

# Multimedia Telecommunications

## Exercise Session 7

### Exercise 1: *lifting steps*

1. Find the lifting steps representation of the following filters: `haar`, `db4`, `cdf3.1`;
2. Write the corresponding polyphase matrices  $\tilde{P}(z^{-1})$  and  $P(z)$ ;
3. Display the corresponding analysis and synthesis filters;
4. For all the considered filters perform the DWT on the images `einstein.jpg`, `mandrill.tif`, `scale.tif` with  $J = 4$  (four decomposition levels) using (i) the classical implementation; and (ii) the lifting steps implementation;
5. Verify that
  - (a) The two decompositions are equivalent;
  - (b) Perfect reconstruction holds in both cases.
6. Quantize the wavelet coefficients of all the subbands uniformly with quantization step  $Q = 4$ . Reconstruct the image and display the result.
7. For the filter `cdf3.1`:
  - (a) Exchange the analysis and synthesis filters and perform the decomposition on the image `einstein`. Are the resulting subbands different from those previously obtained? Why?
  - (b) Quantize the wavelet coefficients of all the subbands uniformly with quantization step  $Q = 4$ . Reconstruct the image and display the result. Is the resulting image different from the one obtained before exchanging the filters? Why?
  - (c) Evaluate the PSNR in the different cases.
  - (d) Perform the DWT of the same images using the *integer* version of the lifting steps implementation. Does perfect reconstruction hold? Give a proof and comment your answer.
  - (e) For the filter `db4` and the image `mandrill`, quantize the wavelet coefficients of all the subbands uniformly with quantization step  $Q = 1$  for both the rational and integer filters. Reconstruct the image in both cases. Do the images differ? Why?