PROF. BRUNO MOTTA DE CARVALHO

Homework 1
Deadline: 12/10/2021   Time: 23:59   Place: SIGAA (online)

Solve the following questions and write a small report. Questions 2 to 5 must be implemented by you using C/C++ or Python. Compress all files into a single zip file and submit it through SIGAA. The images to be processed by the programs developed by you are available at the SIGAA's virtual classroom.

1. Describe, in your own words, what are sampling and quantization. Given the function $f(x) = -0.5x^2 + 3.5x + 1$, generate the binary code that represents the digitized signal using a sampling rate of 0.5 units in the interval $[0, 5]$ and 16 grey levels. Consider that the grey levels 0 and 15 are equal to the function values 0 and 7.5, respectively.

2. Implement, from scratch, convolution on the spatial domain. Your function should receive the kernel and its dimensions as parameters. Considering that the kernel is square and has odd dimensions d, ignore the first and last $d/2$ rows and columns. Use it to perform low-pass and high-pass filtering on some images.

3. Implement, from scratch, the histogram equalization technique and apply it to the images of the test set with low contrast.

4. Implement, from scratch, the median filter and apply it to the images with salt-and-pepper noise.

5. Using a Fourier transform library, implement the high-frequency emphasis filter defined by:

$$g(x, y) = \mathfrak{F}^{-1}\{[k_1 + k_2 H_{HP}(u, v)]F(u, v)\},$$

where $k_1 \geq 0$ offsets the value the transfer function so as not to zero-out the dc term, and $k_2 > 0$ controls the contribution of high frequencies. Process the image "full body PET - original.jpg", varying the values of k_1 and k_2 and select the best values, in your opinion.

6. Given the DFT translation property:

$$f(x, y)e^{j2\pi(u_0x/M+v_0y/N)} \Leftrightarrow F(u - u_0, v - v_0) \ \text{ and}$$

$$f(x - x_0, y - y_0) \Leftrightarrow F(u, v)e^{-j2\pi(ux_0/M+vy_0/N)},$$

show that $f(x, y)(-1)^{x+y} \Leftrightarrow F(u - M/2, v - N/2)$.

7. A professor of archeology doing research on currency exchange practices during the Roman Empire recently became aware that four Roman coins crucial to his research are listed in the holdings of the British Museum in London. Unfortunately, he was told after arriving there that the coins had been recently stolen. Further research on his part revealed that the museum keeps photographs of every item for which it is responsible. Unfortunately, the photos of the coins in question are blurred to the point where the date and other small markings are not readable. The cause of the blurring was the camera being out of focus when the pictures were taken. As an image processing expert and friend of the professor, you are asked as a favor to determine whether computer processing can be utilized to restore the images to the point where the professor can read the markings. You are told that the original camera used to take the photos is still available, as are other representative coins of the same era. Propose a step-by-step solution to this problem.

8. Describe which problem you will try to solve in your end of course project, which are the Image Processing sub-areas involved and which techniques you intend to use.