IMAGE PROCESSING (RRY025)

One of the Exams in 2009/2010

1 NOISE REDUCTION [18 points]

(a) [3p] What is noise? Which are the most important types of noise? Can noise look like the signal?

(b) [5p] What is smoothing? What is thresholding? There is a very important difference between these two methods of noise reduction, a difference which affects the quality of the denoised image. Discuss!

(c) [3p] Consider the following 5-bit image of size 5×5, sent by horizontal raster scanning:

0, 1, 2, 3, 4, 15, 16, 17, 18, 5, 14, 23, 24, 19, 6, 13, 22, 21, 20, 7, 12, 11, 10, 9, 8.

Write down this image in the right format (5×5). What does the image look like? What about its histogram? Pollute this image with salt and pepper noise by choosing 7 pixels randomly and by changing their grey level accordingly, so that the noisy image is still 5-bit. Write down this image. What does the image look like? What about its histogram? What is the (root-mean-square) signal-to-noise ratio of your noisy image?

(d) [5p] Which filter would you choose for denoising your noisy image? Justify the choice of your filter: type, size, etc. Apply your filter. Write down the denoised image. Are you satisfied by the result? Discuss!

(e) [2p] Consider again your noisy image. Denoise it using a simple averaging filter (of the same size as your previous filter), and round the output grey levels to the nearest integer. Compare with the result in **(d)**, and draw your conclusions.

2 MISCELLANEA [12 points]

(a) [1p] Two images have the same, but really the same, Fourier power spectrum. What does this imply?

(b) [2p] An image consists of purely white noise. What does its Fourier power spectrum look like? Are you really sure?

(c) [4p] What are the strong and the weak points of the fast wavelet transform, the block discrete cosine transform and the discrete Fourier transform?

(d) [2p] How would you smooth an image using wavelets? And how would you control the resolution of the smoothed image?

(e) [3p] How would you sharpen an image using wavelets? And how would you high-boost it?

Brief Hints/Answers to Some of the Questions

1 Noise Reduction

(a) ... Which are the most important types of noise? ...

With respect to what?

- Its statistical properties: Gaussian, ...
- Its frequency content: white, ...
- Its coupling to the signal: additive, ...

... Can noise look like the signal?

Yes! And the signal can look like noise!! ...

(b) ... What is thresholding? ...

As a method of noise reduction! See heading of Question 1, and see the next point!!

... There is a very important difference between these two methods of noise reduction, a difference which affects the quality of the denoised image. ...

Smoothing always lowers the resolution of the image. Thresholding, if done appropriately, preserves the resolution of the image. ...

(c) ... Pollute this image with salt and pepper noise... (2)

Salt and pepper → white and black $\xrightarrow{\text{5-bit}}$ 31 and 0 (grey levels)...

... What is the (root-mean-square) signal-to-noise ratio of your noisy image?

$$SNR = \sqrt{\frac{\sum X_{ij}^2}{\sum (Y_{ij} - X_{ij})^2}}$$

$\{X_{ij}\}$ = original image

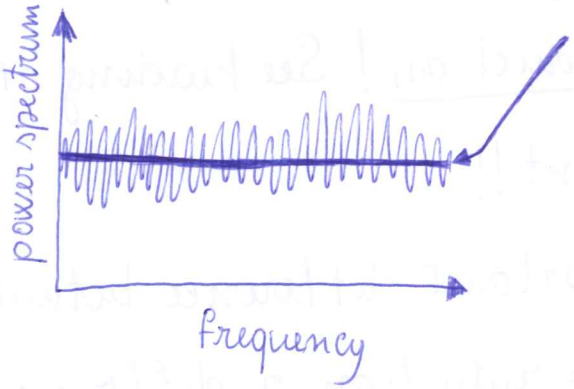
$\{Y_{ij}\}$ = your noisy image

Note: $\sum_{k=1}^{n} k^2 = \frac{n(n+1)(2n+1)}{6}$ ☺

2 Miscellanea

(a) It does not imply that the two images are the same, since nothing is stated about the Fourier phases...

(b)



⟨power spectrum⟩ = constant

but power spectrum ≠ constant!

--- Are you really sure?

