Digital Television Techniques / 2010

Exercise 1, Video compression, 25-March-2010

This exercise shall be returned to the lecturer (Jerker Bjï¿½rkqivst) electronically at https://xprog28.cs.abo.fi/ro.nsf
Deadline is April 7, 2010

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 0x46733D and 0x21824E. 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

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