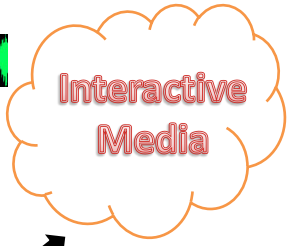
EBU5305

Interactive Media Design and Production

Digitisation

MEDIA
- Digitisation
- Colour models
- Image, Video, Audio representations
- Media Compression

DESIGN
- Cognitive Psychology
- Structure/Navigation
- Use of media
- Heuristic Evaluation



PRODUCTION
- the "Design Process"
- Implementation

Today's main points

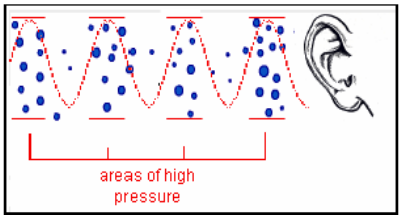
- Sound and images are analogue phenomena that can be represented by complex waveforms
- They must be digitised to be handled by computers: sampling and quantisation
- Sampling and quantisation rates determine the size of the digitised data

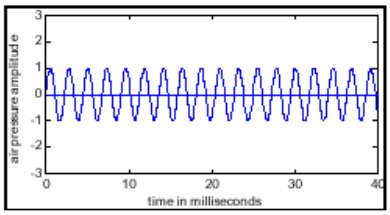
Reading

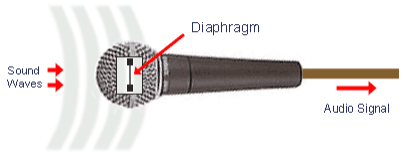
- BurgChapter1.pdf p. 1-21

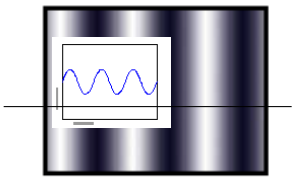
Analogue versus discrete phenomena

Sound and images in the analogue domain

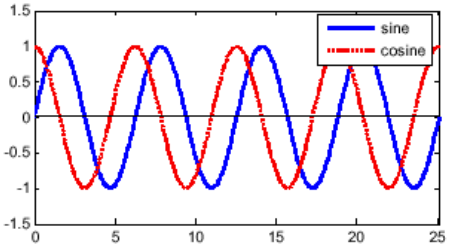








Sinusoidal functions

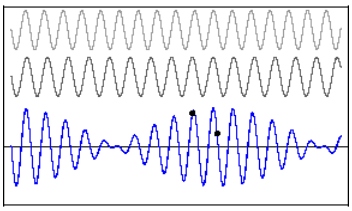


- cycle
- wavelength (m)
- f = frequency (Hz)
- T = period (s) = 1/f
- A = amplitude
- ω = angular frequency (rad/s) = $2\pi f$
- ϕ = phase

$$s(t) = A \sin(\omega t + \phi)$$

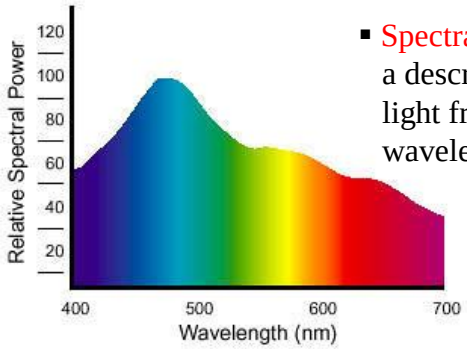
Complex Waveforms

- Most waveforms are complex, i.e. their shape is the result of adding 2 or more waveforms.
- Each complex waveform may be described as the sum of a number of simple sine waves, each with a particular amplitude, frequency (or wavelength) and phase.



Example: Visible Light

- The wavelengths of visible light lie roughly between 400 nm and 700 nm.

