

SOUND SYSTEM

DESIGN, SOURCES, SCENE

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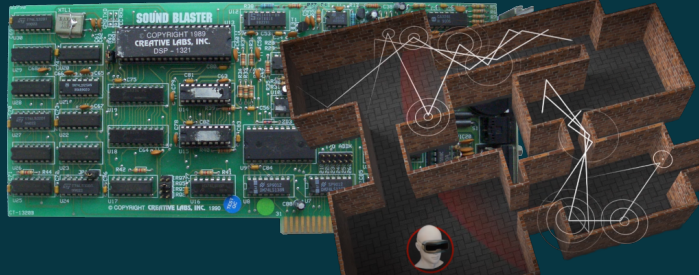
GAME MEDIA STUDIO



INTRODUCTION

SOUND IN GAMES

- User Communication [2]
- Theme, Mood, Emotion [6]
- Movie × Game: Interaction
- Essential Part of Games [3]
 - ▶ User Interface
 - ▶ Interactive Sounds
 - ▶ Communication
 - ▶ World Immersion
- Long History
- → Audio System



SOUND THEORY

PHYSICS OF SOUND

- Compression Wave

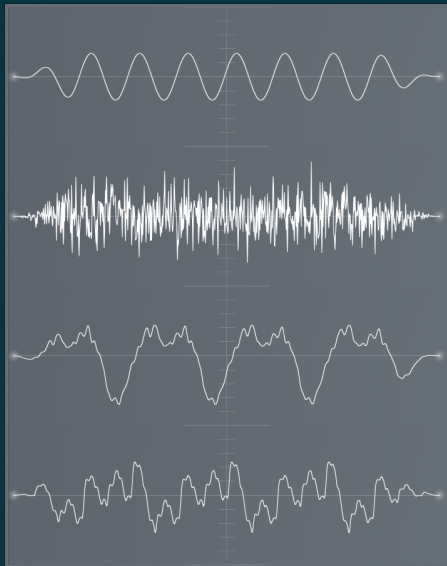
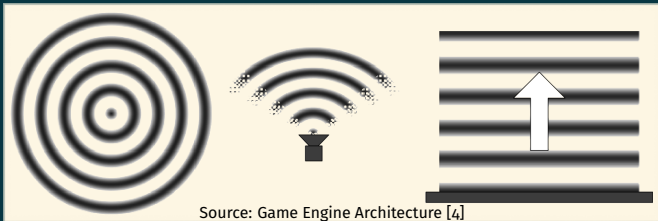
$$p(t) = p_a(t) + p_s(t) [Pa]$$

- Change in Time $\rightarrow$ Signal

- Sound Sources

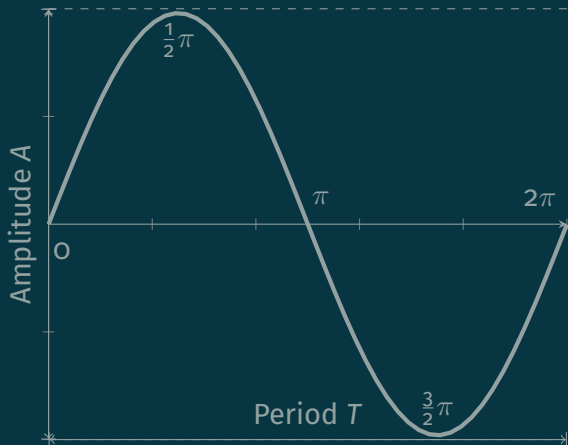
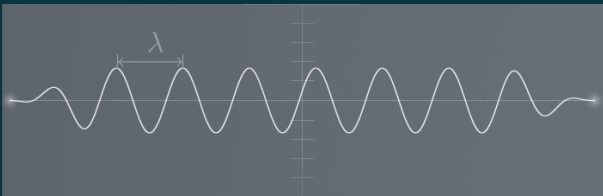
- Propagation in Medium

- ▶ Wave Properties: Reflect, Refract, Diffract
- ▶ Absorption & Falloff: $p \propto \frac{1}{r}$ $I \propto \frac{1}{r^2}$



