

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`, `Flowers.003.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 for $Q = 4$. 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 ranging from $Q = \log_2 \max(abs(c_{i,j})/2, \dots, 1)$ for both the rational and integer filters. For each quantization step calculate the PSNR and plot the results.