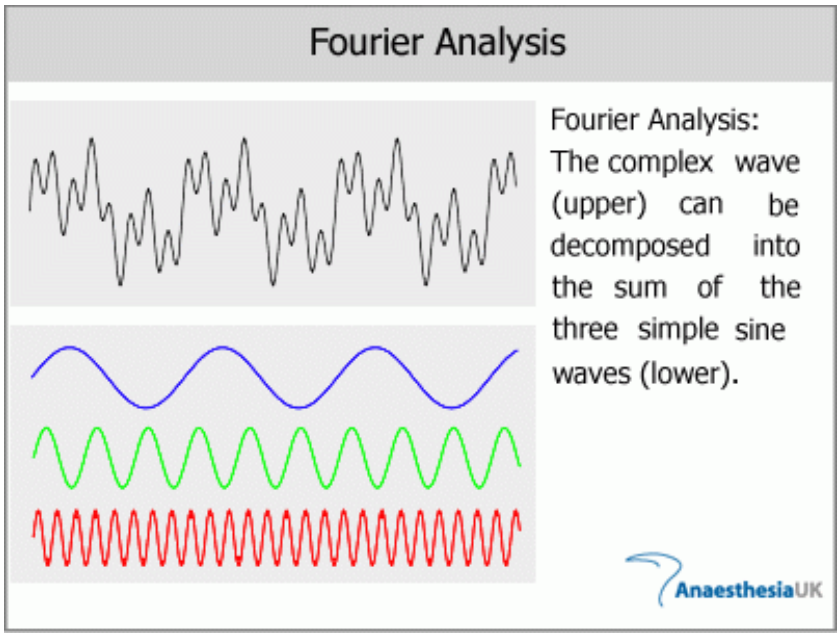


- Spectral Power Distribution (SPD): a description of how the intensity of light from some source varies with wavelength.

Fourier analysis

- Fourier analysis attempts to represent a set of data with a series of sines and cosines with different periods, amplitudes, and phases.
- This representation is done by a mathematical process called a transform : the data measurements in the time domain are *transformed* into the period or frequency domain.

$$F(\nu) = \int f(t) exp(i2\pi\nu t) dt$$



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Summary so far …

- Sound and light (colours and images) are analogue phenomena
- They can be represented by complex waveforms
- Individual components (sine waves) can be extracted from a complex waveform by Fourier analysis

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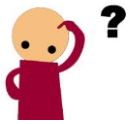
Questions…

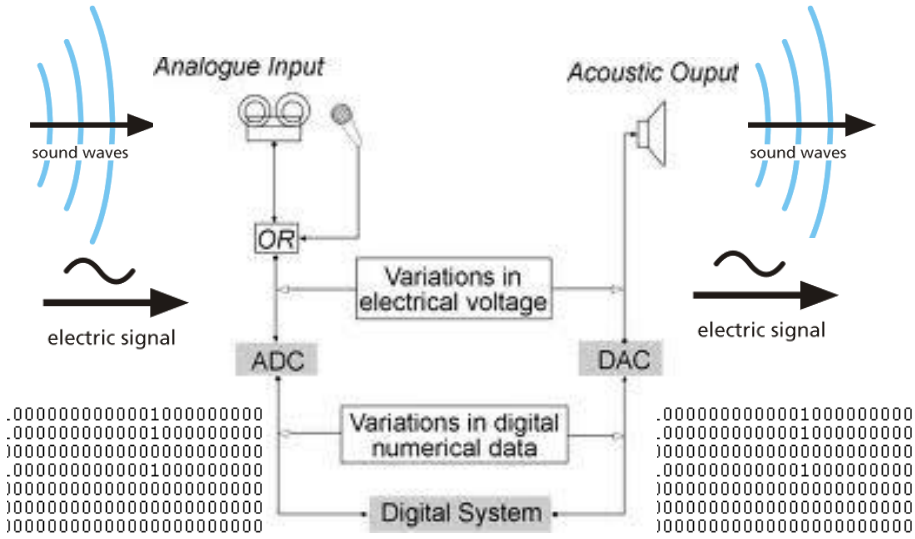


- What kind of sound is represented by a completely regular sine wave ?
- What does the frequency of a wave tell us about the sound it represents ?
- What does the amplitude of a wave tell us about the sound it represents ?
- What information is contained in the wavelength of a light ray ?

