EnvironmentFX™ Audio Environment Modelling

by Adam Philp

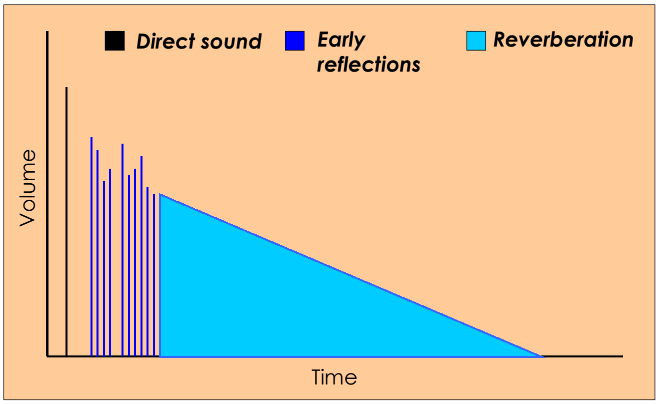


Figure 1: Distribution of direct and reverberant sound in a typical room

Sensaura EnvironmentFX™ Audio Environment Modelling technology takes PC audio to the next level of realism. Not only the sounds themselves, but also the acoustic contribution of the environment envelop the listener and give vital clues about the positions of sound sources. With Sensaura EnvironmentFX, the sound of a distant gunshot echoes down the walls of the dark alleyway, alerting you to danger ahead. As you approach a turning in a long stone passageway, you hear the footsteps of a guard around the corner, but the echoing, reverberant sound lets you know that he is far away. As he approaches, the direct sound of his footsteps emerges out of the echoes - time to run for it before he comes round the corner and sees you!

Sounds exciting? It sure is, and it's a piece of cake for programmers to add EnvironmentFX to their games, since the power of EnvironmentFX can be harnessed via the EAX API, Creative Technology's extension to Microsoft's industry-standard DirectSound3D API.

1 What is Audio Environment Modelling?

Audio Environment Modelling refers to the way in which sound travels to the listener's ears in a particular acoustic environment such as a room. A sound generated within a room travels in many directions. The listener first hears the direct sound from the sound source itself. Somewhat later, he or she hears a number of discrete echoes caused by sound bouncing once off nearby walls, the ceiling and the floor. These sounds are known as *early reflections*. Later still, as sound waves arrive after undergoing more and more reflections, the individual reflections become indistinguishable from one another and the listener hears continuous reverberation that decays over time. This combination of direct and reverberant sound is illustrated in Figure 1.

Sensaura™
3D POSITIONAL AUDIO

www.sensaura.com

2 The benefits of EnvironmentFX

Sensaura EnvironmentFX technology models different acoustic environments using a proprietary, highly efficient and highly reconfigurable reverberation algorithm to generate the early reflections and reverberation, which are then positioned using Sensaura's world-leading 3D positional audio technology to produce a dynamic, immersive, complete 3D audio environment. The audio signal processing path is shown in Appendix A.

These two technologies combine to give EnvironmentFX the following advantages over other reverberation implementations.

- Many reverberation algorithms bunch all the early reflections into the centre of the image. EnvironmentFX individually positions each early reflection in 3D space.
- Each delay and filter in the EnvironmentFX algorithm can be dynamically reconfigured, enabling smooth transitions between each environment.
- EnvironmentFX uses dynamically variable gains to control seamlessly the reverberation mix for each individual sound source.
- EnvironmentFX output is spatialized using Sensaura's revolutionary MultiDrive™ technology to maximize the EnvironmentFX experience on four speakers.
- Sensaura's world leading 3D positional audio ensures that the listener is surrounded by the EnvironmentFX experience when using just two speakers.

3 How does EnvironmentFX create different audio environments?

The characteristics of the reverberant sound heard by the listener provide information about both the positions of sounds within the space and about the space itself. Sensaura EnvironmentFX models the following characteristics to envelop the listener in the sound of the room.

