Today’s topic:
Game Audio

Audible vibration in an elastic medium (usually air)

Amount of pressure change = **Amplitude**

Varies continuously over time
Rate of vibration/pressure change = Frequency

Measured in cycles per second (Hertz or Hz)

Frequency range of human hearing: Approximately 20 to 20,000 Hz

Analog recording and playback

Transducers: Convert one type of energy to another
All transducers introduce distortion

Digital audio

- Experimental recordings: Late '60s
- Jazz/classical: Early '70s
- First symphonic recording: 1976
- First major label recording: 1979
- Ry Cooder's Bop Till You Drop
- Compact Disc
  - Jointly created by Sony/Phillips
  - Introduced October 1, 1982
  - Billy Joel's 52nd Street
  - Biggest seller: Beatles 1 (100M+ copies)

Digital audio based on sampling

Amplitude of signal is measured (and usually recorded) at precise time intervals, converted to stream of numbers
Digital recording and playback

- Extremely accurate, low noise and distortion
- Almost immeasurable wow or flutter
- Easily edited and manipulated
- Essentially perfect replication

Digital sampling (“digitizing”)

- Sample rate
  - Number of samples taken per second
  - Also measured in Hertz
- Sample resolution
  - Range of numbers used to describe each sample
  - Measured in binary bits
  - 8 bits = 256 values (± 127)
  - 16 bits = 65,536 values (± 32K)
  - 24 bits = 16,777,216 values

How often to sample?

- Depends on desired frequency range
  - Nyquist frequency = Sample rate required to fully express a signal
  - 2X maximum required frequency
  - 2X 20 kHz = 40 kHz minimum sample rate to represent full human range

How much to sample?

- Depends on desired dynamic range
- Dynamic range = Difference between softest and loudest sounds
  - Measured in decibels (dB); 1 dB = faintest perceptible sound
  - Real-world range: 10-20 dB (anechoic chamber) to 140 dB (beside jet engine)
  - Each bit of sampling resolution approximately doubles dynamic range

Home audio formats

- Compact Disc
  - Sample rate: 44.1 kHz
  - Sample resolution: 16 bits
  - Dynamic range: >90 dB
  - Two channels for stereo
  - “CD quality”
- HD/BluRay DVD
  - Up to 8 channels 96 kHz 24-bit audio
  - Dynamic range: >120 dB
“CD quality” data rate
- 44,100 samples per second
- 16 bits (2 bytes) per sample
- 2 channels
- $44,100 \times 2 \times 2 = 176,400$ bytes/sec or $10.584$ MB per minute
- Typical pop song 30-40 MB if uncompressed

Compressed digital audio
- Lossless compression
  - Preserves data perfectly
  - Compression ratio: 2:1 typical
- Lossy compression
  - Discards some data to increase compression ratio
  - The trick is: What to throw away?

The game changer: MP3 (1994)
- Lossy compression algorithm based on auditory masking
  - Loud low-frequency sounds can make softer high-frequency sounds inaudible
  - Perceptual coding: Throw away high frequencies that “can’t be heard anyway”
  - Compression ratio: 10:1 or better
  - Pop song becomes a 3 MB file

The MP3 Phenomenon
- First Web appearance: Late ‘94
- Winamp, mp3.com (Summer ’97)
- First portable players (Spring ‘98)
  - 32 MB Eiger MPMan F10, Rio PMP300
- Napster (June ’99)
  - Created by Shawn Fanning (19), Northeastern University

Game audio: Early days
- Apple II and PC: Click the speaker
- Atari, C64, early consoles: FM synths
- Macintosh (January 1984)
- AdLib PC sound card (1976)
- Creative Labs Sound Blaster (1989)
  - AdLib with digital audio + game port
- CD-ROM (1985)
- CD-R (1990)
- MIDI/music synthesis

Game audio: Today
- All game audio is digital
  - Music, SFX, VO delivered pre-rendered
- Typical assets
  - .wav (bigger, no decoding)
  - .mp3 (small, decoded, requires license)
  - .ogg (small, decoded, no license)
  - .flac (smaller, decoded)
- Real-time mixing, effects, spatialization
Tonight’s assignment:
Continue reading Rollings/Morrs
Continue Project 4

Questions?

Friday:
Game design