EEE116 – Multimedia Systems (2007/08)

Solutions to Tutorial Problem Sheet 8
Week 10

(Q14)

Gray level values of an 8-bit 4x2 image are shown below. You have been asked to reduce the colour depth resolution of this image.

251	234	155	191
241	211	171	111

(i) What quantisation factor would you use if you had to reduce the colour depth to 5 bits?

The current representation uses 8 bits.

An 8 bit image can show values from 0-255. (Max value 2^8-1)
A 5 Bit image can show values from 0-31. (Max value 2^5-1)

Therefore, the bit depth conversion should map 255 into 31.

This can be achieved by using a Quantisation factor of 255/31 = 8.226.

(ii) Compute the reconstructed (quantised and de-quantised) image for the above case.

Let us assume
Original value is X;
Quantisation factor = Q = 8.226
Then the quantised value Xq=round(X/Q) (Eq. 1)
The reconstructed value Xr=round(XqQ) = round(round(X/Q)Q) (Eq. 2)

The rounding in the reconstruction equation is to make sure that the result is an integer value, so that the finite number of bits can be used.

X =

251	234	155	191
241	211	171	111

Using (Eq. 1)

Xq =

31	28	19	23
29	26	21	13

Using (Eq.2)

Xr =

255	230	156	189
239	214	173	107

(iii) What is the PSNR (Peak Signal to Noise Ratio) of the reconstructed image?

Peak value for 8-bit image is 255
PSNR = 10 $\log_{10}$ (255^2/MSE)
We need to compute the MSE= Mean (square (error))

Error= Xr – X

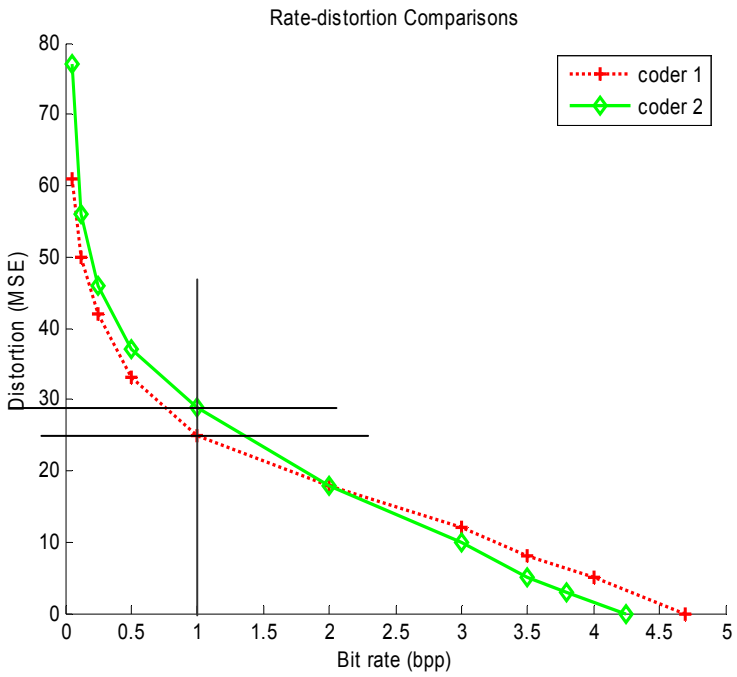
$$= \begin{matrix} 4 & -4 & 1 & -2 \\ -2 & 3 & 2 & -4 \end{matrix}$$

Square(Error) = $\begin{matrix} 16 & 16 & 1 & 4 \\ 4 & 9 & 4 & 16 \end{matrix}$

Mean(square (error)) = (16+16+1+4+4+9+4+16) / 8 = 8.75

PSNR = 10 $\log_{10}$ (255^2/8.75)
= 38.71 dB

(Q15)



Rate-distortion plots for two image coders using an 8 bpp image are shown in the figure.

(i) Compute the lossless compression ratio for each codec and comment on their efficiency.

(ii) Compute the PSNR values for the two codecs when a compression ratio of 8:1 is used.

(iii) Which codec performs better for compressing images to a high compression ratio?

(i) compression ratio = (original bit rate) / (new bit rate)

For lossless coding the distortion is zero. Therefore, MSE=0
Therefore,
Lossless coded bit rate for the coder 1 is 4.7 bits per pixel (bpp)
Lossless compression ratio for coder 1 is 8 / 4.7 = 1.7:1.

Lossless coded bit rate for the coder 2 is 4.25 bpp.
Lossless compression ratio for coder 2 is 8 / 4.25 = 1.88:1.
Coder2 gives better performance, Therefore it is the better coder for lossless coding.

(ii)

The compression ratio of 8:1 corresponds to 1 bpp bit rate. (because the original bit rate was 8 bpp)

At this bit rate coder 1 and coder 2 result in 27 and 29 MSE, respectively.

Using PSNR=10 $\log_{10}$ (255^2/MSE)

The PSNR values are 33.51 dB and 33.81 dB, respectively.

(iii) High compression ratios mean low bit rates.
Lower MSEs are better than the higher MSEs.

Coder1 results in low MSE at low bit rates. Therefore it is the better coder for lossy coding.

(Q16)

An SDTV resolution YCbCr 4:2:2 @ 30 fps video sequence is encoded using the MPEG-2 standard with a Group of Picture (GOP) size of 9 pictures. The coding scheme uses 2 B frames between 2 consecutive P frames.

(i) Compute the data rate of the uncompressed video sequence

SDTV resolution
Resolution of the Y component frame WxH= 720x576 pixel / Frame
Bit resolution (assume) N= 8 bits/pixel
Frame rate T = 30 frames /sec
4:2:2 chroma sampling results in
Y: x x Cb: x Cr: x
x x x x

Total pixels = 4+2+2 = 8
Y pixels = 4
Therefore the chroma sampling factor S= 8/4 = 2

Uncompressed data rate= WxHxNxFXT
=720x576x8x2x30 = 199065600 bits/sec
=189.8 Mbits/sec

(ii) What is the I-B-P coding structure used in this specification?

I B B P B B P B B I

(iii) If the compression ratios obtained for I, P and B frames (including motion vector and prediction error coding) are 20:1, 40:1 and 80:1, respectively, what is the bit rate of the compressed video?

Using the above coding pattern, we will have

1 I frame

6 B frames

2 P frames

for every 9 frames (that is for every group of pictures.)

Assume the original data rate for each frame is X bits/frame respectively.

The data size for original 9 frames is 9X

After compression,

the size of an I frame is X/20 bits/frame

the size of a P frame is X/40 bits/frame

the size of a B frame is X/80 bits/frame

Therefore, the new size of a GOP is = 1(X/20)+6(X/40)+2(X/80)

= (4+6x2+2)X/80 =18X/80

Therefore the compression ratio is

= uncompressed GOP size / compressed GOP size

= 9X / (18X/80)

= 40:1

The data rate of the compressed video is

= uncompressed data rate / Compression ratio

= 189.8 /40 Mbits/sec

= 4.7 Mbits/sec

This is a reasonable data rate for transmission.