Programming Assignment 1: Non-linear averaging for image processing

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1 Introduction

Since the origins of image processing it has been an increasing interest in finding the best way of locating the edges in the images. The edges could be used in a great variety of applications and very specially in segmentation. There are several algorithms that are able to solve this task, like Canny algorithm or masks based in approximations for the discrete form of the first derivation as Sobel or Prewitt, but they are not accurate when the image is noise or when the image presents textures. Removing the noise or blurring the image to avoid problems with textures will lead to an erosion of the edges. This is due to the use of high pass filter, the noise usually has high frequencies and the edges too. Then the easy and classical average is not useful for our purposes. One way to solve the problem is using a non-linear filter.

2 Fundamentals

The filter should consider if the pixel to study is part of an edge (or surrounded by one) or not, giving a certain weight that will change depending in the intensity values of the neighbourhood to consider. Let consider the following expressions for the definition of the new filter.

$$I_0(x,y) = I(x,y) \tag{1}$$

$$I_{n+1}(x,y) = \sum_{i=-1}^{1}\sum_{j=-1}^{1} w_{ij} I_n(x+i,y+j) / \sum_{i=-1}^{1}\sum_{j=-1}^{1} w_{ij} \tag{2}$$

$$w_{ij} = exp(-k|I_n(x,y) - I_n(x+i,y+j)|) \tag{3}$$

In this filter k is a positive number, and the variation on this value is going to be one of the two parameters to set. The other parameter will be the number of iterations, in the case, n. The weights for each pixel depends in the variations with respect to the neighbours that surround, for each iteration.

3 Evaluation and analysis

3.1 Analysis of k variation

First evaluation was made over the different values of k. It will affect the weight, making the filter effect weaker as this value is increased. The effects could be appreciated in the image 1.

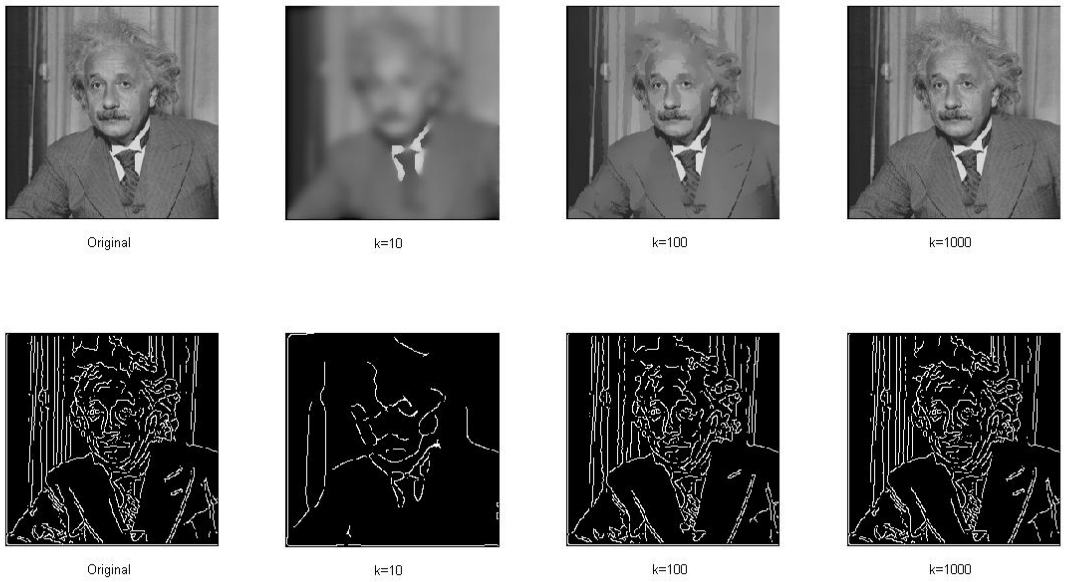


Figure 1: Effects of varying k over the image for 50 iterations

It can be appreciated the differences in the two central images, where some areas have been smoothed while the edges could still been detected. An edge detection have been applied to the same images to check with detail the effects when k varies. If k is too big, the effects of the filter over the image are negligible.

3.2 Analysis of n, number of iterations

The number of iterations is the second parameter that should be set for a good performance of the filter. The bigger the number of iterations the more homogeneous will be the areas that compound the image, but also much more computational expensive.