- **Direct-to-reverberant sound ratio.** The volume of direct sound from a sound source gets louder as it approaches the listener and quieter as it recedes. The reverberation generated by sound reflecting off the room surfaces does not vary in this manner. The level of the reverberant sound remains approximately constant, irrespective of the distance between the sound source and the listener. The ratio between the direct sound and the reverberant sound levels therefore gives the listener an important cue as to the distance of the sound source.
- **Room size.** In a small acoustic space such as a hallway, the distance travelled by sound waves between successive reflections is small, so the reflections are close together and build quickly into diffuse reverberation. In an aircraft hangar, by contrast, sound waves must travel much further between each surface, so the reflections are much further apart and take much longer to build up from discrete early reflections into diffuse reverberation.
- **High frequency cut-off.** When a material reflects sound, not all frequencies are reflected to the same degree. Most materials tend to absorb frequencies higher than a certain value. This high frequency cut-off value varies from one material to another, so that a tiled bathroom, for example, reflects frequencies up to about 14,000 Hz, whereas a living room with surfaces covered by carpets and curtains only reflects frequencies up to about 2,000 Hz.
- **Early reflection level.** Early reflections give the listener the impression that there are walls or other sound reflecting objects close by. The greater the number of walls that are present close to the listener, the higher the percentage of early reflections will be. For example, the close, hard brick walls of an alleyway generate a lot of early reflections, whilst a grass covered field creates almost none.

- **Reverberation level.** The volume of reverberant sound can also vary widely between one environment and another.
- **Reverberation decay time.** This is the length of time taken for the sound to bounce around the room before the room surfaces and the air absorb it. An aircraft hangar, which is a large space with reflective surfaces, has a decay time of about 10 seconds. A padded cell, which is a small space with very absorptive surfaces, has a decay time of only 0.2 seconds.
- **High frequency decay time.** The decay time for high frequency sounds varies relative to that for low frequencies depending upon the reflectivity of the room materials. Materials such as concrete and marble reflect high frequencies well, whereas high frequencies are very quickly absorbed underwater or in a padded cell.
- **Density.** The density of the reflections in a space depends on the number of reflecting surfaces it contains. The higher the reflection density, the more quickly the reflections will build up into reverberation. A typical room with four walls, a ceiling and a floor has a much higher density of reflections than an open plain, for example.
- **Diffusion.** This is the extent to which sound waves are scattered and decorrelated by the surfaces of an environment. A highly irregularly shaped room will create a much more diffuse sound then a regular box-shaped one. Many concert halls, for example, introduce irregularities into their shape to produce a diffuse reverberation.
- **Detuning.** Detuning can simulate the pitch changes that occur when sound is reflected off moving surfaces such as water or trees blowing in the wind. Both the rate and the depth of detuning may be altered.

4 How can programmers use EnvironmentFX?

The capabilities of Sensaura EnvironmentFX are simple to use. EnvironmentFX is accessed using the EAX API, designed by Creative Technology and implemented as a property set extension to Microsoft's industry standard DirectSound3D API. This simple interface gives programmers quick and easy access to 26 different preset environments: domestic environments, such as living room and bathroom; whole buildings, such as concert hall and aircraft hangar; outdoor environments, including forest and mountains; and even underwater. In addition, programmers can easily control volume, decay time and high frequency damping effects. Because the EAX API is an open standard, there is no need for a new SDK for EnvironmentFX. Around 80 PC games have already been released which use EAX, including the smash hit games Unreal, Half-Life and Thief: The Dark Project. Many, many more are in the pipeline.

