Creative Computing II

Christophe Rhodes
c.rhodes@gold.ac.uk

Autumn 2010, Wednesdays:
10:00–12:00: RHB307 & 14:00–16:00: WB316
Winter 2011, TBC

Music File Formats

CD quality:
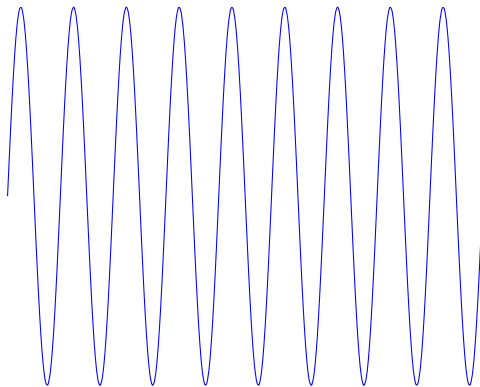
- amplitude samples at 44.1kHz (so *Nyquist frequency* is 22.05kHz);
- 16 bits per sample;
- two channels.

Recording quality:

- 88.2kHz – 176.4kHz
- more than 16 bits per sample
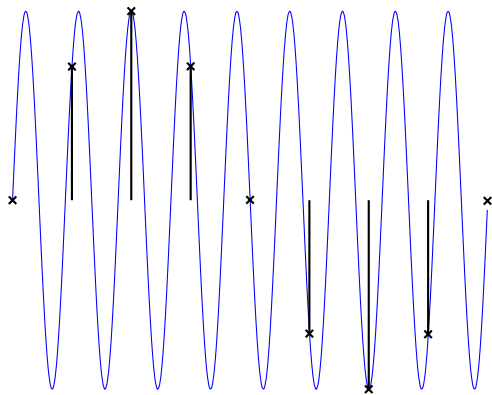- usually more than two channels (one channel per transducer)

Music File Formats

Music File Formats
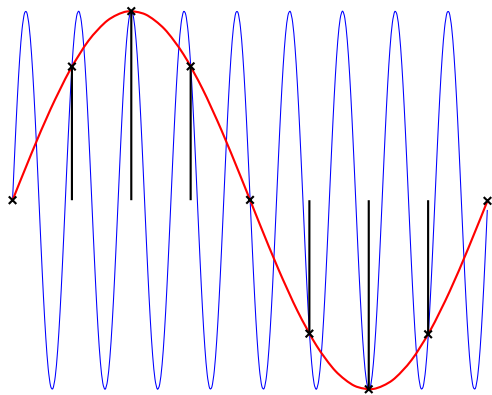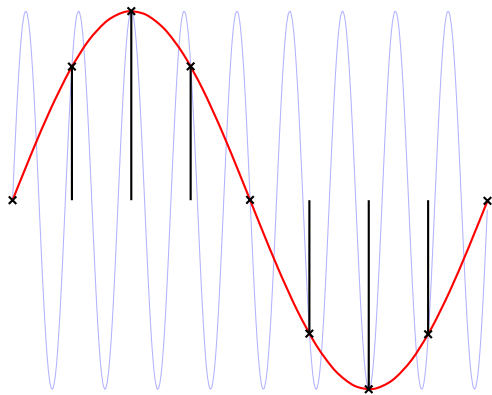
Nyquist Frequency

Music File Formats

Music File Formats

Higher frequency is *aliased* to the lower frequency. (all frequencies $f = |f_0 \pm nf_s|$ aliased together)

Music File Formats

Advantages:

- ▶ fidelity;
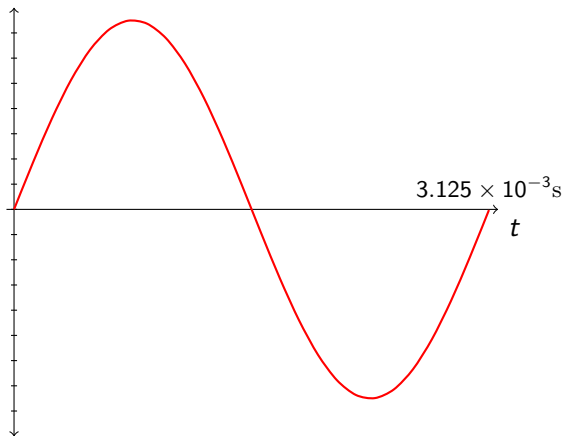
Disadvantages:

- ▶ file size;

Examples:

- ▶ Pulse-Coded Modulation (PCM, WAV);
- ▶ Free Lossless Audio Codec (FLAC);

Note: audio encoded in these formats can be of low quality or degraded with reference to a master copy.

