IPPR Lab 3: Restoration of Noisy Images

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1 Introduction

If an image is corrupted by an additive noise but there is no degradation,[1] then we have

$$g(x, y) = f(x, y) + \eta(x, y)$$

where $g(x, y)$ is the corrupted image, $f(x, y)$ is the actual but unknown image, and $\eta(x, y)$ is the noise. However, since $\eta(x, y)$ is unknown, it is impossible to find actual $f(x, y)$. Even if we know the form of noise $\eta(x, y)$, we cannot restore $f(x, y)$ since we do not know the parameters of the noise. For example, even if we know that the noise is Gaussian, it is not possible to know its mean and variance by observing $g(x, y)$ only. Because of these difficulties, noise reduction is a sort of art that requires intelligent guessing.

Filtering of additive noise is generally done in the spatial domain.

2 Related Concepts

For the purpose of this lab, you require the following definitions. Let S_{xy} denote the pixels in a box of size $m \times n$, centered around (x, y). Let $\hat{f}(x, y)$ denote the estimate of the actual image.

$$\text{Mean filter:} \qquad \hat{f}(x, y) = \frac{1}{mn} \sum_{(r,c) \in S_{xy}} g(r, c)$$

$$\text{Median filter:} \qquad \hat{f}(x, y) = \underset{(r,c) \in S_{xy}}{\text{median}} \{g(r, c)\}$$

Note that the program for calculating mean filter will be similar to that for convolution or correlation. You will require nested loop up to four levels. The first two loops is required to access each pixel, and the remaining two loops to

[1]'Degraded image' is a technical term that should not be confused with corrupted image. Refer to your textbook.

access the pixels within the filter window. In the case of median filter, you need to make an extra effort to sort the elements in the filter window.

To assess the performance of noise reduction algorithms, we can use many objective parameters. If we are given the original image, then we can calculate the mean-squared signal-to-noise ratio, which is defined as following.

$$\mathrm{SNR}_{\mathrm{ms}} : \qquad \frac{\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\hat{f}(x,y)^2}{\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}[\hat{f}(x,y)-f(x,y)]^2}$$

Here, we have consider the images are of size $M \times N$.

3 Problems

1. Implement mean and median filters. For simplicity, consider the filter-box to be a square of size $m \times m$, where m is odd. In addition, you can ignore the boundary pixels. For this problem, you are given three images "messi_N.jpg","ronaldo_N.jpg", and "ronaldo_de_lima_N.jpg". These images are corrupted by different types of noises. Visually inspect the noise types and guess which filter would be better. Apply the appropriate filter and observe the results.

2. You are given the noise-free images for their noisy counterparts in the previous question. The noise-free images are "messi.jpg","ronaldo.jpg", and "ronaldo_de_lima.jpg". For each image pair (noisy-noiseless) and each filter (mean and median), calculate the mean square signal-to-noise ratio and tabulate your results. Which is the better filter in your opinion?