Chapter 5

Sound Spatialization Application Programmer Interface

For the application programmer interface, the VRML97 standard [Bell *et al.*, 1997] [Bell *et al.*, 1996] [Carey and Bell, 1997] [Hartman and Wernecke, 1996] was chosen.

The VRML97 specification defines a file format and semantic interpretation. For sound support, only two nodes, `Sound` and `AudioClip`, are specified. It is assumed that the sink (i.e., listener) is at camera position and/or controlled by the viewer.

The VRML97 specification was extended by this research for nodes specified in this chapter to enable more sophisticated audio modeling and rendering. The nodes are

`SfSoundSink` sound sink, an independent receiver (e.g., dummy head, microphone),

`SfSoundScape` soundscape, scope limitation and room acoustics,

5.1 Audio rendering process

A scenegraph defines a scene with graphical, interactive, acoustical (Figure 5.1), and behavior nodes and can be constructed either by class instantiation or external files which can be created using other authoring tools. Each node is defined in its own local coordinate system. During an audio rendering pass all transformations are resolved and necessary audio control data passed

to the resource manager. Resource management and final rendering in a spatialization backend are calculated in world coordinates. Resource management involves mapping from source—→sink channels to available mixels, spatialization channels, including a scheme to predict the perceptual relevance of a sound source in a given configuration. Resources are used economically by applying a clustering technique which mixes spatially proximate sound sources, representing them as a single sound (representative) source.

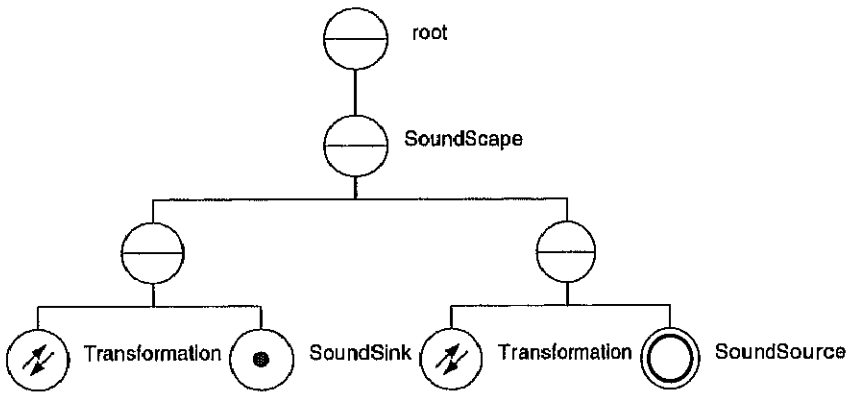

Figure 5.1: Scenegraph with sound objects

5.2 Sound source node

```
SfSoundSource {
  exposedField SFVec3f  direction     0 0 1
  exposedField SFFloat  intensity     1
  exposedField SFVec3f  location      0 0 0
  exposedField SFFloat  maxBack       10
  exposedField SFFloat  maxFront      10
  exposedField SFFloat  minBack       1
  exposedField SFFloat  minFront      1
  exposedField SFFloat  priority      0
  exposedField SFNode   source        NULL
  field        SFBool   spatialize    TRUE
}
```

Figure 5.2: Sound source node specification

Figure 5.2 shows the specification of a sound source. `Location` and `direction` are defined within the object space. The `intensity` inside of the core range ellipsoid, which is given by `minBack` and `minFront`, is one.

Fields in a sound source node:

direction specifies a primary sound-emmision direction as "front," and specified as vector defining the major axis of the audible-sound ellipsoids.

intensity adjusts the gain value of the sound source. An intensity of 0 denotes silence, and an intensity of 1 is the full gain as provided by the AudioClip node.

location specifies the position of the sound source in object space.

maxBack is the distance in the direction opposite the `direction` vector to which the audible range ellipsoid extends.

maxFront is the distance along the `direction` vector to which the audible range ellipsoid extends.

minBack is the distance in the direction opposite the `direction` vector to which the core ellipsoid extends.

minFront is the distance along the `direction` vector to which the core range ellipsoid extends.

priority is a hint to the sound spatialization resource management about how important the sound is. It should be left at 0 for background sounds, and set to 1 to ensure the display of important, short single-event sounds.

source is an AudioClip node which specifies how the sound will be generated (not spatialized); if not specified, the Sound node emits no sound.

spatialize indicates whether the sound should be played as if it's at a particular point in space (TRUE), or whether it should be rendered as ambient background sound (FALSE).

