Design of Human Interface Game Software

- Sound

Audio Programming
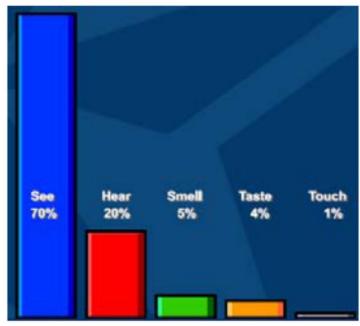
Audio in games is more important than ever before
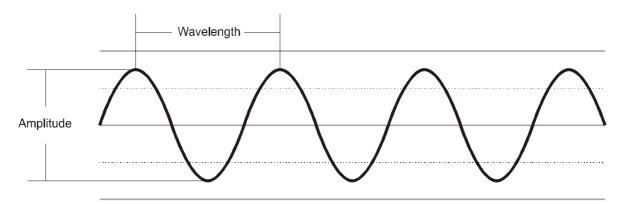
Programming Basic Audio

- **Motivation is user immersion**
  - 20% of perception is acoustic
- **OpenAL**
  - Newer API
  - Available on multiple platforms
- **DirectSound (part of DirectX API)**
  - Only available on Windows platforms
- **Proprietary APIs**
  - Typically available on consoles

Analog Sound Wave

- **Sound**: wave energy requires a medium such as air or water in which to move
- Frequency
  - Measurement of the interval between wave cycles, typically measured in Hertz
  - **Pitch:** The perception of frequency (high or low)
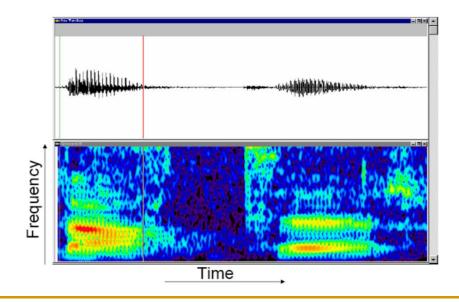 - We hear 20~20,000 Hz (Hertz: cycles/second)

Analog Sound Wave

- **Amplitude**
  - Measurement of a sound wave's size (intensity)
  - What we experience is **loudness**
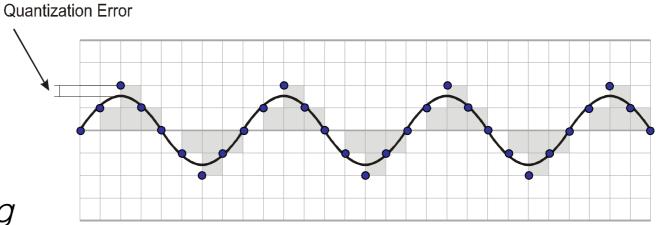 - Measured in decibels (dB)
- **Speed of sound**
  - The speed of sound in air is 344 m/s

Digital Representation of Sound Wave

Quantization Error

- *Sampling*
  - Measuring the amplitude of the analog wave file at discrete intervals
  - The frequency of sampling is known as *sampling rate*
  - Each sample is typically stored in a value ranging from 4 to 24 bits in size: bit depth
  - Music CDs have a sample rate and bit depth of 44.1 kHz (samples/sec) and 16 bits (sample size)

Audio Layers in Games

- **Ambient Sounds**
  - Helps create the fantasy and places user in the desired environments
  - Ex) water dripping in a cave, wind blowing
- **Sound Effects**
  - Indicates what is going on in the game
  - Ex) Speech between characters, footsteps, explosion, crashes
- **Narrator**
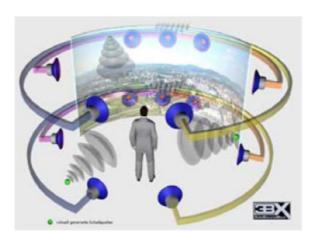 - Explains non-obvious events and story

Sound Design – Spoken Dialog

- **Text To Speech (TTS)**
  - Sound is artificially synthesized from a text
  - Significant progress over the last decade
  - However, it is still hard to convey emotions
  - http://www.microsoft.com/speech/default.mspx
- **Hire actors to do a script**
  - Approach in most games and animations
  - Requires storage for sound files
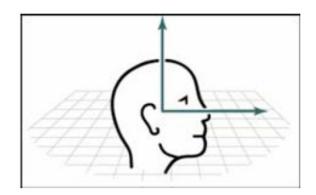
Sound Design – Sound FX

