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Strategies to Improve X3D v4 Sound Component

Summary: the X3D Graphics International Specification includes a 3D spatialized sound model for inclusion of sound sources in 3D scenes. Multiple audio sources are supported, with a small set of required formats as well as options for alternate formats. The current X3Dv3 sound model is simple (circa VRML era) and deserves multiple improvements. This document presents a suggested topic list of potential capabilities and references that can be integrated in a comprehensive manner as part of the forthcoming X3D version 4 specification.

1. **3D spatialization algorithms for Sound node attenuation ellipsoids**
    a. McDermott 2014: Bouncing Reflections, Reflected Path
    b. RESound: Interactive Sound Rendering for Dynamic Virtual Environments, http://gamma.cs.unc.edu/Sound/RESound
    c. Others, perhaps including parameterized/extensible algorithms
    d. Consider ordered list of supported algorithms, corresponding to computational complexity and X3D player support
    e. Define corresponding list of enumerations for each spatialization algorithm
    f. Scoping within scene graph: boolean *global* variable for localization, computational efficiency?
    g. Boolean attributes to enable/disable, also to facilitate disabling attenuation effects
    h. Consider composable regions of higher/lower fidelity or salience
    i. Various graphics techniques such as ray tracing or radiosity

2. **Audio material properties**
    a. Add to *Material* node, or add new *AcousticMaterial* within Shape node
    b. Properties: absorption, dispersion, medium attenuation, others
    c. Frequency distribution of attenuation
    d. Characteristics of transmission media, perhaps refraction

3. **Scene graph integration: simplified geometry for satisfactory sound reflection**
    a. Direct integration within *Shape* node
    b. Consider further restrictions via *Collision-proxy* or *Collision-acoustic*
    c. Consider bounding box restrictions in addition to (overriding) outer attenuation ellipsoid
    d. Fast Fourier Transform (FFT) precomputations: allow? How to include precompiled values?
    e. Similarities, differences, relationships with radiosity, haptics, and shadows

4. **World Wide Web Consortium (W3C) efforts**
    a. W3C Audio Group https://www.w3.org/2011/audio efforts
        i. Web Audio API v1, Candidate Recommendation
        ii. Web Midi API, working draft
        iii. Web Audio Processing: Use Cases and Requirements, Working Group Note
        iv. Web Audio API v2 planning, goals and issues list
    b. W3C Audio Publications, Milestones https://www.w3.org/2011/audio/wiki/PubStatus
    c. File formats: match accepted standards, royalty-bearing formats can only be optional
    d. Streamable input: simply file-format capability? perhaps other aspects with common metadata
    e. Filter chains on sound sources, Web audio models http://www.webaudiomodules.org

f. W3C Audio and Video https://www.w3.org/standards/webdesign/audiovideo.html
g. W3C Accessibility https://www.w3.org/standards/webdesign/accessibility.html
h. Compatibility with hardware acceleration developments
i. Follow WebVR developments https://w3c.github.io/webvr to ensure matching (or at least compatible) aspects related to wearable devices and user settings/preferences.
j. Possible discussions, collaboration with Khronos regarding hardware/driver support for audio.

5. **X3D Standards Evolution**
    a. X3D v4.0 scene-related acoustics model
    b. X3D v4.1 (MAR) user customization for AR/VR
        i. Head shadow, head motion, pinna and shoulder response, interaural distance
        ii. Head related transfer functions (HRTF) https://en.wikipedia.org/wiki/Head-related_transfer_function
        iii. Includes adoption of WebVR specification
        iv. Implement ISO/IEC SC25/29 WG9, Mixed Augmented Reality (MAR) Reference Model
    c. Other ISO and industry standardization efforts regarding audio and sound presentation?
    d. X3D player implementations in C/C++, Java, JavaScript, others emerging
    e. Example scenes demonstrating auralization effects with corresponding visualization assists
    f. McDermott Three Dimensional Sound (TDS) Simulator improvements to support/evaluate X3D
    g. Careful observance of Web3D Standards Strategy, Contribution Submission Guidelines and Web3D Intellectual Property Rights (IPR) Policy to achieve widely implementable royalty-free (RF) solutions that are device-agnostic while benefiting software developers, content authors and end users.

6. **References**
    a. X3D Abstract Specification: Sound component
    b. X3D Tooltips: AudioClip, Sound
    c. X3D Scene Authoring Hints: Audio
    d. X3D for Web Authors, slideset Environmental Sensor and Sound Nodes and video
    e. X3D Example Archives, X3D for Web Authors, Chapter 12 Environment Sensor Sound
    f. X3D Examples Archive, NIST Conformance Suite: AudioClip, Sound
    g. X3D Example Archives, VRML 2 Sourcebook, Chapter 24 Sound

7. **References**

    a. Micah Taylor and Francis Meng. "Web-based geometric acoustic simulator ," Proceedings of the 23rd International ACM Conference on 3D Web Technology (Web3D 2018). ACM, New York, NY, USA, Article 6, 5 pages. DOI: https://doi.org/10.1145/3208806.3208817
    b. McDermott 2014: Bouncing Reflections, Reflected Path
    c. RESound: Interactive Sound Rendering for Dynamic Virtual Environments, http://gamma.cs.unc.edu/Sound/RESound

8. **Feedback**
    a. Comments are welcome, please send them to brutzman@nps.edu or X3D public mailing list, x3d-public@web3d.org

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