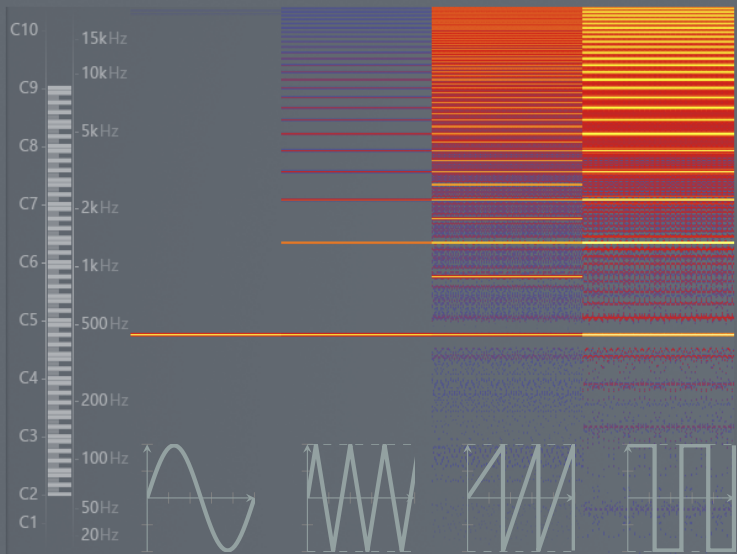
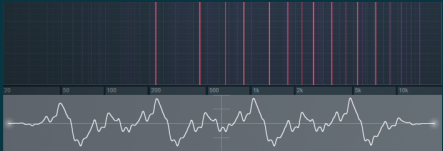
SOUND WAVE ATTRIBUTES

- Periodic Nature
- Period T [s]
- Frequency f [Hz]
- Phase ϕ [rad]
- Speed v [ms⁻¹]
- Wavelength λ [m]



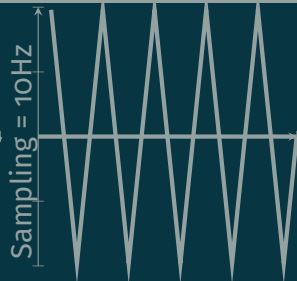
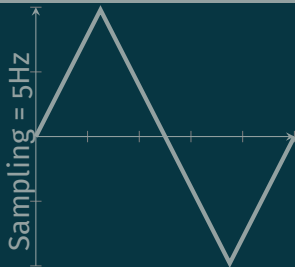
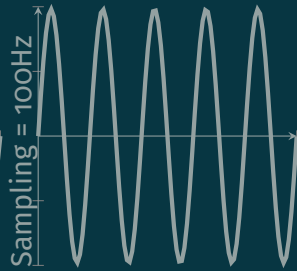
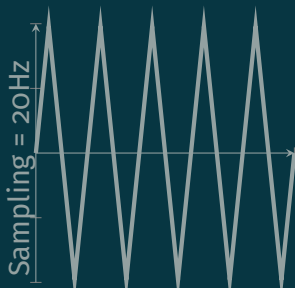
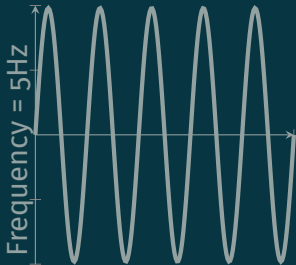
SOUND SPECTRUM

- Signal = Sinusoid Sum
- The Spectrum
- Fourier Transform
time $\leftrightarrow$ *frequency*
- Wave Shapes
 - Sine
 - Triangle
 - Sawtooth
 - Square



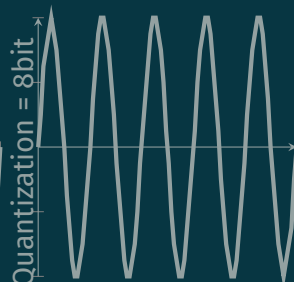
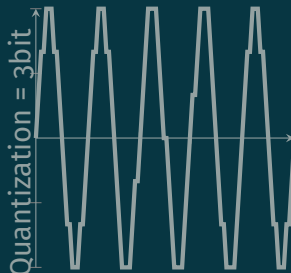
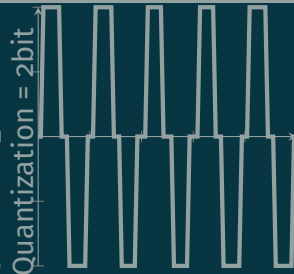
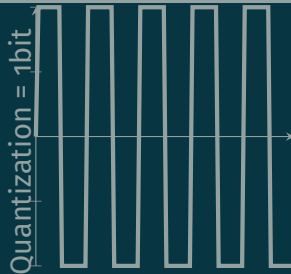
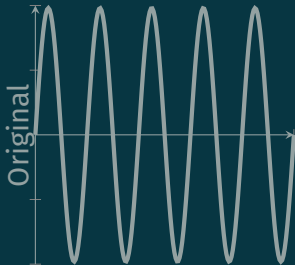
SAMPLING

- Analog → Digital
- AD & DA Converters
- Sampling Frequency
Nyquist–Shannon Theorem
- Quantization