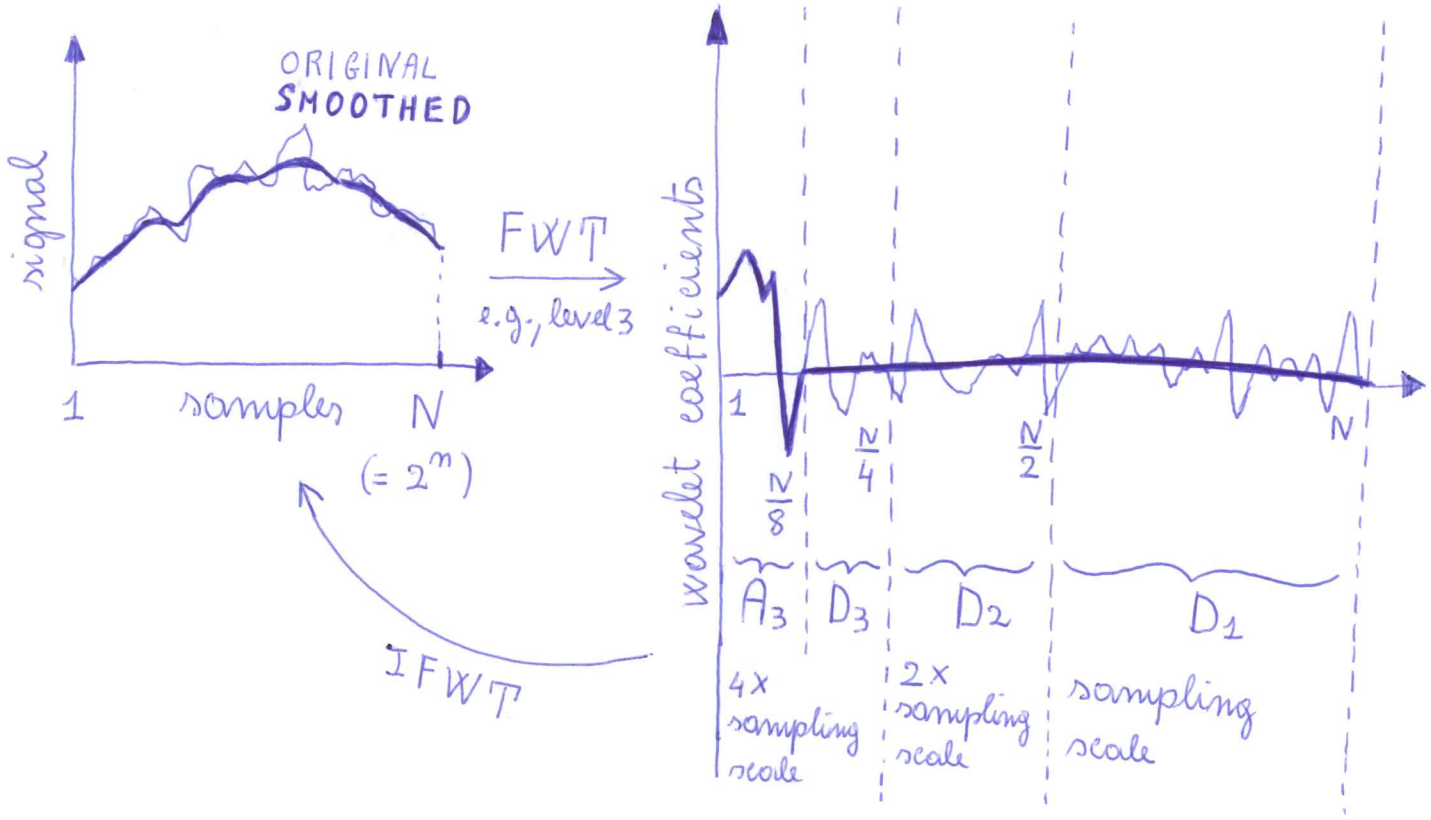
(In case you answer: power spectrum = constant)

Reflect further:

- Sampling ---
- Truncation ---

(d)

smooth in wavelet domain = set the details to zero



- D_ℓ = details at $2^{\ell-1}$ × sampling scale →

How to **smooth** at resolution = 2^r × sampling scale:

* FWT at level $\ell = r+1$
* Set the detail coefficients to zero
* IFWT

(e) Similarly to (d):

How to **sharpen** at resolution = 2^r × sampling scale:

* FWT at level $\ell = r+1$
* Set the approximation coefficients to zero
* IFWT

How to **high-boost** at resolution = 2^r × sampling scale:

* FWT at level $\ell = r+1$
* Multiply the detail coefficients by a factor $f > 1$
* IFWT