Taking a geometrical model into account, the resource management can calculate the volume at listener position from the `direction` and `location` fields. The `spatialize` and `priority` fields are used besides other indicators like loudness and scope for selecting sources which will get a channel assignment.

5.3 Sound sink node

Exocentric views and multiple sinks motivated the extension to the VRML97 standard with a node which represents a sound sink, similar to a camera description. The sound sink node shown in Figure 5.3 allows separate control of listening location and viewpoint and forms the basis of a general scheme for multiple sinks (see Section 2.2.3).

```
SfSoundSink {
  exposedField SFRotation  orientation   0 0 1 0
  exposedField SFFloat     sensitivity   1
  exposedField SFVec3f     location      0 0 0
  exposedField SFFloat     farDistance   10
  exposedField SFFloat     nearDistance  1
  exposedField SFFloat     priority      0
  field        SFBool      enable        TRUE
}
```

Figure 5.3: Sound sink node specification

Fields of a sound sink node:

orientation is defined as a rotation of the sound sink direction from its default (0,0,-1) vector. The up direction is (0,1,0). This field, along with the current geometric transformation, specifies the orientation of the sound sink in world coordinates.

sensitivity adjusts the gain of the incoming sound signals; an intensity of 0 indicates total deafness, and an intensity of 1 indicates full gain.

location is the position of the sound sink in object space.

farDistance is the radius of the sensible range sphere.

nearDistance is the radius of the core sphere (inner ear distance in case of HRTF-based processing [CRE, 1994]).

priority is a hint to the sound spatialization resource management about how important this sound sink is, especially applicable in case of multiple sinks.

enable indicates whether the sink should contribute to the spatialization (applicable in case of multiple sinks).

5.4 Soundscape node

Inspired by the Java3D specification [Sowizral *et al.*, 1997], the soundscape nodes (Figure 5.4 relates medium definition and space. The bounding box limits the range of aural attributes specifications.

```
SfSoundScape {
  exposedField SoSFVec3f min                    0 0 0
  exposedField SoSFVec3f max                    1 1 1
  exposedField SoSFAuralAttributes attributes   NULL
}
```

Figure 5.4: Soundscape node specification

Fields of a soundscape node:

min is the first corner of the bounding box.

max is the second corner of the bounding box.

attributes SfAuralAttributes node specifing the aural attributes.

Bibliography

[Bell *et al.*, 1996] Gavin Bell, Rikk Carey, and Chris Marrin. The Virtual Reality Modeling Language, Version 2.0 Specification, ISO/IEC CD 14772, August 1996. `http://www.vrml.org/VRML2.0.old/`.

[Bell *et al.*, 1997] Gavin Bell, Rikk Carey, and Chris Marrin. ISO/IEC 14772-1:1997: The Virtual Reality Modeling Language (VRML97), 1997. `http://www.vrml.org/Specifications/VRML97/`.

[Carey and Bell, 1997] Rick Carey and Gavin Bell. *The Annotated* VRML *2.0 Reference Manual.* Addison-Wesley Developers Press, 1997. ISBN 0-201-41974-2.

[CRE, 1994] Crystal River Engineering, Inc. *CRE_TRON Library Reference Manual*, August 1994. Revision B.

[Hartman and Wernecke, 1996] Jed Hartman and Josie Wernecke. *The* VRML *2.0 Handbook.* Addison-Wesley, Inc., 1996.

[Sowizral *et al.*, 1997] Henry Sowizral, Kevin Rushforth, Michael Deering, Warren Dale, and Daniel Petersen. Java^{TM} 3D API Specification. Sun Microsystems, August 1997. `http://www.javasoft.com/products/java-media/3D/forDevelopers/3Dguide/j3dTOC.doc.html`.