SAMPLING

- Analog → Digital
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PERCEPTION OF SOUND

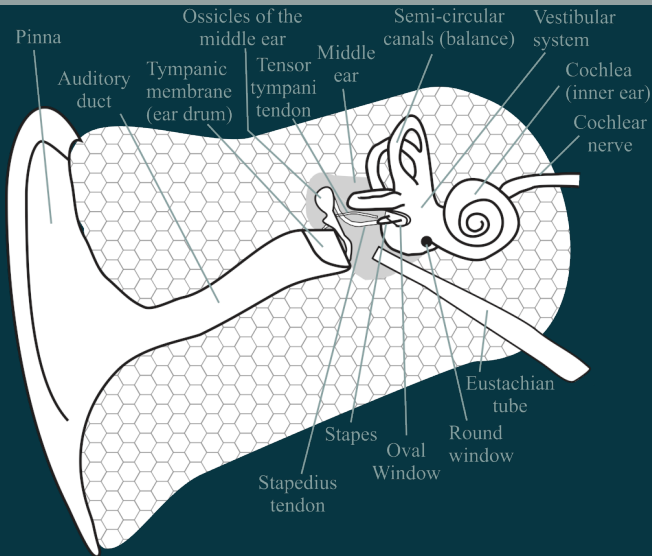
■ Ear Construction [1]

- ▶ External Ear
- ▶ Middle Ear
- ▶ Internal Ear
- ▶ Neural Encoding

■ Sound Loudness [4]

- ▶ Sound Pressure
- ▶ Wide Dynamic Range
- ▶ Logarithmic → decibels [dB]
- ▶ Sound Pressure Level (SPL)

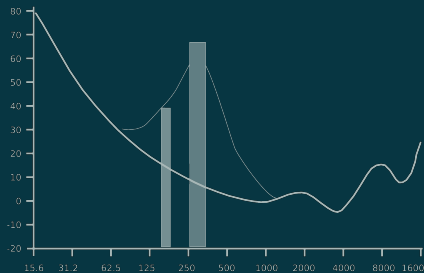
$$L_p = 10 \log_{10} \left(\frac{p_{rms}^2}{p_{ref}^2} \right) [dB]$$



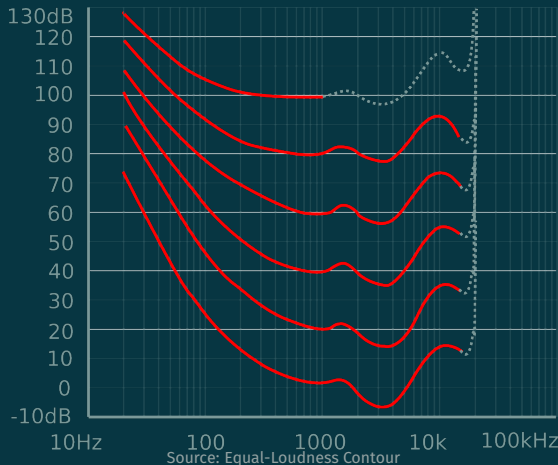
Source: Engineering Noise Control [1]

PSYCHOLOGY AND ACOUSTICS

- Signal Processing → Perception
- Limits of Hearing : 20 Hz–20 kHz
- Psychoacoustics
 - ▶ Fletcher-Munson Curve [5]
 - ▶ Auditory Masking ⇔ [1]
- Gestalt Psychology



Source: Psychoacoustics



Source: Equal-Loudness Contour

SOUND DESIGN

HISTORICAL DEVELOPMENT: 8-BIT

- Arcade Machines [2]
 - ▶ Specialized Hardware
 - ▶ Digital Recording $\rightsquigarrow$ DAC
 - ▶ Sound Synthesis $\rightsquigarrow$ PSG
- Home Consoles [2]
 - ▶ Shared I/O Chip
 - ▶ Programmable Sound
 - ▶ Looping Tracks
- Personal Computers [2]
 - ▶ The Beeper
 - ▶ Programming & Memory



HISTORICAL DEVELOPMENT: 16-BIT

■ Programmable Sound Generator

- ▶ Voice Channels
- ▶ Envelope & ADSR (D)

■ Subtractive Synthesis (I)

■ Frequency Modulation Synthesis [2]

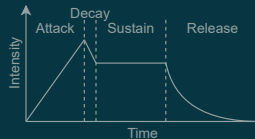
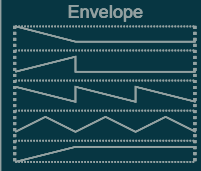
- ▶ Frequency Modulation (I) (II)
- ▶ Synthesizer (I) (II)

