Digital Television Techniques / 2013

Exercise 1, Video compression, 28-March-2013

This exercise shall be returned to the lecturer (Jerker Bjï¿½rkqivst) electronically at https://abacus.abo.fi/ro.nsf Deadline is April 12, 2013.

1. The transformation from the (R, G, B) color plane to the (Y, Cr, Cb) is in TIFF and JPEG (YCC, Rec 601-1) defined as

$$
\begin{bmatrix} Y \\ Cr \\ Cb \end{bmatrix} = \begin{bmatrix} 0.2989 & 0.5866 & 0.1145 \\ 0.500 & -0.4183 & -0.0816 \\ -0.1687 & -0.3312 & 0.500 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}
$$

   Calculate the (Y, Cr, Cb) representation (0-255) for the (R, G, B) values 0x36733D and 0x22824E. Note! The Cr and Cb values must be shifted up with 127.5. What is the reverse transform?

2. The DCT transform in 2 dimensions are defined as

$$
S(u, v) = C(u)C(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} s(x, y) \cos\left[\frac{(2x + 1)u\pi}{2N}\right] \cos\left[\frac{(2y + 1)v\pi}{2N}\right]
$$

   where $s(x, y)$ is the original signals of the $N \times N$ sized matrix of luminance values corresponding to picture pixels, x and y are the coordinates in the spatial plane, $S(u, v)$ are the frequency components and u and v the coordinates in the frequency plane. The coefficients $C(k)$ are defined as

$$
C(k) = \begin{cases} \sqrt{\frac{1}{N}} & \text{if } k = 0 \\ \sqrt{\frac{2}{N}} & \text{if } k \neq 0 \end{cases}
$$

   For the following picture s, calculate the corresponding DCT transformation.

$$
s = \begin{bmatrix} 1 & 2 & 3 & 2 \\ 2 & 3 & 5 & 2 \\ 3 & 7 & p & 3 \\ 2 & 5 & 5 & 3 \end{bmatrix}
$$

   where p is the last digit of the day of the month of you birth date (e.g. for July, $p = 7$).

   After this, perform a quantization of the coefficients in 3 bits (8 levels), as scaling you can use $S = aS' + b$ where a and b are coefficients and S' is the quantified matrix. Calculate the matrix S' and the scaling factors. After this, perform the inverse DCT transformation. What is the error compared to the original signal?

   IDCT is defined as

$$
s(x, y) = \sum_{u=0}^{N-1} C(u) \sum_{v=0}^{N-1} C(v)S(u, v) \cos\left[\frac{(2u + 1)x\pi}{2N}\right] \cos\left[\frac{(2v + 1)y\pi}{2N}\right]
$$

3. Two pictures are given in the files:

   http://user.abo.fi/jbjorkqv/cat1.txt
   http://user.abo.fi/jbjorkqv/cat2.txt

The picures, size 232x217, are given as pixel greyscale levels 0-255, each row corresponds to a row in the picutre, each column to to a column, in comma separated ASCII format. Calculate the motion (i.e cat2 vs. cat1) vector for the Macroblock (16x16) located at position (112,112).

The motion vector in this case is a relative movement of the macroblock.