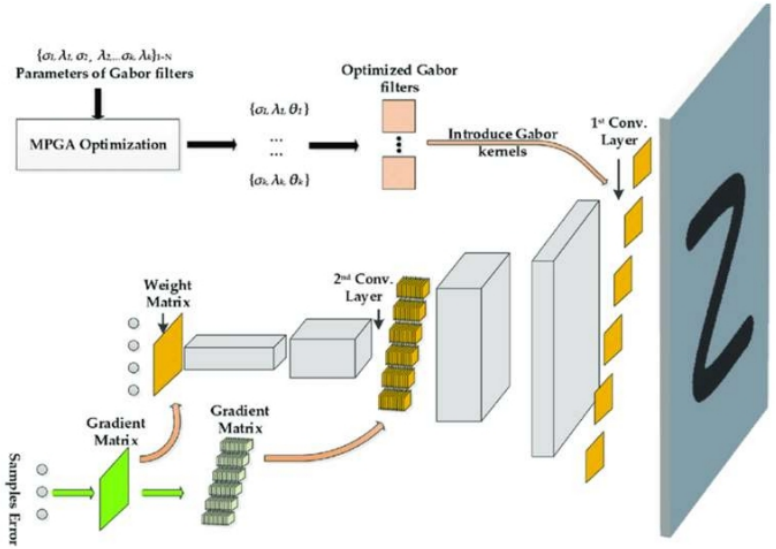
Estimation theory – Image Analysis and statistical tests

Nils Dörr, Stefan Hinz
Institute of Photogrammetry and Remote Sensing, Karlsruhe Institute of Technology





Homework

- Write a Matlab/Python function to choose a patch on an image
  - Input: Image, Patch center, Half-side of the patch
  - Output: Image patch
- Write a Matlab/Python function that adds noise on the image patch
  - Input: Image patch, type of noise (Gaussian for optique, speckle for SAR), standard deviation
  - Output: Noisy patch
- Write a Matlab/Python function that filter the image patch
  - Input: Image patch to filter, size of the filter, standard deviation of the filter
  - Output: Filtered image
  - Please take a special care with the border of the image patch (propose an extrapolation method)
  - Compare your filter with Matlab implemented function

Homework

- Write a Matlab/Python function to compute the histogram of the image
  - Input: Image patch
  - Output: Histogram (vector providing the gray value occurences from 0 to 255).

- Write a Matlab/Python function that compute the central moments of an histogram
  - Input: Histogram (e.g. 256 vector)
  - Output: Mean, variance, standard deviation, skewness, curtosis, excess

- Write a Matlab/Python function that calculate the normalized and cumulative histogram
  - Input: Histogram
  - Output: Two vectors for respectively the normalized and cumulative histogram

Homework

- Write a Matlab/Python function that performs the 2-sample Kolmogorov-Smirnov test
  - Input: Cumulative histogram 1, Cumulative histogram 2, significance level
  - Output: Vector of differences D, Decision (0 or 1)

- *Write a Matlab/Python function that calculates the Kullback-Leibler divergence*
  - *Input: Histogram (distribution) 1, Histogram (dsitribution) 2*
  - *Output: Relative entropy $D(P||Q)$, Decision*
  - *Pay Attention, the sample size must be high enough (does not work on 3x3 patches)*

Homework

- For each question it is asked to write a Matlab/Python function. Please write it without any preprogrammed matlab function and compare it to the corresponding Matlab/Python function. For example, in the case of the filter, compare your own script with the imgaussfilt function. Or for the KS-test, compare your resulting decision with the kstest and kstest2 functions.

- Please make your script robust and avoiding errors. For example by selecting the image patch, if the center of the patch has the coordinates [10,10] and the half-side of the patch is 40, the script should return the corresponding area without errors. Please also add some exception handling for wrong input parameters (e.g. negative std for gaussian filter).

- Please write also functions to plot nice graphs of the results of the corresponding functions

Homework

- Please use your Matlab/Python function on 2/3 patches and present the results. Please present the similarities/differences between your and the preprogrammed matlab function
- For the KS-test please do both possibilities: you can compute the corresponding gaussian cumulative histogram of the image patch and lead the KS-test on the image patch histogram and on the gaussian histogram. The decision will be then (it does/does not follow a normal distribution). You can also compare two neighbour patches on the image.
- For th KL-Divergence, select one patch and compute the KL-Divergence on the whole image. Display the result of the KL on the whole image.
- Write a small report presenting the results and answering the questions of the next slide. Send the report and your functions to nils.doerr@kit.edu

  Deadline: 14.05.2024 – Max. group size: 4

Key questions

- What does the standard deviation tell about the contrast of an image?
- It is correct to state that the histogram tells nothing about spatial data patterns or the structure of an image? Why? Why not?
- What can be guessed about noise in the data , if the excess is negative and large?
- Why is the KS-test apparently very sensitive – or even over-sensitive – for a Normal Distribution with small variance?