

Dustin Painter – MFA in Recording Arts and Technologies

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ABSTRACT

The creative and technological limits of binaural audio production have continued to be unmet. A primary factor hindering audio control advancements for immersive experiences is the need for individualized Head-Related Transfer Functions (HRTFs). HRTFs are highly dependent on each end-user because of the independent physiological factors of humans. Recent research shows, particularly within the context of Extended Reality (XR) experiences, humans can learn generic HRTFs deployed within audio pipelines from game engines such as Unity and Unreal Engine quickly. In the same way humans have independent physiological factors within their aural systems, people have individual localization capabilities. HRTF commonalities of excellent localization candidates provide greater generalized HRTFs for public use. With these developments, and the human ability to relearn HRTFs, XR experiences are a prime avenue for testing the ability to equalize and shape the timbre of an immersive audio experience. Within a headphone-based binaural audio delivery system, the end-user can use gain compensated equalization to shape the timbre of their experience without degrading the quality of audio or immersion and without the need for a personalized HRTF.

OBJECTIVES

- Design a user controllable equalizer which can be manipulated in real time within a Virtual Reality environment without ruining localization of sound sources.
- Create a Virtual Reality application for the Oculus platform using the Unity game engine that showcases the use and design of the equalizer.
- Compose and produce spatial music tracks with individual instruments placed throughout a 360-degree spatial field and the ability to adjust listening position and perception via head-tracking.
- Create and implement nature ambiances within Unity to provide additional immersion into the virtual natural environment.

APTITUDE AUDIO MONITOR PATH EQUALIZER (MPE-Q)

The equalizer used in Seasons Forest VR was designed in conjunction with, and programmed, by Andrew Bainton of Aptitude Audio. Named the "Monitor Path Equalizer," this EQ uses automatic gain compensation in each band. Contrary to typical equalizers, which also boost amplitude levels and cause phase shifts, MPE-Q simply adjusts the timbre of the final binaural output, preventing adjustments and shifts in localization. Each band can be adjusted in "linked" mode, which equally adjusts the timbre of each band in both the left and right outputs simultaneously, or "unlinked" mode, which allows users to adjust the timbre of the left and right channels of the binaural output individually.



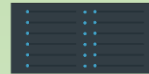
In Game Version of the MPE-Q

DustinPainterXR
Immersive Music Experiences

ADJUSTABLE EQ BANDS

The MPE-Q was designed with simplicity in mind. Each band is given an adjective to describe the frequency content in a manner which is accessible to the general public. Each band boosts up to 8 dB total.

- Band 1 – Feel – 20 Hz to 60 Hz
- Band 2 – Power – 60 Hz to 120 Hz
- Band 3 – Warmth – 120 Hz to 250 Hz
- Band 4 – Color – 250 Hz to 2000 Hz
- Band 5 – Presence – 2000 Hz to 6000 Hz
- Band 6 – Brilliance – 6000 Hz to 20000 Hz



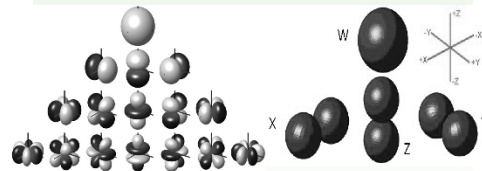
VST3 Version of MPE-Q

FIRST-ORDER AMBISONICS (AmbiX) MUSIC PRODUCTION

The music for Seasons Forest VR was composed, produced, and mixed using Cubase Pro 11. Each composition was mixed in Third-Order Ambisonics and decoded to First-Order Ambisonics (AmbiX), a four-channel spatial audio file compatible with Unity and the OculusSpatializer toolkit, for the final application. Beginning in Third-Order Ambisonics provided greater spatial resolution and detail, particularly for panning into the elevation plane, when compared to beginning in AmbiX. The Ambisonic panner used within Cubase Pro 11 was the DearVR Pro panner. DearVR Pro contains mixing parameters which assist with improving auralization and localization of sources such as embedded reverb, reflections, room parameter and size adjustments per instrument, and occlusion.



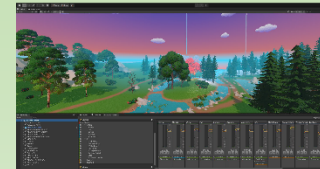
DearVR Pro Ambisonic Panner



Spatial Resolution of Third-Order Ambisonics (Left) vs. First-Order Ambisonics (Right)

UNITY BUILD AND INTEGRATION

Unity 2019 was used to build the VR environment using purchased assets from the Unity Asset Store. All nature ambiances were placed in the elevation plane and spatialized using the DearVR Unity asset. Music files were imported as AmbiX files and decoded by the OculusSpatializer asset to retain head-tracking. A .dll (Unity Native Audio Plugin) version of MPE-Q was placed directly onto the Master audio output, which adjusts the timbre of all incoming audio. The current build of the project is deployable to the Quest 2 and PC tethered Oculus equipment such as the Rift S.



Unity 2019 Seasons Forest VR Build

RESULTS



Planes of Localization

MPE-Q Parameters in Unity

- The Brilliance band increases localization and clarity of elements in the elevation plane, specifically elements 90-degrees positive in the elevation plane. Embedded source reverb height perception increases when using the Brilliance band. Brilliance also improves panning localization in the azimuth plane by assisting with problems related to in-the-head-localizedness.
- The Presence band increases localization and clarity of elements within the elevation plane, particularly elements panned within the 45-degree elevation plane. Transient heavy instruments, such as percussion, become easier to localize as the detail of the transient attack become clearer using the Presence band.
- The Color band increases localization and clarity of elements on the azimuth plane. The width of embedded source reverbs becomes clearer when using the Color band, increasing localization capabilities in both the azimuth and distance planes.
- The Warmth band does not increase localization of any elements, but also does not shift the localization of sources. This band is useful as a utility band to add warmth and fullness to spatial audio when using the inherently bright Quest 2 speakers.
- Feel and Power do not increase localization, or shift localization, within Seasons Forest VR. These bands may be helpful in more combat heavy VR experiences where there is more emphasis on powerful sound design elements with bass and sub-bass harmonic content or for mixing spatial audio using the VST/AU version of MPE-Q.

CONCLUSIONS

- Gain compensated equalization can be used to adjust the timbre of Virtual Reality based spatial audio without degrading localization ability.
- Localization capabilities within an immersive audio experience improve with this form of equalization when boosting selected frequencies between 250 Hz and 20000 Hz.
- AmbiX music production produces both a superior immersive listening experience and improvement in game engine performance when compared to individual point source Audio Components being used for individual instrument tracks within Unity.
- Instruments with greater low-mid to mid frequency content should be placed in the elevation plane when performing Ambisonic mixing. Brighter timbred elements increase further in brightness, to the point of harshness, when panned into the elevation plane.
- DearVR Unity provides the best overall spatialization of sound design elements when compared to other spatialization assets currently available for use within Unity.
- Further information will be gathered from comments and reviews of the application on SideQuestVR to continue researching and improving this method of equalization for VR applications and spatial audio production.

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