Lab 1

3 March 2014

This lab is based on the VCDemo software, developed by the ICT-Group at Delft, and on Matlab.

1. **RD vs Bit Rate for Various Image Compression Methods**

   (i) Load the "Birds" image - in case you cannot find this image in the VCDemo default image folder, download the Data folder from the course website (moodle). Compare the rate distortion (RD) behavior of the following image compression methods. Use the RD utility provided by the VCDemo.

   (a) PCM. Use different bit rate values from $1\ldots7$ bpp.

   (b) DCT. Use all the available bit rate values.

   (c) DPCM. Use different bit rate values from $1\ldots6$ bpp.

   (d) JPEG. Here we consider two versions of JPEG; one with "standardY" quantization table and one with "Flat" quantization table. For each version, use bit rate values of {0.2, 0.5, 1, 2, 3, 4} bpp.

   (e) JPEG2000. Use all the available bit rate values.

   Plot the RD curves for all methods in the same graph. What do you observe?

   (ii) Load the "Build512B" image. Compare the RD curves of JPEG2000 between the two images. Discuss the results.

   (iii) Load the "Birds" and "Build512B" images. For each of them, make a visual comparison between the JPEG and JPEG2000 compressions at low bitrate (0.2 bpp for example). Which compression is the best according to the visual quality? What are the visual artifacts brought by these two kinds of compression?

2. **DCT**

   (i) Write a MATLAB code that examines the effect of quantization in the DCT domain. Use an 8×8 DCT, and choose the quantization step sizes to be multiples of the following quantization table.

$$\begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}.$$

   Try scale factors of 0.5, 1, 2, 4, 8, and 16. What is the largest scale factor that still provides a satisfactory image? Use "Lenna" for testing.
   (Hint: use the `blockproc` and `dct2` built-in MATLAB functions)

   (ii) Modify your MATLAB code so that it also examines the effect of approximating an image with a partial set of DCT coefficients. Use again 8x8 DCT and reconstruct the image with $K < 64$ coefficients, for $K = 2 \times 2, 4 \times 4, 6 \times 6$. Try the partial reconstruction on both the quantized (scale factor = 2) and the original set of DCT coefficients. How many coefficients are necessary to provide a satisfactory reconstruction? Use "Lenna" for testing.
   (Hint : have a look at `idct2` input arguments)

3. 2D Wavelets

A 2-level 1D Discrete wavelet transform scheme is given in Fig 1. This scheme is applicable to 2D images by applying the filters on rows and columns separately. Fig 2 shows 1st level decomposition in which L denotes the lowpass filtered part and H denotes the highpass filtered part.

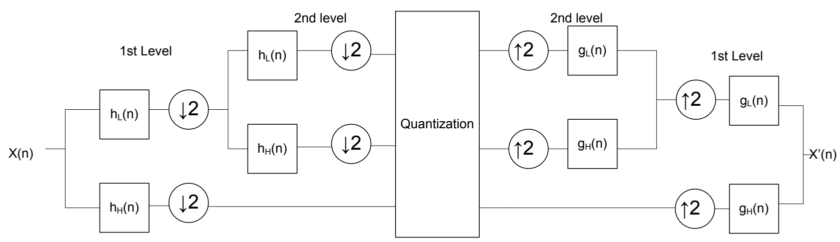

Figure 1: 1D Discrete Wavelet scheme with an optional quantization step

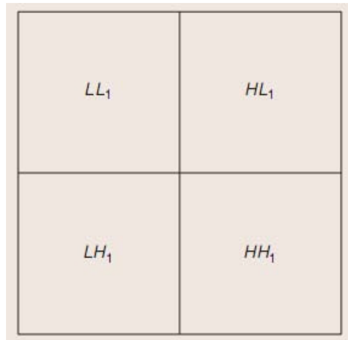

Figure 2: 1st level decomposition step

h_L, h_H are lowpass and highpass filters for the analysis part of the scheme. g_L, g_H are the synthesis filters. In this exercise, we will use 9-tap / 7-tap Daubechies filter set which is used in JPEG2000 image compression. Filter functions are available in filters.mat file which can be downloaded from the course webpage (moodle).

(a) Plot the filter functions.

(b) Implement the **first level** wavelet analysis and synthesis scheme. (Hint: use `conv2` function for the filtering operations.) Apply the scheme on Lena image. Plot LL,LH,HL,HH images and the reconstructed image.

(c) Truncate HH part of the coefficients and observe the image, comment on the result. Truncate LH,HL and HH parts and reconstruct the image. Comment on the result. What is the advantage of such a decomposition?