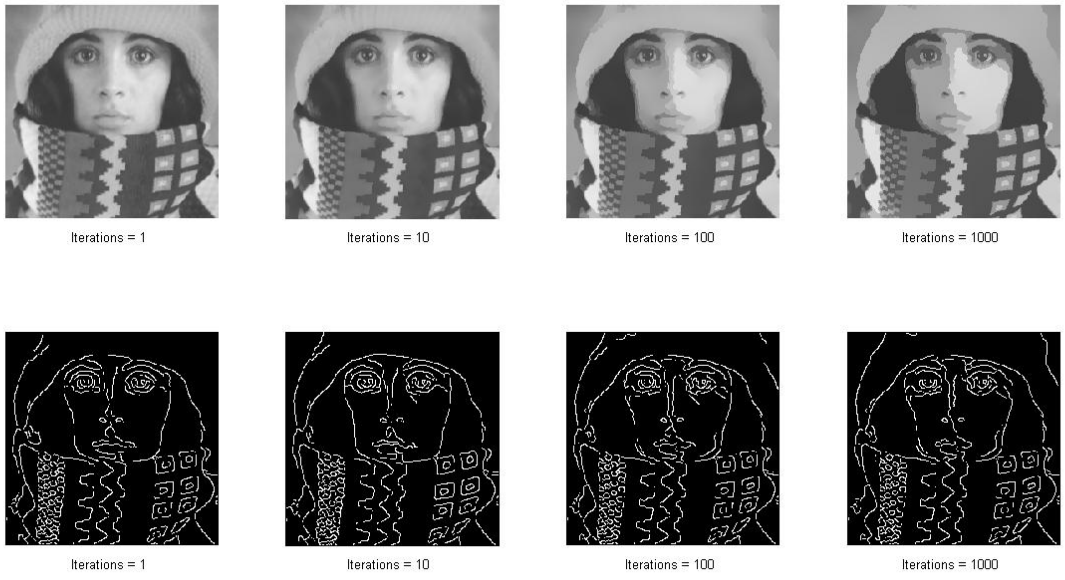
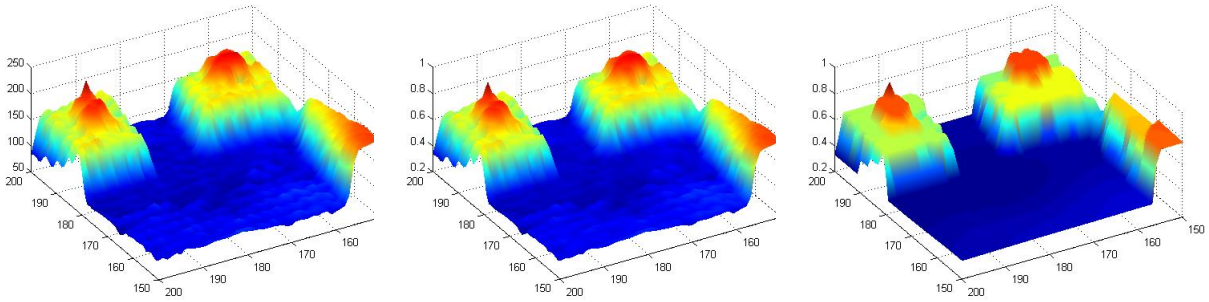


Figure 2: Effects of varying n, n of iterations for k=100

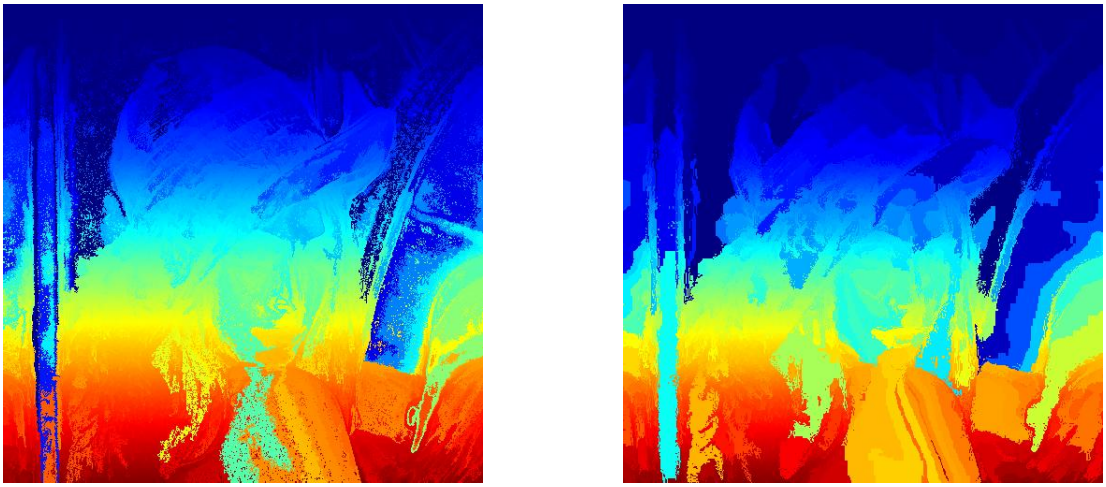
In the Fig.2, several experiments with different number of iterations were performed. For a deeper analysis a mesh plot over a small area of the same image will be shown in Fig.3.



(a) Original (b) n= 1 Iteration (c) n= 100 Iterations

Figure 3: Analysis with mesh grid plot for [125:200 ;125:200] for 'trui.tif'and k=100

As a simple example of how much the noise can be reduce and how good it could be for segmentation purposes the region growing algorithm was implemented over two different images, as is reflected in Fig.4



(a) Original image (b) n= 100 iterations, k= 100

Figure 4: Region growing segmentation analysis

The results shows a great reduction of the noise for the filtered image. The information of the edges is remaining but special care should be taken with the illumination sources and its effects over the filtered image.

References

[1] Perona, Pietro, and Jitendra Malik. "Scale-space and edge detection using anisotropic diffusion." Pattern Analysis and Machine Intelligence, IEEE Transactions on 12.7 (1990): 629-639.

[2] 'Advanced Image Analysis Notes', Alexander Belyaev, Heriot Watt University, 2014