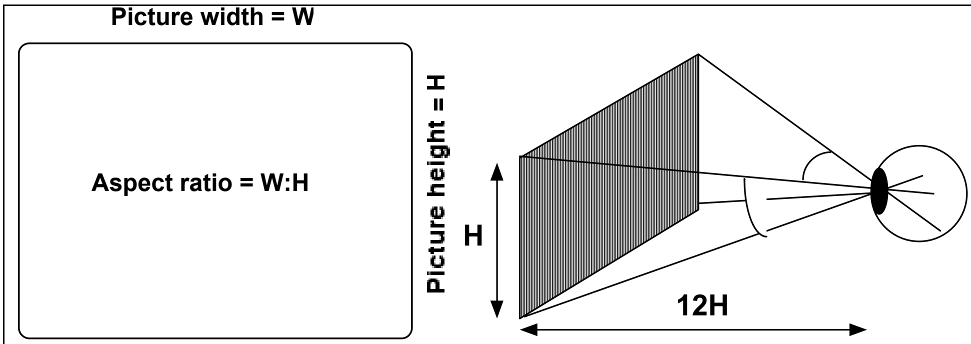
EEE116 – Multimedia Systems (2006/07)

Solutions to Tutorial Problem Sheet 7
Week 9

(Q.11)

(i) Estimate the resolution (in pixels (picture elements) of a static display



Vertical angle subtended on eye = H /12H = 1/12 radians = 4.8 degrees
Horizontal angle subtended on eye = (1/12)*(4/3) =1/9 radians = 6.4 degree

Spatial cut-off frequency= 60 cycles per degree

Therefore, No of cycles per picture height = 288
No of cycles per picture width = 384

Using the Nyquist limit,

Pixels per picture height = 288 x 2 = 576

Pixels per picture width = 384 x 2 = 768

Spatial resolution is 768 x 576

(ii) Estimate the computer memory requirements (in bits) to hold (a) one monochrome screen, and (b) one full colour screen.

(a) Monochrome levels =100
Solve 2^N=100 to get N=7 bits per pixel
Therefore, total bits for a screen (a frame) = 576x768x7= 3,096,576 bits

(b) Different colour levels = 50000 – usually represents as 2 chroma spectral bands.
Solve 2^N=50000 to get N=16 bits per pixel.
In total 16+7=23 bits per pixel
Therefore, total bits for a screen (a frame) = 576x768x23= 10,174,464 bits

(iii) Estimate the total memory requirements to store one hour of video

The flicker rate is 70Hz. That means

Considering the Nyquist limit we should sample 140 frames per second.

Totals bits per second = total bits per frame * frames per second
= 10,174,464 bits/frame * 140 frames/second
= 10,174,464 x140
Total bits per one hour= 10,174,464 *140*60*60
= 5.1279e+012 bits
(divide by 2^{30}x8 to convert to G Bytes)
= 597 Gbytes

(iv) How do the above estimates compare with the actual screen resolution of practical displays and the total memory capacity of a DVD disc? Comment on your answers.

SDTV actual resolution 788*576 @25 frames per second interlaced with 24 bits per pixel colour.

A CD-ROM can store 850 Mbytes

A single–layer DVD can store about 4.5 Gbytes.

A standard size of a hard disc in a PC is about 100-200 Gbytes

(v) If the available bandwidth is premium and the Nyquist limit can be relaxed, revisit (i) and (iii) and define the new spatial and temporal resolutions. What is the new data rate?

If the Nyquist limit is relaxed we can exploit the CRT display mechanisms to reduce the bandwidth by reducing the spatial resolution and the frame rate.

Revisiting (i)

Number of active lines using the Kell factor of 0.7 lines= 288/0.7 = 411

Therefore, active pixels per line = 411*4/3 = 548

Spatial Resolution = 548 x 411

Revisiting (iii)

The flicker rate is 70Hz. That means 70 fields per second of interlaced video is sufficient. In other words, 70 fields per second are equivalent to 35 frames per second.

The number of bits per pixel is still 23.

Now we can compute the new data rate:

= bits/pixel x pixels/line x lines/frame x frames/sec

= 23x548x411x35

= 181,308,540 bits/sec

for one hour

= 181,308,540 x 60 x60 bits/sec (Now divide by 2^{30}x8 to convert to G Bytes)
= 76 Gbytes.

Data rate can be further reduced by Chrominance sub-sampling and of course by compression.

For example by using 4:2:2 we need only 7 bit for luminance + 16/2 bits for chrominance. (4:2:2 results in WxH/2 resolution)

Therefore we only need an equivalent of 15 bits/pixel for 4:2:2.

In 4:2:0, the chrominance resolution is W/2xH/2. That means they only need 16/4 bits for chrominance data. Therefore the total equivalent bits per pixel is 7+4 =11 bits/pixel. You can approximately halve the data rate (11~23/2) by using 4:2:0.