■ Table-Based Synthesis

- ▶ WaveTable
- ▶ Granular

Programmable Sound Generator

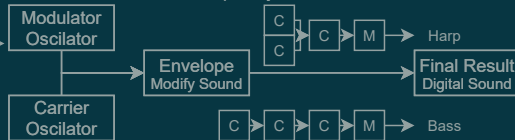
Channel	Frequency	Volume	Envelope
A	440 Hz	0.75	0.75
B	293 Hz	0.50	0.50
C	X X	0.00	0.00
...			
Noise	X X	0.00	0.00



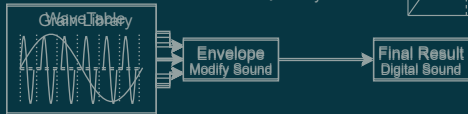
Subtractive Synthesis



Frequency Modulation



WaveTable Granular Synthesis



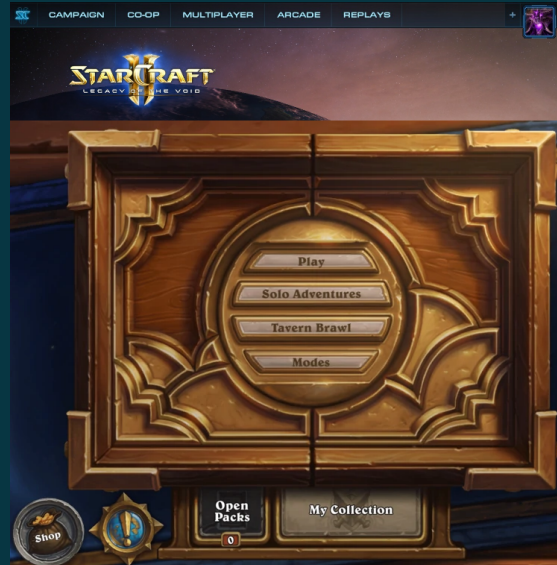
HISTORICAL DEVELOPMENT: SEQUENCING

- “Programmer-Composer”
- Sequencer → Synthesizer
- MIDI
 - ▶ Standard Format
 - ▶ Command Interface
 - ▶ Hardware Dependant Sound
- iMUSE [2] (I)
- Music Tracker (I)
- Digital Audio Workstation



DIGITAL SOUND DESIGN

- DAW → Samples & Synthesis
- Magic of Sound Design (I)
- Diegetic vs Nondiegetic [2]
- Music Track
- Sound Effects Library
- User Interface (I)
 - ▶ Digital
 - ▶ Mechanical



PHYSICAL SOUND DESIGN

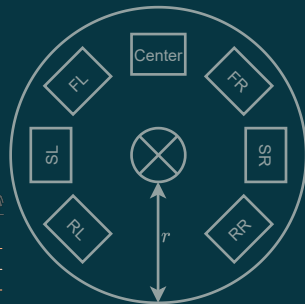
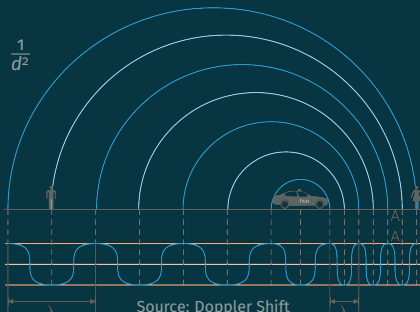
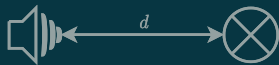
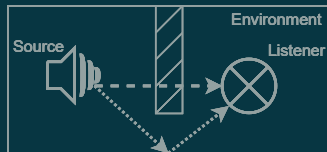
- Physical × Synthesis
- Recording + Touch Up
- Sound Effects
- Music & Voice
- Foley (I) (II)



