Assignment 2
Modelling of audio attenuation and occlusion using a virtual environment

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ABSTRACT
The utilization of virtual environments (VE) in environmental noise assessments require the VE to be fully immersive; audio attenuation and occlusion are key. A number of audio systems were examined to explore the level to which audio can be immersive within Unity 3D. Impulsonic's SoundFlow easily, simply and accurately attenuates and occludes audio within the VE, however, rendering times exponentially increased with size of the project. Future developments into the occlusion method are required to create a realistic VE audio system. Current systems provide a good basic audio system.

Keywords
Unity 3D, virtual environment, audio, attenuation, occlusion

INTRODUCTION
Using VE can provide an invaluable tool to help provide comprehensive and highly detailed models of built and natural environments for industries, such as automotive, architectural, engineering and environmental[15,10,12,7,1]. These controlled experimental computers based models help test proposed plans or ideas for future developments for a range of audiences.

The integration of audio into these VE can provide a very immersive and informative experience for the user/s. Audio integration in VE can be utilized in range of situations including noise assessments, safety warnings, video games and even hospital treatment for audiological conditions such as subjective tinnitus[3,8,5,4,17]. Creating VE that are convincingly realistic requires a highly dynamic and detailed environment[13]. For audio within VE to be fully immersive and informative, two main properties are required: realistic audio attenuation (distance) across the VE; and realistic occlusion (environmental effects) by objects and/or terrain within the VE[16].

NOISE ASSESSMENT STUDIES
Environmental noise assessments[12,5,4] are a key part of manufacturing and construction planning processes (for example during wind turbine developments, motorway construction, residential home design, active construction sites or expansion of airports) to ensure minimal impact on the individual user or surrounding individuals.

The utilization of VE allows companies to predict potential noise levels before construction begins, and enables the design management team to be informed to ensure the noise levels are kept to a minimum. The VE can be continually developed and tested through prototype creations until the desired reduction of noise impact and final design has been created.

PROJECT OVERVIEW
This project aimed to explore the development of a realistic audio system within a VE that provides the user/s with an immersive and informative experience. The project involved examining the methods of audio attenuation (louder or quieter audio depending on distance from audio source), and audio occlusion by solid objects (audio volume and quality reduction when behind a solid object).

The project used the popular 3D game engine Unity 3D (v.5.2.3f1) in which the development of a realistic audio system can be explored. As the audio was the main focus of the project, and due to the available computer/laptop hardware, a basic VE was developed to examine the methods of audio attenuation and occlusion. Therefore, the objects included within the VE were basic objects (cubes/spheres) as the audible objects, simple buildings (single room house), and basic terrain (single hill/mountain). This basic VE in Unity 3D was enough to enable the exploration of the development of audio attenuation and occlusion. The Unity project is provided with this report.

DEVELOPMENT STEPS
The project was split into a two stage process to explore the development of audio attenuation and occlusion with Unity 3D. The first stage investigated the level to which the already available audio system within Unity 3D could be used, while the second stage investigated two other methods of developing and designing a realistic audio system within Unity 3D, *Propagate* (Package provide on the Unity Asset Store)[2] and *Phonon SoundFlow* (Impulsonic Unity 3D package)[11].

Unity 3D (v.5.2.3f1) built-in feature

The development of a realistic audio system using Unity 3D's build-in audio system was assessed first. The majority of the audio system development using Unity 3D's built-in feature was conducted prior to this project in a smaller student project during the Advanced Visualisation module. However, this project applied the audio system to a simple scene with multiple audible objects and modified terrain.

Unity 3D has a simple to use, built-in, audio system (Controller needs to be the only '*audio listener*'). Applying the '*Audio Source*' component to any object in Unity 3D can give realistic 3D audio to that object. This provides the audio attenuation required. The built-in system includes a number of settings including audio roll-off settings over a set distance, volume control, pitch control and priority control.

However, it does not provide audio occlusion by objects within the scene; the sound stays the same quality where ever you are, either open spaces or behind objects, within the audible radius. To add audio occlusion to the system, additional Unity packages are required. A number of Unity packages were examined; Propagate[2], Sectr Audio[6], 3Dception[9], RealSpace3D[14] and Impulsonic SoundFlow[11], with Propagate and SoundFlow being used in this project.

