CS474/674 Image Processing and Interpretation

Fall 2020 – Dr. George Bebis

Programming Assignment 4

Due Date: 12/9/2020 @ 1pm

In this assignment, you will experiment with filtering in the frequency domain; the steps have been discussed in class extensively and are outlined on pages 312-313 in your textbook.

Experiment 1 (noise removal): In this experiment, you will consider the effects of additive noise and the use of DFT to remove this kind of noise. The noisy image shown below (i.e., can be downloaded from course's webpage) has been generated by adding “cosine” (i.e., periodic) noise to the original image. **(a)** Using frequency domain filtering, devise a procedure for removing the noise and show your results. For comparison purposes, you can try to remove the noise in the spatial domain using Gaussian filtering (e.g., 7 x 7 or 15 x 15 filters). Compare your results between the spatial and frequency domains. **(b)** Instead of removing the noise pattern, devise a procedure to extract the noise pattern and show your results. **(c)** Systems that perform face verification and recognition (see definitions below) can greatly benefit from high quality face image inputs. What are some possible implications on face verification and recognition performance of failing to remove/reduce noise in face images or introducing artifacts due to algorithmic errors? This is a free response question; you can discuss both safety and economic implications. Provide proper citation for any information obtained from other sources.

Definitions: Face verification is concerned with validating a claimed identity based on the image of a face (**one-to-one matching**). Face recognition is concerned with identifying a person based on the image of a face (**one-to-many matching**).

Experiment 2 (convolution in the frequency domain): Repeat the experiment described in Example 4.15 (page 317), using the “lenna” image. For comparison purposes, perform the convolution both in the spatial and frequency domains (i.e., see Figure 4.38, page 319) and compare your results.

Experiment 3 (homomorphic filtering): Many times, images suffer from shading problems due to uneven illumination. The role of homomorphic filtering is to alleviate such problems. In your experiments, use the image shown below (i.e., can be downloaded from the course's webpage). As discussed in the class, the main idea behind homomorphic filtering is to separate the illumination and reflectance components by applying the logarithmic function on the image. You would then need to apply an appropriate high-pass filter, which will emphasize high frequencies and attenuate lower ones, preserving fine detail at the same time.

Here are the main steps:

1. Apply the **ln** function (natural logarithm) on the image.
2. Take the Fourier Transform of the image from step 1.
3. Apply high-pass filtering
4. Take the Inverse Fourier Transform of the image from step 3.
5. Apply the **exp** function (exponential function) on the image from step 4.
6. Display the magnitude of the image from step 5.

Note that in certain cases, the gray levels will be higher than 255; applying a regular normalization and displaying the image will not give good results and it is better if you use a **log** function as we did with the spectrum of the Fourier Transform. The high-pass filter to be used in your experiments is a **high-frequency emphasis** filter:

$$H(u,v) = (\gamma_H - \gamma_L)\left[1 - e^{-c\left[(u^2+v^2)/D_0^2\right]}\right] + \gamma_L$$

where D_0 is the cutoff frequency of the filter and γ_L γ_H are the gains for the low and high frequencies correspondingly. Note that before you apply the filter on the image, you must first **center** it as in the case of the Fourier Transform spectrum.

Experiment with different parameter values. As a starting point, choose D_0=1.8, c=1, γ_L=0.5 and γ_H =1.5. Then, keep the cutoff frequency the same and increase/decrease γ_L and γ_H. For example, assume combinations of γ_L and γ_H, with γ_L taking values from [0.0-1.0] and γ_H taking values from [1.0-2.0]. Show and comment your results. Which set of parameters seems to be working the best? Is there a consistency in your results as γ_L increases/decreases? What about γ_H?

Laboratory Write-up: For each programming assignment, you are to turn in a report (please, follow closely the instructions posted on the course's website). **The report is very important in determining your grade for the programming assignment.** Be well organized, type your reports, and include figure captions with a brief description for all the figures included in your report. Motivation and initiative are greatly encouraged and will earn extra points.