Digital Audio

What is Sound?

Source — Generates Sound

- Air Pressure changes
- *Electrical* — Loud Speaker
- *Acoustic* — Direct Pressure Variations

Destination — Receives Sound

- *Electrical* — Microphone produces electric signal
- *Ears* — Responds to pressure **hear** sound (**more later (MPEG Audio)**)

Digitising Sound (Recap from CM0268)

- **Microphone produces *analog* signal**
- Computer like discrete entities

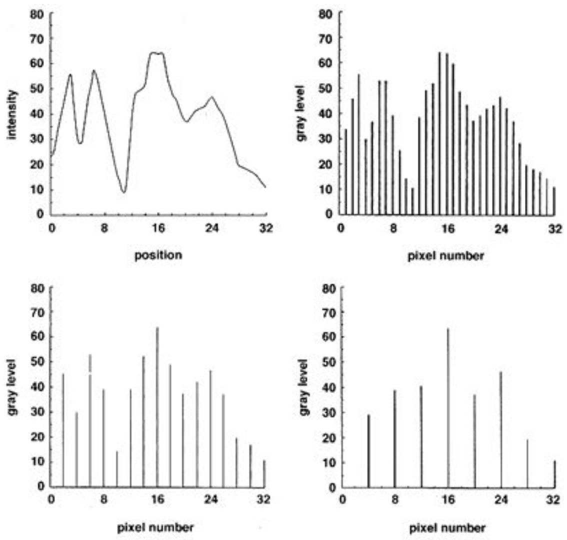
Need to convert Analog-to-Digital — Specialised Hardware

Also known as *Sampling*

Digital Sampling

Sampling basically involves:

- Measuring the analog signal at regular discrete intervals
- Recording the value at these points



Computer Manipulation of Sound (Audio FX Preview)

Writing Digital Signal Processing routines range from being trivial to highly complex:

- Volume
- Cross-Fading
- Looping
- Echo/Reverb/Delay
- Filtering
- Signal Analysis

Sample Rates and Bit Size

How do we store each sample value (*Quantisation*)?

8 Bit Value (0-255)

16 Bit Value (Integer) (0-65535)

How many Samples to take?

11.025 KHz — Speech (Telephone 8 KHz)

22.05 KHz — Low Grade Audio
(WWW Audio, AM Radio)

44.1 KHz — CD Quality

Nyquist's Sampling Theorem

Sampling Frequency is Very Important in order to accurately reproduce a digital version of an Analog Waveform

Nyquist's Theorem:

The Sampling frequency for a signal must be **at least** twice the highest frequency component in the signal.

Common Audio Formats

- Popular audio file formats include
  - .au (*Origin: Unix, Sun*),
  - .aiff (*MAC, SGI*),
  - .wav (*PC, DEC*)
- Compression can be utilised in some of the above but is not **Mandatory**
- A simple and widely used (by above) audio compression method is Adaptive Delta Pulse Code Modulation (ADPCM).
  - Based on past samples, it
    predicts the next sample and
    encodes the difference between the actual value and the predicted value.
  - More on this later (Audio Compression)

Common Audio Formats (Cont.)

- Many formats linked to audio applications
- Most use some compression
- Common ones:
  - Sounblaster — .voc (Can use Silence Deletion (More on this later (Audio Compression))
  - Protools/Sound Designer – .sd2
  - Realaudio — .ra.
  - Ogg Vorbis — .ogg
  - AAC , Apple, mp4 — More Later
  - Flac — .flac, More Later
  - Dolby AC coding — More Later
- **MPEG AUDIO — More Later (MPEG-3 and MPEG-4)**

Synthetic Sounds — reducing bandwidth?

- Synthesise sounds — hardware or software
- Client produces sound — only send parameters to control sound (**MIDI/MP4/HTML5 later**)
- Many synthesis techniques could be used, For example:
  - FM (Frequency Modulation) Synthesis – used in low-end Sound Blaster cards, OPL-4 chip, Yamaha DX Synthesiser range popular in Early 1980's.
  - Wavetable synthesis – wavetable generated from sampled sound waves of real instruments
  - Additive synthesis — make up signal from smaller simpler waveforms
  - Subtractive synthesis — modify a (complex) waveform but taking out (Filtering) elements
  - Granular Synthesis — use small fragments of existing samples to make new sounds
  - Physical Modelling — model how acoustic sound in generated in software
  - Sample-based synthesis — record and play back recorded audio, often small fragments and audion processed.
- Most modern Synthesisers use a mixture of samples and synthesis.

Synthetic Sounds — Analogies with Vector Graphics

- Use more *high-level* descriptions to represent signals.
- Recorded sounds and digital images: regular sampling; large data size; difficult to modify
- Synthetic sounds and vector graphics: high level descriptions; small data size; easier to edit. Conversion is needed before display – synthesis or rasterisation
- Difference: 1D vs 2D

More on how synthesis works next