Sound Occlusion and Diffraction Effects

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Overview

• Overview of Sound Occlusion
• Overview of Sound Diffraction
• Fresnel Acoustic Diffraction
• Runtime System
• Future Directions
Overview of Sound Occlusion

- Physical
  - The partial absorption of propagating sound waves moving through a transmitting surface.
    - e.g., a window
- Perceptual
  - Attenuation (distance-dependent, surface-dependent)
  - High-Frequency Roll-off (surface-dependent)
  - Phase decorrelation (blurred imaging at high frequencies)
Overview of Sound Diffraction

• Physical
  – The partial absorption of propagating sound waves bending around the edges of an obstructing (or transmitting) surface.
    • e.g., a boulder

• Perceptual
  – Attenuation (distance-dependent, direction-dependent)
  – High-Frequency Roll-off (direction-dependent)
  – Enhanced direct path ITD (Inter-aural Time Difference)
Fresnel Acoustic Diffraction Principle

• Every point on a source’s primary wavefront can be thought of as a continuous, direction-dependent emitter of secondary sources that combine to produce a new wavefront in the direction of propagation.

\[ d = \text{distance in units to zone } z_1 \]
\[ R = \text{source to listener distance} \]
\[ w/2 = \text{half wave length (} \pi \text{ radians)} \]
\[ p_0 = \text{first ray/sphere intersect} \]
\[ p_1 = \text{a single, projected emitter} \]
\[ \theta = \text{angle to } p_1 \]
Fresnel Acoustic Diffraction Zones and Emitters

• For a given primary sound source, we can project N secondary emitters \( P_n \) across the surface of a sphere of radius \( d \).

• Each of the N secondary emitters has the following attributes:
  - equidistant from the primary sound source
  - scaled by a common inclination factor
  - phase-locked with respect others in the same zone.

\[
Z_n = \left[ \left( \frac{(d - R)}{w} \right) + \theta \right]
\]

\[
f(\theta) = (1 + \cos(\theta))^{\cdot\cdot\cdot}
\]

\[
P_n = d \sin(\theta)
\]
Fresnel Acoustic Diffraction Sampling

- Emit rays from the listener to $N$ uniformly sampled positions $P$ within a zone $Z$.
  - Special Case: $N == 1$ (only process occlusion)
- Determine visibility ratio $V \left( \frac{N_{\text{visible}}}{N_{\text{total}}} \right)$

![Diagram](image-url)
Runtime System Rendering

• Occlusion and Diffraction Filters
  – Must support wet and dry path filtering.
  – Coefficient-resultant magnitudes and slopes must scale smoothly, both in high frequency and low frequency visibility tests.
• Will need to write an adaptive moving-average filter.
  – low-pass notch frequency response
  – variable length averaging
  – modulation in series (multiple poles)
Runtime System
Optimizations

• Variable Sample Size (LOD)
  – Each source has a maximum sample count. We roll off this count toward 0 as the relative gain-based distance increases relative to the listener’s position.

• Staggered Collision Tests
  – As the collision test count increases, staggering the tests may result in lower overall computational averages.

• Cone-based Collision Test
  – Perform a single broad phase test. Then perform multiple narrow phase tests in the sampling region. This would require an addition to the Collision Sys.
Runtime System
Benefits

• Extends occlusion to include diffraction
• Size-dependent filtering effects
• Avoids self-occlusion issues with sources
• Scalable algorithm and filter processing
Future Directions

• Integrate over multiple Fresnel Zones
  – Averages sample lines at increased distance
• Add spatial filtering (phase delays) based on listener orientation with respect to collision distance from sample zone.
Questions?