Music File Formats

Quantization and Sampling:

3.125×10^{-3}s

t

Music File Formats

‘Lossless’ Audio Formats: PCM

Quantization and Sampling:

Music File Formats

Quantization and Sampling:

Music File Formats

PCM in the wild: WAV files

- ► mono or stereo;
- ► 8 or 16 bits per sample;
- ► variable sample rate (typically 8kHz, 44.1kHz)
- ► (bitrate between 64kbps and 1.4112Mbps)

Music File Formats

PCM in the wild: WAV files

- ► mono or stereo;
- ► 8 or 16 bits per sample;
- ► variable sample rate (typically 8kHz, 44.1kHz)
- ► (bitrate between 64kbps and 1.4112Mbps)

File format:

- ► header information;
- ► sound data.

Music File Formats

PCM in the wild: WAV files

- ▶ mono or stereo;
- ▶ 8 or 16 bits per sample;
- ▶ variable sample rate (typically 8kHz, 44.1kHz)
- ▶ (bitrate between 64kbps and 1.4112Mbps)

File format:

- ▶ header information;
- ▶ sound data.

Octave support:

- ▶ `wavread` / `wavwrite`

Music File Formats

PCM in the wild: WAV files

- ▶ mono or stereo;
- ▶ 8 or 16 bits per sample;
- ▶ variable sample rate (typically 8kHz, 44.1kHz)
- ▶ (bitrate between 64kbps and 1.4112Mbps)

File format:

- ▶ header information;
- ▶ sound data.

Octave support:

- ▶ wavread / wavwrite

Minim equivalents:

- ▶ AudioSnippet.loadSnippet() / AudioRecorder.save()

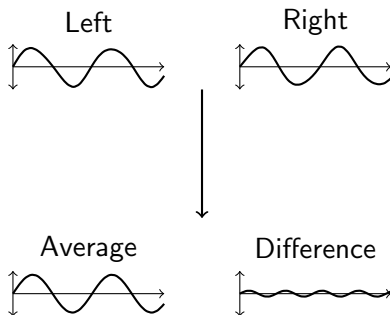(but Minim offers other ways of working with audio)

Music File Formats

Free Lossless Audio Codec:

- ▶ lossless compression for audio (original PCM reconstructible);
- ▶ two main parts:
    - ▶ channel decorrelation;

Left   Right

Average   Difference

Music File Formats

Free Lossless Audio Codec:

- ▶ lossless compression for audio (original PCM reconstructible);
- ▶ two main parts:
    - ▶ channel decorrelation;
    - ▶ predictive coding.

Constant: $\hat{s}_1(n) = s(n-1)$

Music File Formats

Free Lossless Audio Codec:

- ▶ lossless compression for audio (original PCM reconstructible);
- ▶ two main parts:
    - ▶ channel decorrelation;
    - ▶ predictive coding.

Linear: $\hat{s}_2(n) = 2s(n-1) - s(n-2)$

Music File Formats

Free Lossless Audio Codec:

