VRWORKS AUDIO
IMPROVING IMMERSION WITH ACOUSTIC FIDELITY

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AGENDA

Introduction
Virtual Reality
Psychoacoustics, VR, & Audio
VRWorks Audio
Immersive Sound Now
Best Practices for Geometric Audio
GAMEWORKS & VRWORKS

SDKs that unleash the power of the GPU

Developer

Improved productivity
Accessible, cutting-edge capabilities

End-User

The most compelling gaming and VR experience available
NVIDIA VRWORKS AUDIO
NVIDIA VRWORKS AUDIO
A STARTING POINT

SYNTHESIS
Creation of Source Sounds

DIRECTION
Location of Incoming Sound

PROPAGATION
How Sound Moves in Space
IMPORTANT DISTINCTION
Psychophysics - It’s Not Just for Mad Scientists

Sensation
A physical experience

Psychophysics

Perception
A purely mental experience

Cue - Property of a stimulus which affects its perception

Psychoacoustics - Psychophysics in the auditory system
PSYCHOACOUSTICS 101
Introduction to Human Hearing

**Sensation**
- Frequency
- Wave Shape
- Pressure
- ITD
- ILD
- Spectrum
- Delayed Repetitions

**Perception**
- Pitch
- Timbre
- Loudness Distance
- Direction To Source
- Size of Space
- Presence of Boundaries
PSYCHOACOUSTICS 101

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**Synthesis**

**Direction**

**Propagation**

**Keywords**
- Frequency
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VR IS GAME CHANGING

Making and experiencing VR is fundamentally different than traditional gaming
VR IS A SENSORY TAKEOVER

Hijacking The Senses With Synthetic Stimulation

Outside VR: unavoidable cues break immersion

In VR: HMD’s hijack the visual system; headphones hijack the auditory system

Can create only stimuli

**VR Challenge:** Create and present stimuli to multiple senses that all instill the same, intended perception
Immersion is the agreement of perceptions from different senses

- Vision
- Auditory
- Proprioception
- Haptic

Disagreement between visual and proprioceptive cues is a major source of VR nausea.
ANSWERING BIG QUESTIONS

SYNTHESIS
What is it?

DIRECTION
Where is it?

PROPAGATION
Where am I?
Surprise is the distance between expectation and observation

Stimuli from one sense must agree with expectations established by others
SPOILER ALERT
You Cannot Unhear; You Cannot Unlearn
EXTERNALIZATION

Psychoacoustica Esoterica

Sounds Displayed on headphones are **internalized**

**Internalization** - perception that stimuli originates within the listener

HRTFs give angular direction but do not solve internalization

Research indicates propagation **cues** are responsible for **externalization**
TO SUMMARIZE

To feel like you’re there, make it sound like you’re there

1. Cues, properties of stimuli, control the perceptual experience

2. Cues delivered through different senses must agree on a single perceptual experience

3. Auditory cues provide information about both sound sources and the scene
   Cues provided by indirect audio paths reinforce a perceptual experience of immersion
   Cues provided by indirect audio paths contribute to externalization
Achievement unlocked
Survived academic background part of the talk
VRWORKS AUDIO

Path Traced Audio

• Real-time modeling of the following effects:
  • Sound propagation, direct and indirect paths
  • Occlusion for direct and indirect paths
  • directionality/HRTF
  • attenuation
  • diffraction
  • material reflection, absorption, & transmission
VRWORKS AUDIO
A Full set of Auditory Cues

Direct Path Cues: Occlusion, distance attenuation, transmission

Indirect Path Cues: Early reflections/echoes, direct-to-indirect energy ratio

Spatial Cues: Indirect delay, reverberant energy & spectrum

Directional Cues: Incorporates HRTF technology for directional information

Accumulates all of these into a set of convolution filters
& provides an engine to apply those filters
VRWORKS AUDIO PIPELINE

Application

Scene Information

Simulation

Filters

Filter Application

‘Dry’ Audio

‘Wet’ Audio

VRWorks Audio

GPU
INCORPORATING IN YOUR APPLICATION

Accessible Acoustics

Applications

**NVIDIA Acoustic Raytracer (NVAR) API**

Library: .h, .lib, .dll

Game Engines

Unreal Engine 4.15

Integration and Plugins

*More engines coming soon*
C API SDK SAMPLES

nvAudioBasic

Creates simple cube geometry
Places one source and listener inside box
Generates filter, applies to input .wav, writes output .wav

Demonstrates API function calls
Interactive demo with three sources
Graphical rendering included to explore the Sponza geometry
Demonstrates using NVAR within an interactive, game-type application
VRWORKS AUDIO IN UNREAL ENGINE 4
Integration and Plugins
**KEEPING IT SIMPLE**

Presets for Effect Level

**Effect presets:**

- **LOW** - Subtle effects, primarily early reflection; fast attenuation
- **MEDIUM** - Realistic effects; balanced reverb and early reflections
- **HIGH** - Rich, aesthetically-pleasing reverbs; long-lived acoustic energy

API exposes parameters for more detailed tweaking
SIMULATION COMPLEXITY

Compute Presets

**Compute Presets**

**LOW** - Single-GPU, rapid effect generation
   
   Good quality filters

**HIGH** - Simple scenes, or multi-GPU
   
   Pro-Audio quality filters
ACOUSTIC GEOMETRY AND MATERIALS
We Measured So You Don’t Have To

Simple to understand user-facing material model:

Reflection coefficient, transmission coefficient

Predefined materials:

Wood, Metal, concrete, plastic, cloth, glass, carpet
DYNAMIC SCENE SUPPORT
The Power of Interactive Simulation

Screenshots from Unreal Tournament by Epic Games
DYNAMIC SCENE SUPPORT
The Power of Interactive Simulation

Interactive acoustic simulation allows real-time reconfiguration

Change

- Material properties, Material of mesh, Mesh transformation, Source location, listener location and orientation, source effect preset & parameters

Add/Delete

- Meshes, Materials, Sound Sources
VRWorks Audio includes an optimized convolution engine for auralization

Filters can also be retrieved for analysis or application outside VRWorks Audio
NOTHING SAYS IMMERSIVE AUDIO LIKE WATCHING A VIDEO ON A PROJECTOR AND LOUDSPEAKERS IN A CONFERENCE ROOM THE MORNING AFTER THE GTC PARTY SO LET’S DO IT
VRWORKS AUDIO IN ACTION
Optis HIM Human Ergonomics Evaluation
GETTING VRWORKS AUDIO

VRWorks Audio in Your Projects

VRWorks Audio SDK

https://developer.nvidia.com/vrworks/vrworks-audio

Unreal Engine With VRWorks Audio

https://github.com/NvPhysX/UnrealEngine/tree/VRWorks-Audio-4.15.1
MAKING THE MOST OF IMMERSIVE AUDIO

#1: Spatialize sounds coming from the player in a single submix
   Footsteps, speech, gunshots, breathing

#2: Prioritize speech and impact/explosion sounds for geometric effects

#3: Apply spatialization effects last in any DSP chain
OTHER ADVICE

As beautiful as it sounds (https://www.youtube.com/watch?v=e4dT8FJ2GE0&t=57), monster reverb sounds aren’t always the most realistic.

Capture sounds as anechoically as possible

Balloon Pop - Stock Sound Effect

Balloon Pop - Recording in Anechoic Chamber
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VRWORKS AUDIO
Enhanced Immersion Through Acoustic Fidelity

FREE AND AVAILABLE TODAY

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