Propagate Unity Package (v.1) (Luke Perkin)

Propagate is a Unity Package that is available on the Unity Asset Store ($20) that provides *'real-time sound propagation'*[2]. It provides the integration of audio occlusion into the built-in Unity audio system, creating the immersive and informative experience required.

Propagate uses a system of 'audio-nodes' that can be added into the VE scene. The 'audio-nodes' placed across the VE scene are all interconnected with one another via links. The nodes and links can be added in a number of places including open internal and external spaces, through open and closed doorways, and in stairways. These nodes and links provide the audio system with enough information to accurately attenuate and occlude the audio across the VE. It works by allowing the audio from the source to travel to a nearby 'audio-node', along the links through adjacent nodes and to the appointed *'audio listener'*. The audio quality and volume is then be automatically adjusted by Propagate depending on the distance travelled along the nodes and links, and also the material that the links pass through.

However, Propagate is not accurate enough to provide reliable audio attenuation and occlusion across the VE. The audio would often not take the correct path along the audio-nodes and links, or jump from node to node randomly, and therefore create an inaccurate audio system.

Impulsonic's Phonon SoundFlow 1.5 Beta

The Phonon SoundFlow 1.5 Beta is a Unity Package that is available direct from Impulsonic (Free for a month, $299 for a license) that *'make your sounds truly belong to the game world with correct occlusion and diffraction'*[11]. Similar to Propagate, it provides a method of integrating audio occlusion into the built-in Unity audio system.

Phonon SoundFlow uses a system of C# script components that can be applied to objects and terrain within Unity 3D. There are 3 main components that allow SoundFlow to assess the level of audio attenuation and occlusion based on the objects and terrain to ensure a realistic audio system is created. The 'Phonon Geometry' component allows SoundFlow to assess the shape of the solid objects and terrain. The 'Phonon Material' component allows SoundFlow to assess the material of which objects and terrain are made of. The 'Phonon Grid' component applied to the terrain provides a grid of regular interval points to which SoundFlow can calculate the level of audio attenuation and occlusion at each point across the scene whilst taking into account the Phonon Geometry and Phonon Material components on all objects and terrain.

This system of components provides a very simple and quick method of developing a realistically accurate audio system in Unity 3D, and appears superior to Propagate.

PROTOTYPE STATUS

The prototype with this report provides an example of the 3 audio systems examined (1 per level/scene); Unity 3D, Propagate and SoundFlow. The user can use the controller within the scenes to walk about and experience the 3 audio systems, with portals provided to the other audio systems given at the edge of each level. A simple basically designed scene was used (2 audible objects, a house and mountain), due to audio being the focus, and not overall design.

CONCLUSION

Overall, the project showed there is enormous potential for a VE with realistic and accurate 3D audio attenuation and occlusion to be developed within Unity 3D to be used for environmental noise assessments. The built-in Unity audio system is simple, yet lacks the occlusion feature. However, there are a number of packages that can be integrated into Unity to provide the audio occlusion, with the best tested audio system being Impulsonic's SoundFlow. This was accurate and very simple to use, however, with a growing project size, rending times may become an issue. A suggestion for the projects next step would be to investigate other developed audio packages that may provide a more accurate audio system.

FUTURE DEVELOPMENTS

There are a number of developments that are required in the future before VE audio becomes fully immersive and informative. The system by which audio occlusion occurs needs to be improved. This is the basis of the realistic audio system, and needs to be accurate without causing increases in rendering times. Impulsonic's grid system is easy and simple to use, and provides great basic audio occlusion, but still lacks very accurate audio occlusion. Also, the method to which audio systems can be applied to a scene need to be simple. Users want simple, fast and easy systems to

integrate into their potentially already designed VE. In the future, studying and recording characteristics of audio from real-life objects are key to the development of audio within VE. These key characteristics can then be applied to create a realistic VE that is fully immersive and accurate.

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