SGN-12006 Basic Course in Image and Video Processing

EXERCISE 8

26.10.2015-28.10.2015

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 exercise

1. Noise generation and restoration. (3 points)

Download the '`lena.jpg`', which is a 512x512 gray-level image.

Add the following noises to the image respectively:

a) **Gaussian noise:** Use `imnoise` function to generate the noisy image.
b) **Salt & pepper noise:** Use `imnoise` function to generate the noisy image.
c) **Rayleigh noise:**

- Assume a uniform random number, *w*, in the interval (0,1). We wish to generate random numbers, *z*, with a Rayleigh CDF of the form:

$$F_z(z) = \begin{cases} 1 - e^{-(z-a)^2/b} & \text{for } z \geq a \\ 0 & \text{for } z < a \end{cases}$$

where $b > 0$. To find *z* we solve the equation

$$1 - e^{-(z-a)^2/b} = w$$

$$z = a + \sqrt{-b\ln(1-w)}$$

- MATLAB: R = a + sqrt(-b*log((1-rand(M,N))
- Add the generated noise to the image to obtain the noisy image.

Select the noise parameters so that image quality deterioration is noticeable and the image quality approximately is same in each case.

<u>Restoration of Noisy Images:</u>

Create 3 × 3

a) Arithmetic mean filter:

$$\hat{f}(x,y) = \frac{1}{mn} \sum_{(s,t) \in S_{xy}} g(s,t)$$

MATLAB: f = imfilter(g, fspecial('average', [m n]))

b) Geometric mean filter:

$$\hat{f}(x,y) = \left(\prod_{(s,t)\in S_{xy}} u(s,t) \right)^{\frac{1}{mn}},$$

MATLAB: f = exp(imfilter(log(g), ones(m, n), 'replicate')) .^ (1/(m*n))
! log(a*b*c…) = log(a) + log(b) + log(c) + ...

c) Harmonic mean filter:

$$\hat{f}(x,y) = \frac{mn}{\sum_{(s,t)\in S_{xy}} \frac{1}{u(s,t)}},$$

MATLAB: (m*n) ./ imfilter(1 ./ (g + eps), ones(m, n), 'replicate');

Note. Present your resulting images in four 2-by-2 subplots. The first subplot contains the original image and three types of noisy images. In the second subplot to the forth, you should have the noisy image of one type on the top left and filtered images in the following.

2. Noise cleaning with Weighted Median Filter. (2 points)

An extension of median filter which we learned several weeks ago is weighted median filter (WMF). Besides having the same strength including edge preserving and removing the impulse noise, WMF has a better details preserving property over the original median filter*. In this exercise, we implement a simple WMF and identify its strength.

a. Load the `baboon.png`, and add salt and pepper noise with a variance of 0.02.
b. Implement the WMF with a window of 5 by 5. The output of weighted median is presented in the equation below. Fill the center of weight kernel with 5 and keep the rest with 1.

$$y(n) = \text{MEDIAN}[W_1 \diamond x_1(n), W_2 \diamond x_2(n), \ldots, W_N \diamond x_N(n)],$$

c. Show the original image, noisy image, original median filtered image and the one by WMF in a 2-by-2 subplot.

Homework:

1. Clarify the terms: image denoising, image restoration and image enhancement. (1 point)
2. Which filtering method do you suggest for eliminating the specific noises created in the 1st problem in our lab exercise? Describe the effects of the filters on each noisy image. (1 points)
3. Also, in page 29 of this lecture, we see the effect by mean filters of different types. If we closely observe the subimage on the top right corner, we can see the resulting image by geometric mean filter is less blurred. Discuss the reason behind it. And why are the black components by geometric mean filter thicker? If we apply arithmetic mean filter, geometric mean filter or weighted median filter together with the Laplacian filter onto the same image, which combination remains the same if we swap the order and why? (3 points)

Note! The whole report should NOT exceed 1 page.

*More details can be found in Yang, et al., "Optimal Weighted Median Filtering Under Structural Constraints", IEEE Transactions on Signal Processing, 1994.