Universidade de Brasília (UnB)
Faculdade de Tecnologia (FT)
Departamento de Engenharia Elétrica (ENE)

Course: Image Processing
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Semester: 2017.1

LIST 03
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Part 1 – Theory

Question 1.1: One way to obtain the 2-D discrete derivative (approximation) is to calculate the differences $f(x + 1, y) - f(x, y)$ and $f(x, y + 1) - f(x, y)$.

(a) Find the equivalent filter in the frequency domain $(H(u, v))$.

(b) Show that this filter is a high-pass filter.

Question 1.2: Consider the images in Figure 1. The image on the right was obtained by: (1) filtering the image on the left with a low-pass Gaussian filter and (2) filtering the result with a high-pass Gaussian filter. The images have 420×344 pixels and both filters have a cut-off frequency $D_0 = 25$.

(a) Explain why the central part of the image on the right (the ring) has a solid and shiny appearance, considering that the main characteristics of the filtered image are the lines in the outer border of the objects (e.g. fingers, bones, etc.) with a darker area between these lines. In other words, wouldn't it be expected that the high-pass filter produced a constant area inside the ring, given that the high-pass eliminates the DC term?

(b) If we invert the order in which we apply the filters, would the result remain the same?

Question 1.3: The white bars in the image shown in Figure 2 are 7 pixels wide and 210 pixels high. The separation between the bars is 17 pixels wide. How would this image look if we apply:

(a) Arithmetic average filters of size 3×3 and 7×7;

(b) Geometric average filters of size 3×3 and 7×7;

(c) Contra-harmonic filters with $Q = 1$ and $Q = -1$, with size 3×3 and 7×7;

(d) Median filters of size 3×3 and 7×7.

Question 1.4: Consider a linear and position invariant degradation system with impulsive response:

$$h(x - \alpha, y - \beta) = \exp^{-[(x-\alpha)^2 + (y-\beta)^2]}.$$
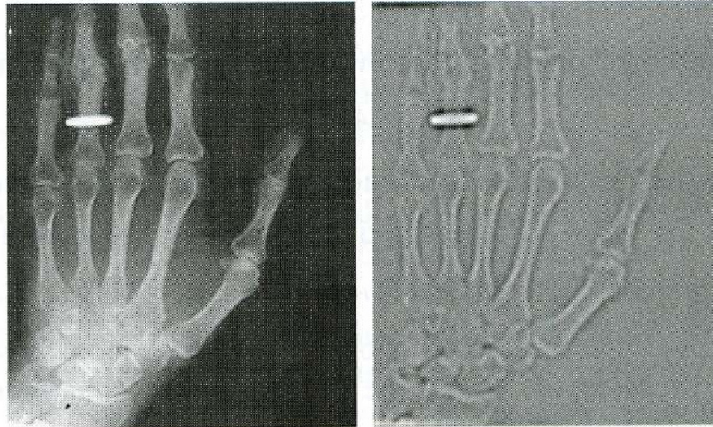
Original image courtesy of Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School.
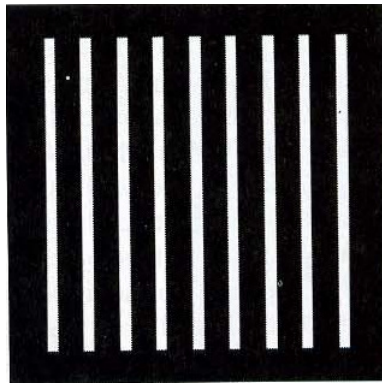
Figura 1: X-ray images.

Figura 2: Image with vertical bars.

Suppose that the input of the system is an image consisting of one line of infinitesimal width, located at $x = a$ and modulated by $f(x, y) = \delta(x - a)$, where δ is the impulse functions. Assuming that there is no noise, what is the output image $g(x, y)$?

Question 1.5: Show that the subtraction of the Laplacian of an image is proportional to the 'unsharp masking'. Use the Laplacian definition given by equation (3.7-4).

Part 2 – Practice

Question 2.1 Download the images fig_lista3_1.bmp e fig_lista3_2.bmp from the course homepage, using them as the originals for the questions below.

(a) Implement a equalization algorithm using a global approach, i.e. an approach based on the histogram of the full image. Calculate the histograms of the original images. Apply the global equalization method for the two images. Display the original images and their equalized versions, along with the corresponding histograms.

(b) Implement a equalization algorithm using a local approach, i.e. instead of using the histogram of the full image, apply the equalization method in small sub-areas (sub-images) of the image. Apply the local equalization method for the two images, considering areas of sizes 5×5 and 7×7. Display the original images and their equalized versions, along with the corresponding histograms. Compare the results with the results obtained in (a).

Question 2.2

(a) Write a program that executes a spatial filtering of an image. Your program should allow that the user enter with the coefficients and the size of the spatial mask.

(b) Use the program developed in (a) to implement an enhancement (sharpening) technique using a Laplacian filter. Test your program with the image 'catedral' (available for download in the course homepage).

(c) Use your program to implement a 'high-boost' filter. The low-pass filter h_{lp} to be used here is given by:

$$\mathbf{h_{lp}} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

Use the implemented high-boost filter to enhance the 'catedral' image.

Question 2.3: Download the file 'imagensruidosas' from the course homepage. This compressed file has a set of noisy images. Implement 5 filters (your choice) to remove noise. Use these filters to remove the noise in each of the images. Discuss the obtained results. When possible, describe the type of noise present in the image.