Today's main points

- Sound and images are analogue phenomena that can be represented by complex waveforms
- They must be digitised to be handled by computers: sampling and quantisation
- Sampling and quantisation rates determine the size of the digitised data

Analogue-to-digital conversion

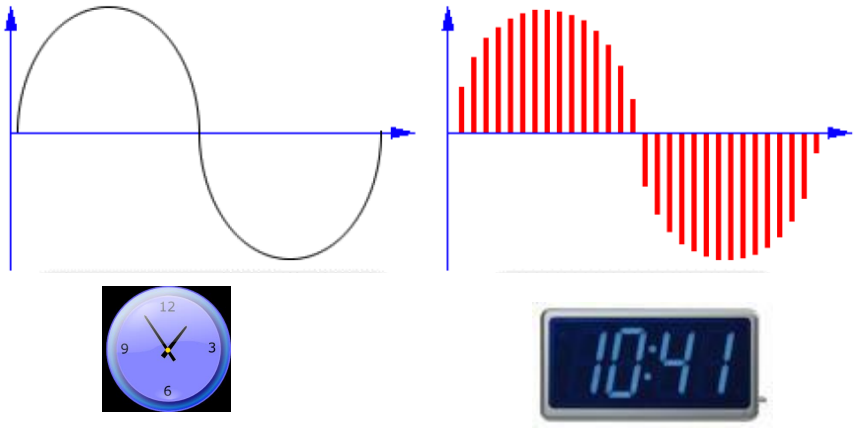


Analogue-to-digital conversion

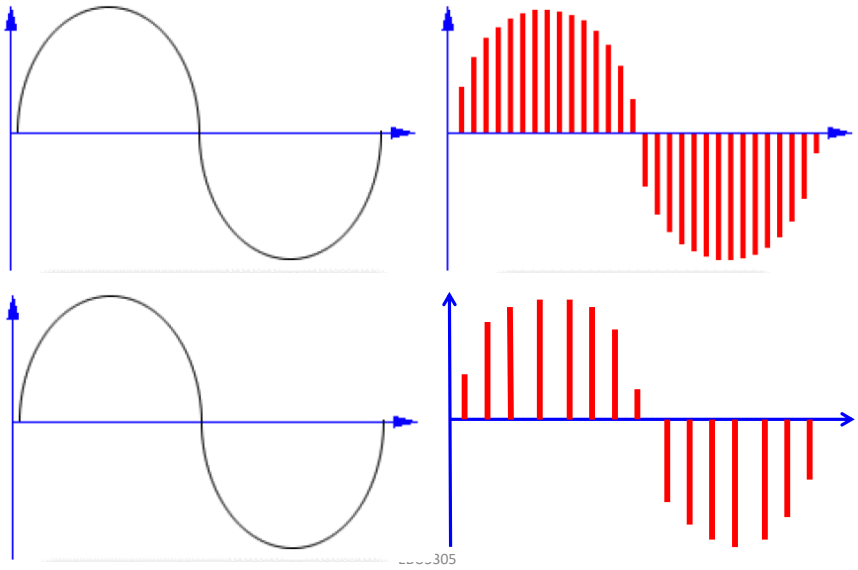
= converting the continuous phenomena of images, sound, and motion into a discrete representation that can be handled by a computer.

- Digitised pictures and sound can now be captured in fine detail.
- Digital data communication is less vulnerable to noise than is analogue.
- Digital data can be communicated more compactly than analogue.

