Foundations of Audio Technology

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Partially based on:

- MusonicX: Music Technology Foundations - University of Adelaide
  - https://www.edx.org/course/music-technology-foundations
  - https://www.youtube.com/channel/UCCbr_KhAzyMGeja81KjolRA

Technology in Sound

- Creation of sound
  - Bells, Musical Instruments, Synthesizers
- Recreation of sound
  - Musical Notation, Recording and playback, Magnetic tapes, PCM recording
- Analog vs. Digital

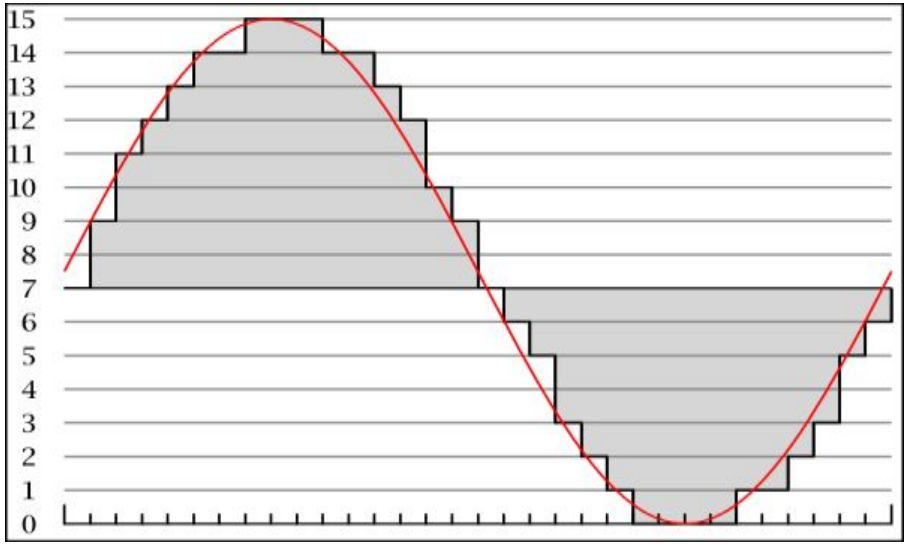
Recording Sound

Audio Technology

- Analog audio involves the creation or imitation of a continuous wave.
  - vinyl, tape, analog synths, etc
- Digital audio data is the actual representation of sound, stored in the form of samples.
  - Samples represent the amplitude of sound at a discrete point in time.
  - Quality of digital recording depends on the sampling rate, the number of samples taken per second.
  - Remember ADC & DAC?

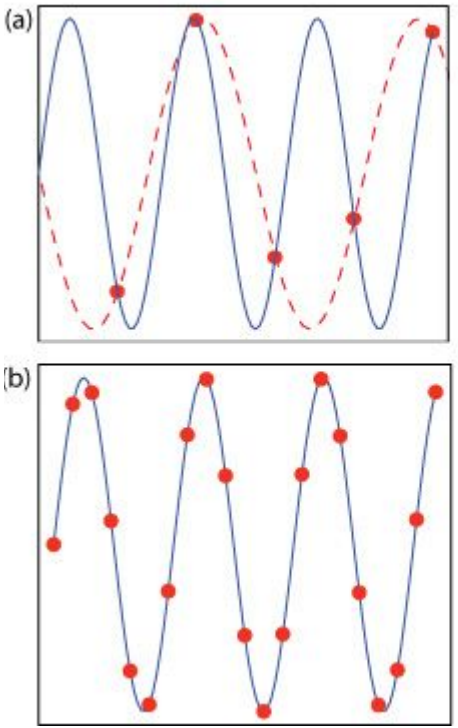
Digitising Analog Audio

- Sampling:
  - Divide the horizontal axis (time) into discrete pieces
- Quantization:
  - Divide the vertical axis (signal strength - voltage) into pieces.
  - For example, 8-bit quantization divides the vertical axis into 256 levels.



Digitising Analog Audio

- Nyquist Theorem
  - Nyquist theorem is used to calculate the optimum sampling rate in order to obtain good audio quality.
  - For Lossless digitization, the sampling rate should be at least twice the maximum frequency responses.
  - Digitally sampled audio has a bandwidth of (20Hz - 20KHz). By sampling at twice the maximum frequency (40KHz) we could have achieved good audio quality.
  - CD audio slightly exceeds this, resulting in an ability to represent a bandwidth of around 22050 Hz.



Digitising Analog Audio

Sampling Rates	Used As...
8000	Telephony Standard, Popular in UNIX Workstations
11000	Quarter of CD rate, Popular on Macintosh
16000	G.722 Standard (Federal Standard)
18900	CD-ROM XA Rate
22000	Half CD rate, Macintosh rate
32000	Japanese HDTV, British TV audio, Long play DAT
37800	CD XA Standard
44056	Professional audio industry
44100	CD Rate
48000	DAT Rate

Audio Quality vs. Data Rate

Quality	*Sample Rate (kHz)*	*Bits per Sample*	*Mono / Stereo*	*Data Rate (kBytes/sec) (uncompressed)*	*Frequency Band*
Telephone	8	8	Mono	8	200-3400 Hz
AM Radio	11.025	8	Mono	11.0	540-1700 KHz
FM Radio	22.050	16	Stereo	88.2	
CD	44.1	16	Stereo	176.4	20-20000 Hz
DAT	48	16	Stereo	192.0	20-20000 Hz