- To create sound associated with explosions, guns, car crashes, etc.
  - Usually small wave samples (.wav, .mp3, ...)
  - Channels – each normally corresponds to a speaker
    - Mono: one channel
    - Stereo: two channels – left, right
    - Surround Sound : 5.1 channels
      – center, left/right front,
        left/right rear,
        subwoofer (low frequency)

Aural Pipeline

- **Basic Elements**
  - Buffers
  - Sound Sources
  - Listener
    - Position
    - Orientation
    - Velocity
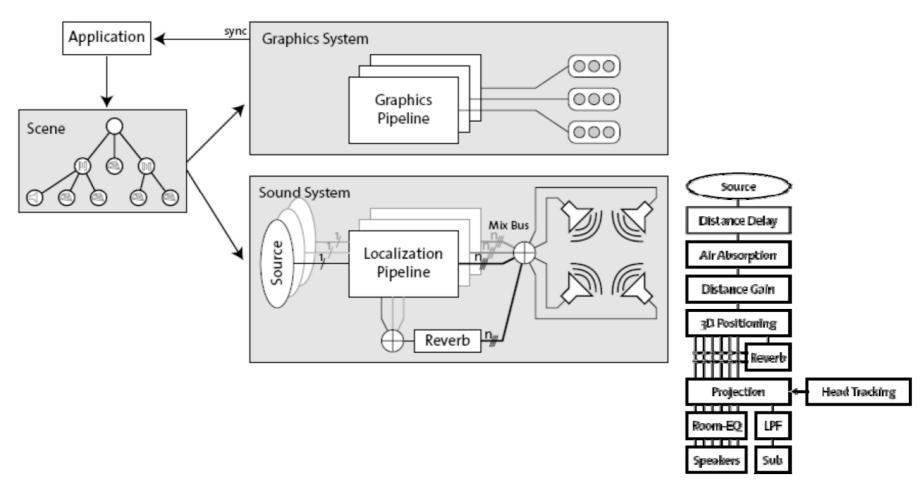
- **Enhanced Elements**
  - Directionality
  - Doppler Shift

Aural Pipeline – Functionality

- **Playback**
  - Play
  - Pause
  - Stop
  - Rewind
  - Loop
- **Notifications**
  - Important for synchronization

- **Volume/Gain**
  - Adjustable
    - Smooth fades
    - Panning/positioning

- **Frequency**
  - Resampling
  - Pitch shifting

Aural Pipeline

Images from: [Naef, 2002]

3D Audio

- Two sets of data required when working in world coordinates:
  - Listener Data
    - Composed of world position and orientation (virtual microphone in the world)
  - Source Data
    - Composed of sound position, orientation, velocity, etc (virtual sound source in the world)
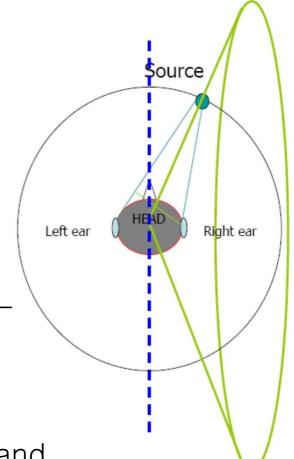
How do we perceive sound location?

- **Measure attributes of received sound at the two ears**
- **Compare sound received at two ears**
  - Level differences
  - Time differences
- **Time delay**

$$|x\text{-}x_L| - |x\text{-}x_R| = c\ \delta t$$

  - Delays same for points on cone-of-confusion
- **Level differences are small**
- **Other mechanisms necessary**
  - Scattering of sound off our bodies and off the environment

Source

Left ear   HEAD   Right ear

Aural Rendering Pipeline – Goals

- ## 3D localization

  - Head related impulse response

- ## Room simulation

  - Room related impulse response

- ## Speed and efficiency

  - Balance number of sources against real time constraints

- ## Output

  - Stereo, surround sound