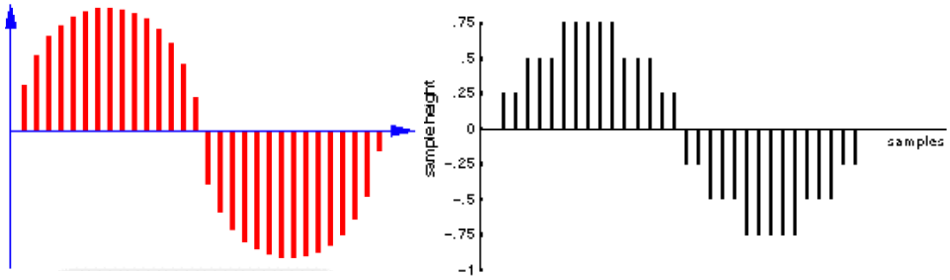
Sampling



Sampling



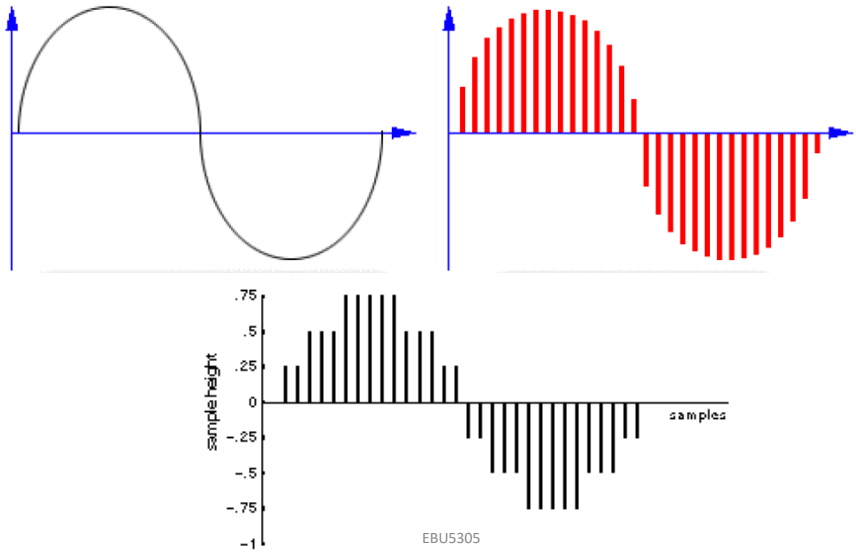
Quantisation



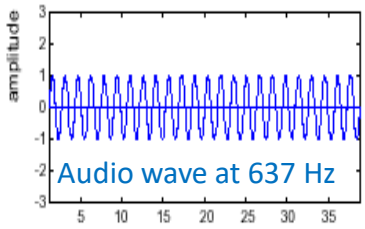
Let *n* be the number of bits used to quantize a digital sample. Then the maximum number of different values that can be represented, m, is

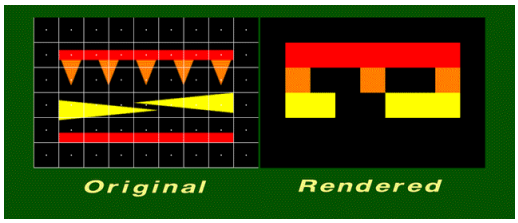
$$m = 2^n$$

Sampling + Quantisation



Aliasing (sampling error)





Nyquist theorem

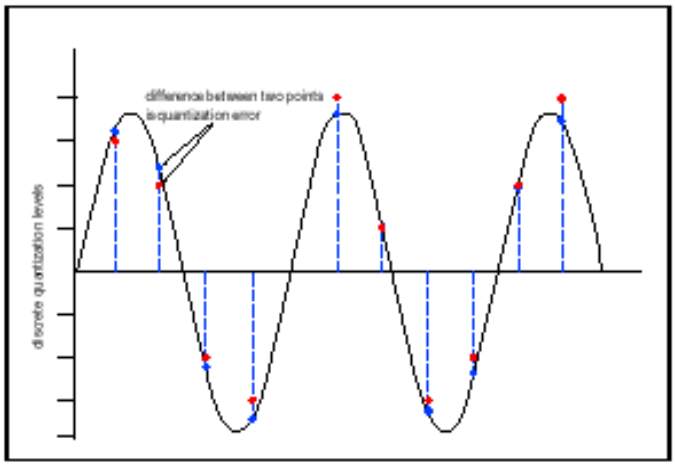
Sample twice as often as the highest frequency you want to capture