IMPLEMENTATION

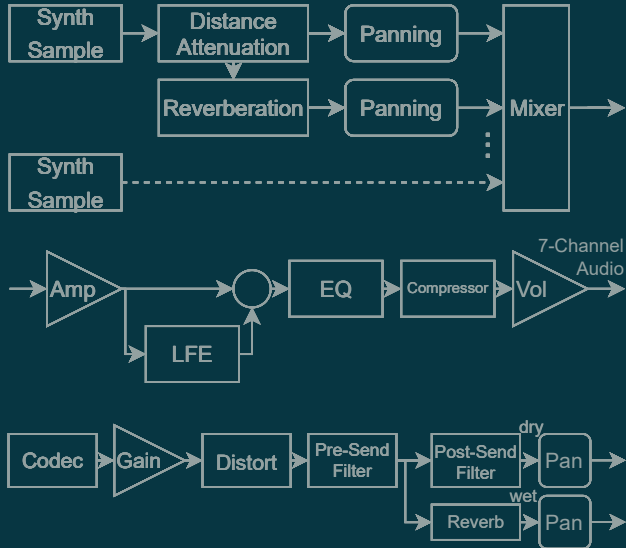
RENDERING THE AUDIO

- Direct PlayBack?
- Modeling the World [4]
 - Environment
 - Sound Sources
 - Listeners
- Sound Synthesis & Triggers
- Occlusion → Indirect
- Spatialization
 - Distance Attenuation $\frac{1}{d^2}$
 - Volume Panning
- Acoustic Modeling
- Doppler Shift
- Real-Time Tricks



AUDIO ENGINE ARCHITECTURE

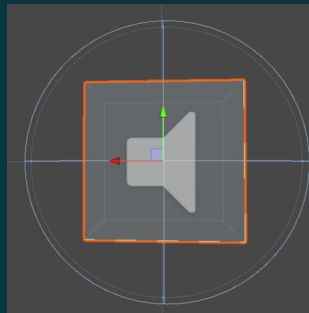
- Audio Processing Pipeline
- Sound Voices
 - Degree of Polyphony
 - $2D \times 3D$
- Voice Pipeline
- The Master Mixer
 - Mixing Voices
 - Depth & Rate Conversion
- Output Bus
- Audio Engines:
 - System Audio
 - FMOD
 - Wwise



AUDIO IN UNITY

AUDIO OVERVIEW

- Hierarchy Integration
- Audio Source & Listener
- 2D and Full 3D
- Audio Asset Support
- Profiler Section
- Tracker Modules



Audio Source

AudioClip: None (Audio Clip)

Output: None (Audio Mixer Group)

Mute: ☐

Bypass Effects: ☐

Bypass Listener Effects: ☐

Bypass Reverb Zones: ☒

Play On Awake: ☒

Loop: ☐

Priority: 128

Volume: 1

Pitch: 1

Stereo Pan: 0

Spatial Blend: 0

Reverb Zone Mix: 1

3D Sound Settings

Doppler Level: 1

Spread: 0

Volume Rolloff: **Logarithmic Rolloff**

Min Distance: 1

Max Distance: 500

Listener

1.1

0.9

0.8

0.7

0.6

0.5

0.4

0.3

0.2

0.1

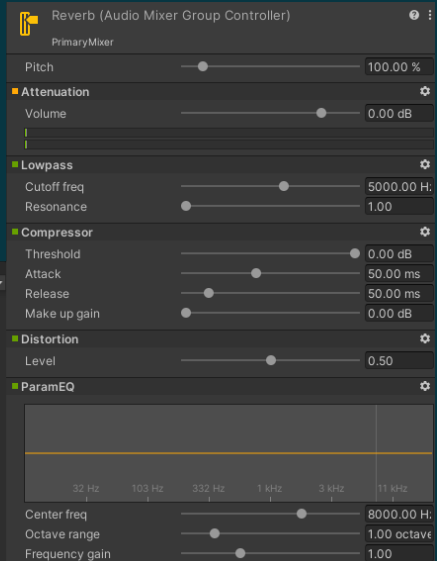
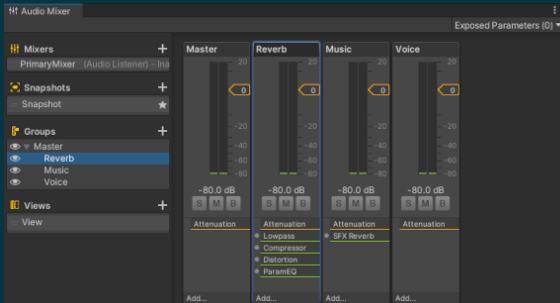
0

0 50 100 150 200 250 300 350 400 450 500

■ Volume ■ Spatial Blend ■ Spread ■ Reverb Zone Mix

AUDIO MIXING

- Spatial Blending & Distance
- Equalizer → Groups
- Filters, Parametric Equalizer
- Effects: Reverb, Echo, ...



ADDITIONAL RESOURCES

- [YouTube] Trackers: the sound of 16-bit
- [YouTube] Augmented Second - An Analysis of the Arabic Interval
- [YouTube] Signal Processing for Sound Design
- [YouTube] Magic of Making Sounds
- [Software] Sonic Pi



Source: Toxic Biohazard Synthesizer

Thanks For
Your Attention!

AudioSurf

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