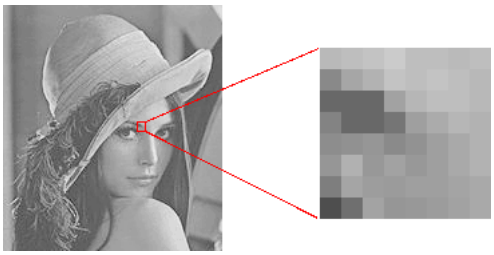
Exercise Multimedia Technology WS 2003/2004

Sheet 2 (October 31st 2003)

2.1 DCT coding

The table below lists gray values for a given block of the well-known image *lena*.



185	190	195	203	190	190	186	190
137	166	178	195	190	195	190	184
104	104	104	162	182	190	190	184
131	104	104	117	159	171	182	178
141	145	150	138	146	159	169	178
150	177	152	162	152	159	169	178
126	165	157	155	159	159	164	169
78	111	163	150	152	156	162	169

Transform the block according to the forward 2D DCT equation presented in the lecture. The resulting coefficients may be rounded to full integer values by cutting values after the decimal point. The table of gray values is located at the following URL:
http://www.informatik.uni-mannheim.de/pi4/data/8x8block.txt

Coefficients after the transformation of the image:

1281	-121	-21	-11	-7	-6	-7	-6
83	-3	-9	29	17	10	-2	-7
60	32	-41	-39	-12	0	4	-2
72	85	31	-17	-7	-6	-5	-9
-20	0	14	-1	0	7	19	17
-7	-2	16	24	11	-3	-6	0
-7	-15	-2	3	11	5	-3	-7
-2	-3	-6	-3	1	0	0	-2

2.2 DCT Quantization

Now do the quantization of the coefficients from the previous exercise according to the following quantization table. Again, round the values like you did before.

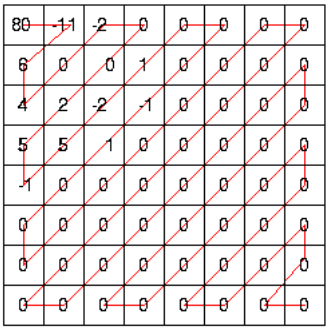
16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

The URL for the above table is
http://www.informatik.uni-mannheim.de/pi4/data/qtable.txt

80	-11	-2	0	0	0	0	0
6	0	0	1	0	0	0	0
4	2	-2	-1	0	0	0	0
5	5	1	0	0	0	0	0
-1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

2.3 Zig-Zag order

What is the longest run of continuous zero values according to the zig-zag ordering of the coefficients?



The longest run consists of 45 zeros.

2.4 Reconstruction of the image

Now decode the quantized coefficients. You may have to investigate the equation for the inverse DCT[1]. Display both the original image and the decompressed version. How did the characteristics of the image change? Try to explain why.

Forward DCT:

$$S(v,u) = \frac{C(v)}{2}\frac{C(u)}{2}\sum_{y=0}^{7}\sum_{x=0}^{7} s(y,x)cos\left(\frac{(2x+1)u\pi}{16}\right)cos\left(\frac{(2y+1)v\pi}{16}\right)$$

Inverse DCT:

$$s(y,x) = \sum_{v=0}^{7}\frac{C(v)}{2}\sum_{u=0}^{7}\frac{C(u)}{2}S(v,u)cos\left(\frac{(2x+1)u\pi}{16}\right)cos\left(\frac{(2y+1)v\pi}{16}\right)$$

$$C(u) = 1/\sqrt{2} \text{ for u=0 and } C(u) = 1 \text{ else}$$

$$C(v) = 1/\sqrt{2} \text{ for v=0 and } C(v) = 1 \text{ else}$$

The reconstructed image appears to be smoother. This is caused by the high quantization values in the quantization table. Those coefficients which are responsible for the higher frequencies are quantized by large values, causing a rougher approximation. This is justified since the human visual system is less sensitive for high frequencies.
A sample implementation is available at:
http://www.informatik.uni-mannheim.de/pi4/data/dct.tgz

References

[1] J. Mitchell W. Pennebaker. *JPEG - Still Image Data Compression Standard.* Van Nostrand Reinhold, New York, 1993.