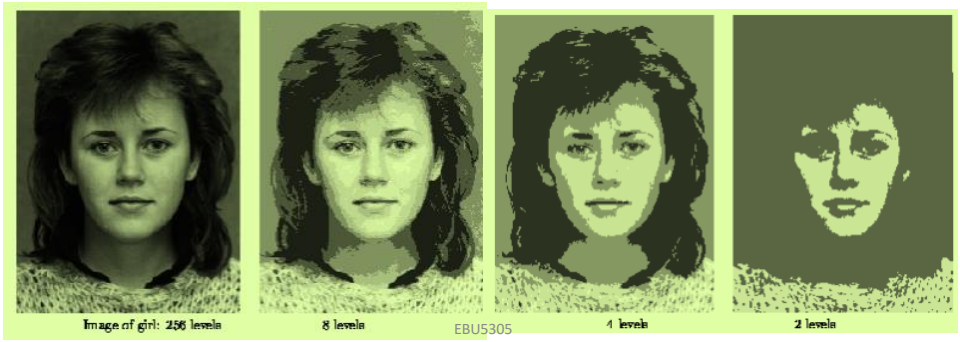
Let *f* be the frequency of a sine wave. Let *r* be the minimum sampling rate that can be used in the digitisation process such that the resulting digitised wave is not aliased. Then:

$$r = 2f$$

r is called the ***Nyquist frequency***.

Quantisation error

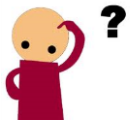




Summary so far …

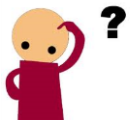
- Analogue sounds and images must be digitised
- Digitisation includes two processes: sampling and quantisation
- Undersampling causes aliasing (the original data cannot be reproduced)
- Quantisation errors cause loss of details
- The Nyquist theorem helps us choosing an adequate sampling rate

Question 1



If you are recording an audio file and you expect that the highest frequency in the file will be 10,000 Hz, what is the minimum sampling rate you should use to ensure that you will not get audio aliasing?

Question 2

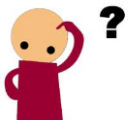


The number of possible colours in an image is determined by the quantisation rate. How many different colours can be represented with 12 bits?

Question 3

Prove that, if we double the number of bits used to hold a quantised value, then we square the number of quantisation levels.

Question 4



You have a digital image in 8 bit colour that has blocky areas of colour, lacking the subtle gradations from one colour to the next that you would like to see. Is this a matter of aliasing or quantisation error? Explain.

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Data size (example): audio file

Sampling rate: 44.1 kHh (44,100 samples/s)
Quantisation rate: 32 bits per sample (16 for each of two stereo channels)
Number of minutes: 1 minute
Total number of bits:

44,100 * 32 * 60 = 84,672,000 bits
84,672,000 bits = 10,584,000 bytes

File size: ~ 10.58 Mbytes for 1 minute
Data rate of the file: ~ 1.41 Mbits/s

Data size : image file

Example:
Sampling: 1024 pixels x 768 pixels
Bits per pixel: 24

Data size : video file

sampling: 720 pixels x 480 pixels
Bits per pixel: 24
Frame rate : 30 frames/s
Length: 1 minute
Audio : 44,1 KHz, 32 bits

Exercise

Compute the number of bytes needed for 1 minute of video that has 720 x 576 pixels per frame, 25 frames per second, 3 bytes per pixel, and CD-quality stereo audio.

Today's summary

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- They must be digitised to be handled by computers: sampling and quantisation
- Sampling and quantisation rates determine the size of the digitised data