5 What next for EnvironmentFX?

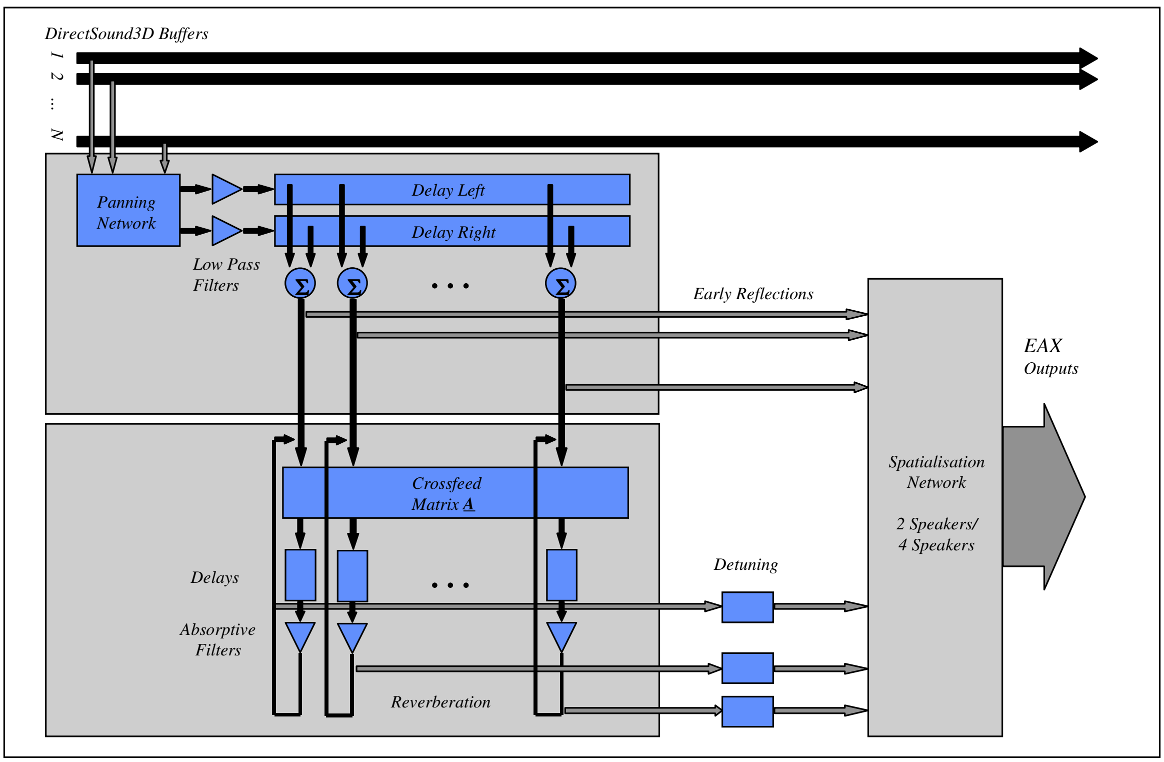
As if all this wasn't enough, Sensaura EnvironmentFX will soon include these new features to make your gaming experience even more exciting.

- **Obstruction.** This simulates the effect of when a sound source and the listener are in the same acoustic environment and the sound source moves behind an object, such as a stone pillar. The direct sound from the source is obstructed by the object, but the reflected sound is unaffected.
- **Occlusion.** When the sound source is in a different acoustic environment to the listener, both the direct sound and the reflected sound from the source are muffled (occluded) because they must travel through the dividing wall between the two environments.

- **More complete interface for controlling room effects.** Material reflectivity, early reflection delay, reverberation onset delay, density, diffusion and room size can be dynamically controlled directly by the game, allowing an even wider range of acoustic environments and worlds to be created.
- **Room roll-off factor.** Games can control the way in which the level of reflected sound varies with the distance between each sound source and the listener.

All of these new capabilities will be accessed using the new industry standard I3DL2 property set extension to Microsoft's DirectSound3D API. So, once again, games developers will be able to use these exciting new features quickly and easily to make games with more realistic, more involving and more exciting audio than ever before.

Appendix A: Block diagram of the EnvironmentFX algorithm



For further information please contact:

Email: dev@sensaura.com
WWW: www.sensaura.com
Tel: +44 20 8848 6636

Sensaura Ltd
Dawley Road, Hayes
Middlesex UB3 1HH
United Kingdom

A Scipher Company

DEVPC/010/0001/1