052600 VU Signal and Image Processing

Lab Assignment 4: Wavelet Analysis

Due: 24.06.2018, 23:55

In this lab assignment you will learn some of the main applications of Wavelet transforms for image processing. You can use MATLAB Wavelet Toolbox or Octave Signal Package but **only functions for single-level 1D processing**. Thus **it is not allowed to use functions like wavedec or any 2D analysis** ones like dwt2/idwt2 or wavedec2/waverec2 as part of the exercise is that you implement them yourself.

A good documentation of the toolboxes can be found online:
https://de.mathworks.com/help/wavelet/functionlist.html
https://octave.sourceforge.io/signal/overview.html
https://octave.sourceforge.io/ltfat/overview.html

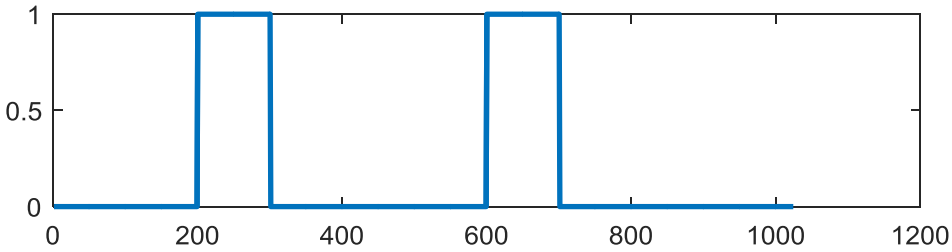
A maximum of 15 points is awarded for this assignment.

You need to submit a PDF report and one Matlab/Octave function for each task and a documented script main.m that sequentially performs the implemented tasks, all in the same zipped folder. Please write (at least) your name and student ID on top of each Matlab file and also on the PDF report. Feel free to define other auxilary functions.

The exercise is based on the following paper:
L. Zhang, P.Bao: “Edge detection by scale multiplication in wavelet domain”. Pattern Recognition Letters 23(14):1771-1784, 2002
https://pdfs.semanticscholar.org/09f0/c64b0769a545b444360b2172a925d9471898.pdf
The main idea is illustrated in Fig. 1

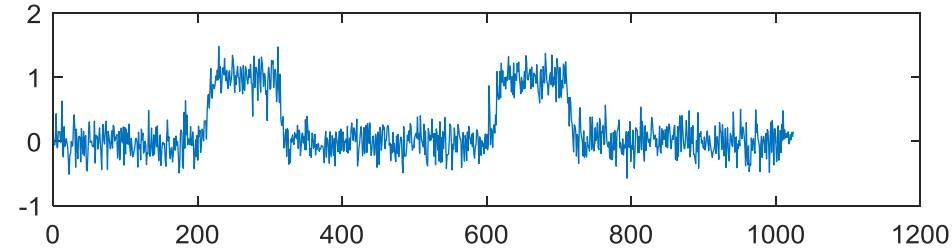
1D Edge Detection

(2 points)
Generate a 1D signal with two rectangular pulses. Something like:



Smooth it with a Gaussian-based filter having a sigma=5. You need to design and apply the filter yourself, i.e., do not use an inbuilt smoothing function.

Add a noise with standard deviation of 0.2 (20% of the amplitude) to the smoothed signal. The final signal should look something like:



(2 points) Using 1D DWT produce a wavelet decomposition with Haar wavelet up to 6 levels. Visualize the approximation and the detail coefficients across the levels. What happens to the noise?

(3 points) Following the paper, produce the *scale multiplications* and try identify edges at different scales using thresholding. What do you observe?

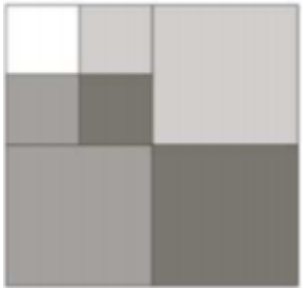
2D Edge Detection

Download a set of test images from (http://www.io.csic.es/PagsPers/JPortilla/content/BLS-GSM/test_images/test_images.zip). Select one test image for this exercise and display it.

(5 points)
Implement a 2D wavelet transform using 1D Haar wavelet transform. It should have the following interface:

y2d = wt2d(x2d, Lo_D, Hi_D, nlevels)
where x2d is the input image, Lo_D is the 1D low-pass approximation filter while Hi_D is the 1D high-pass detail filter for decomposition. The number of desired scales is specified by nlevels. You can obtain the Haar coefficients using the function wfilters in MATLAB or e.g. at http://wavelets.pybytes.com/family/db/.

The encoded signal y2d should have the standard layout, having approximation at the top-left block and the detail coefficients around it.



Decompose the chosen image into 4 levels and visualize the decomposition.

(3 points) Analogous to 1D case and as described in the paper, produce an edge detection algorithm based on *scale multiplication* and thresholding over the available scales.