SGN-12006 Basic Course in Image and Video Processing

EXERCISE 6

05.10.2015 - 07.10.2015

This exercise consists of both lab exercises and homework. Complete the lab exercises and present your results for the TA. Prerequisite for submitting the homework is attendance in an exercise session. Homework should be submitted only online using Moodle2.

Follow the naming format 'ExN_surname_ID.pdf' (N is the number of exercise). Also please clearly write down your full name and student number in the document. The homework report should be no more than 1 page long and it should be done individually (no pairs allowed). Questions on this exercise should be addressed to TA's email address: (firstname.surname@tut.fi).

Lab exercises

1) DFT of Images (3 points)

Create the following 128 x 128 gray-scale images:

(a) Constant value 0.5 for whole image;
(b) 20x20 white square in the middle;
(c) Ramp from 0 to 1 in one direction, constant in the other; (help nncopy)
(d) Delta function at the center of the image;
(e) Cosine signal having four periods in both directions; (help meshgrid)

All the images should be created using the full range 0 to 1, and without using any for or while loops. Perform the 2D Fourier transform on all the images. (help fftshift, fft2, log)

For each gray-scale image create (and save) an image, where you have the original image and its transform side by side. You will need these images in the homework part.

2) Filtering in the Frequency Domain (2 points)

Butterworth filters can be defined as:

(a) Butterworth low-pass filter: $H(u,v) = \frac{1}{1+\left(\frac{D(u,v)}{D_0}\right)^{2n}}$

(b) Butterworth high-pass filter: $H(u,v) = 1 - \frac{1}{1+\left(\frac{D(u,v)}{D_0}\right)^{2n}}$

where D_0 is the so called cut-off frequency distance. $D(u,v)$ is

$$D(u,v) = \sqrt{\left(u-\frac{M}{2}\right)^2 + \left(v-\frac{N}{2}\right)^2}$$

where M*N is the image size.

Use the given Butterworth low-pass filter (BWLPfilter.m) Choose D_0 =20 and n=2 order and filter the image *cameraman.tif* with both (a) and (b) filters. Show images of the filters and the final filtered images.

3) Discrete Cosine Transform Matrix (3 points)
Write a MATLAB function mydctmtx, which is taking the image height N (for square image $N\times N$) as an input parameter and then creating an $N\times N$ cosine transform matrix, C ,which is defined as

$$C(k,n)=\begin{cases}\sqrt{\frac{1}{N}}, & k=0, 0\le n\le N-1\\ \sqrt{\frac{2}{N}}\cos\frac{\pi(2n+1)k}{2N}, & 1\le k\le N-1, 0\le n\le N-1\end{cases}$$

Use your function to generate $N\times N$ transformation matrix and then use it to generate all $N\times N$ basis images in MATLAB. (You may verify your matrix using the MATLAB's function "dctmtx") Design a way to visualize all the images in one figure/image. The figure should contain N by N tiles with horizontal frequencies increasing from left to right and vertical frequencies increasing from top to bottom. You may separate the tiles using some black lines. Show results for N=8 and N=16.

Homework:

3) Understanding DFT of images (2 points)

a) Explain shortly what information you can obtain from a DFT of an image.

b) Consider the images from task one. Where is the FFT energy concentrated in each case and why?

Include the images in your report and remember to label them. The images should be sufficiently large to see the details. Keep your answers concise and to the point.