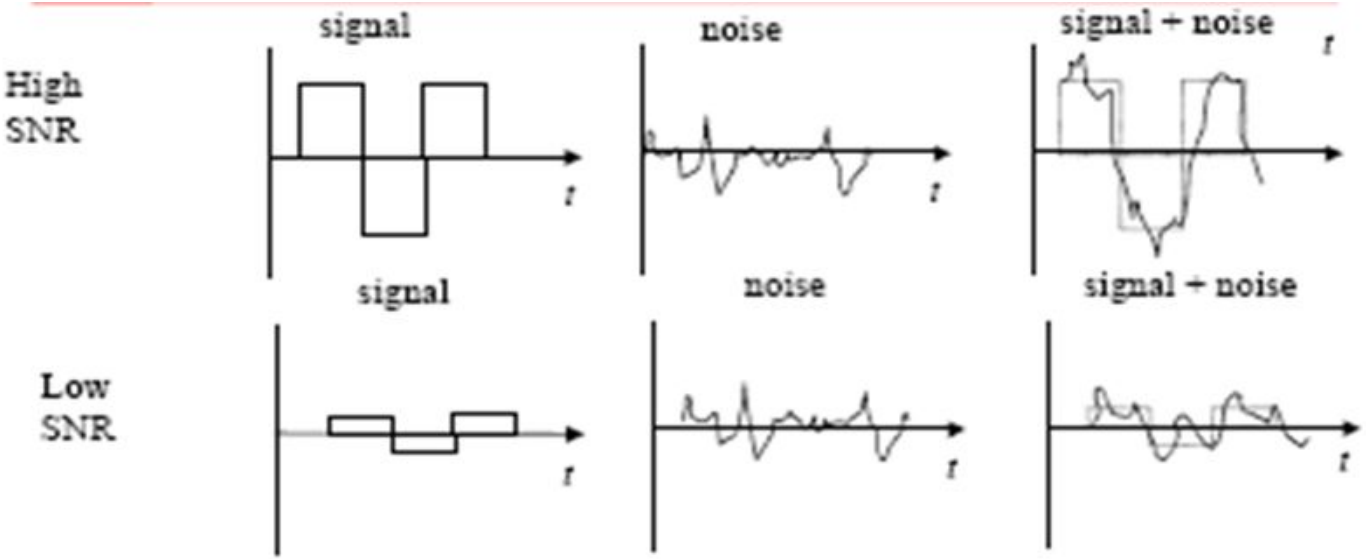
Digitising Analog Audio

- Sampling date
  - Samples per second
  - Determines frequency range that can be recorded
  - CD: 44,100 Hz
  - Pro: 48,000 Hz
- Bit depth
  - Quality of each sample
  - Determine the quality of dynamic range
  - CD: 16 bit
  - Pro: 24 bit

Digital Audio Processing

- Once a recording had been completed, it almost always needs to be edited.
- Basic sound editing operations include trimming, splicing and assembly, volume adjustments and working on multiple tracks.
- Additional available sound editing operations include format conversion, resampling or downsampling, fade-ins and fade-outs, equalization, time stretching, digital signal processing, and reversing sounds.

Digital Audio Noise



$$\text{SNR} = \frac{\text{Average Signal Power}}{\text{Average Noise Power}}$$

Signal-to-Noise Ratio

Audio Device	Frequency Response (Bandwidth)	Signal-to-Noise Ratio	Total Harmonic Distortion
CD	20 Hz - 20,000 Hz	98dB	0.005%
Cassette tape	20 Hz - 17,000 Hz	75dB	0.01%
FM Radio	20 Hz - 15,000 Hz	75dB	0.01%
AM Radio	50 Hz - 5,000 Hz	60dB	0.1%
Telephone	300 Hz - 3400 Hz	42dB	Poor

Digital Audio File Formats

- Uncompressed
  - Recording, editing
  - Maintain full information
  - .wav, .aiff
- Compressed
  - Transfer, stream
  - Reduce file size
  - .mp3, .ogg

Digital Audio Compression

- Compression can be either
  - Lossless: The quality of uncompressed audio equals the quality of original audio file
  - Lossy: The quality of uncompressed audio is lower than the original (e.g. mp3, wma)
- For compressing and decompressing matching algorithm pairs (codecs) are used - Codecs (MP3, WMA, OGG, APE, FLAC)

MIDI Audio

- **M**usical **I**nstrument **D**igital **I**nterface is a protocol that enables computer, synthesizers, keyboards, and other musical devices to communicate with each other.
- MIDI is a shorthand representation of music stored in numeric form.
- A sequencer software and sound synthesizer is required in order to create MIDI scores.
- It is not digitized sound.
- MIDI is device dependent.

Live streaming of Innovate Sri Lanka

Were you there at the exhibition?

- How was it?
- Any problems?
- Any learnings?

Practicals

Class Project 1

Recording & Editing Sounds

1. Record 3 sounds from your local environment using a mobile phone.
2. Edit and clean the audio samples using a digital editing software.
3. Compile all 6 clips into a single audio file.
4. Upload this to LMS as a compressed audio file.

Doing is learning