- ▶ lossless compression for audio (original PCM reconstructible);
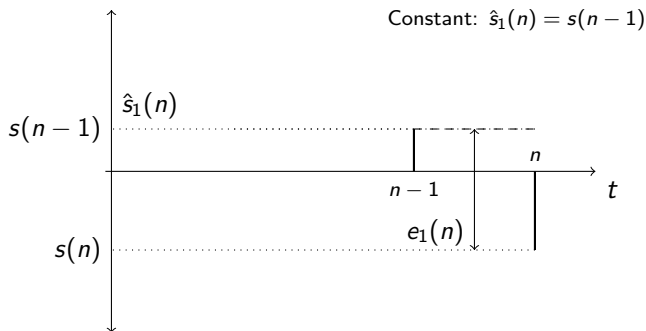- ▶ two main parts:
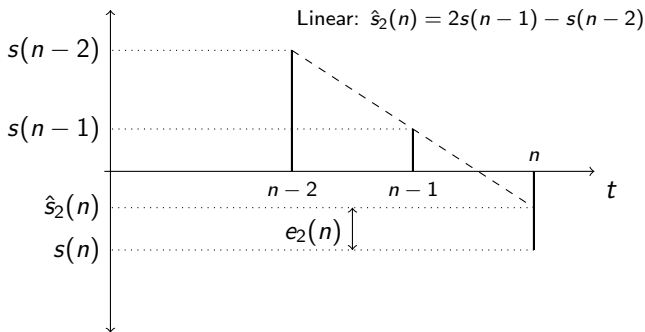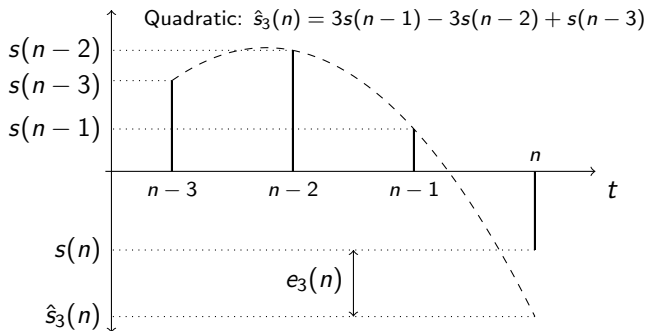 - ▶ channel decorrelation;
  - ▶ predictive coding.

Quadratic: $\hat{s}_3(n) = 3s(n-1) - 3s(n-2) + s(n-3)$

Music File Formats

Advantages:

- ▶ small(er) file size;

Disadvantages:

- ▶ loss of fidelity;
- ▶ processing power needed to decode.

Examples:

- ▶ MPEG 1 Layer 3 (MP3)
- ▶ Advanced Audio Coding (AAC)
- ▶ Ogg Vorbis

Note: Ogg Vorbis is intended to be 'patent-free'.

Masking:

- ► Simultaneous masking
  - ► $A\sin(\omega t) + \gamma A\sin((\omega + \epsilon)t)$
  - ► higher-frequency sound is 'masked'.
- ► Temporal masking
  - ► $\delta(t - \tau) + \delta(t - (\tau + \epsilon))$
  - ► second-occurring onset is 'masked'

Frequency response:

- ► Removal of 'irrelevant' frequencies
- ► Example: telephone transmission

Music File Formats

'Symbolic' formats

Examples:

- ▶ MIDI: Musical Instrument Digital Interface;
- ▶ Score-notation formats:
    - ▶ Lilypond;
    - ▶ MEI;
    - ▶ abc, **kern;
    - ▶ MusicXML;
    - ▶ ... the list is endless.

Notes:

- ▶ MIDI is also used for performance;
- ▶ MusicXML is not a well-defined standard.

Music File Formats
MIDI Files

- binary format;
- events;
- 'note on' and 'note off' model
- NB: note on with 'velocity' 0 not the same as 'note off'
- different MIDI devices (and programs) interpret things in different ways.

Music File Formats

Global attributes:

- ▶ file format, division, tracks

Cross-track attributes:

- ▶ tempo map, time signature

Track events:

- ▶ note on, note off
- ▶ effects: pitch bend, aftertouch
- ▶ meta messages: lyrics, text, key signature
- ▶ program change

Music File Formats

General MIDI instruments (selected by program change messages):

- ▶ 1: Acoustic Grand Piano
- ▶ 5: Electric Piano 1
- ▶ 6: Electric Piano 2
- ▶ 34: Electric Bass (finger)
- ▶ 35: Electric Bass (pick)
- ▶ 50: String Ensemble 2
- ▶ 53: Choir Aahs
- ▶ 102: Goblins
- ▶ 123: Seashore
- ▶ 126: Helicopter
- ▶ (128 total)