Sound xR Core for Unity
Release Note / Installation Manual

Introduction

- Sound xR® is a spatial audio solution for earphones/headphones that has been developed based on YAMAHA's ViReal™ total solution technology for immersive sound.
- Sound xR Core enables you to design an interactive and high-quality sound image localization and sound space in the application area of xReality, which is a generic term for VR/AR/MR/SR.
- Sound xR Core for Unity (hereinafter referred to as "this package" or "this plugin") provides the Plug-in for developing Windows, macOS, Android, and iOS applications under the Unity environment, in the Unity Package format.

Before using this package

- To use this package, you need to obtain a license from YAMAHA Corporation.
- For the terms of use of this package, refer to such as "Terms of Use" and "License Agreement" that you agree to when obtaining a license from YAMAHA Corporation.
- It is prohibited to use the contents of this package beyond the scope permitted by YAMAHA Corporation.

Assumed environment

The usage environment assumed for this package is as follows:

- Platform
  - Windows10/11 (64bit only)
  - macOS 11.6.2 or later (Intel/Apple silicon)
  - Android 10 or later (ARM64 only)
  - iOS 14.2 or later
- Unity
  - Unity 2020, 2021, 2022
- Headphones and earphones only
  (You cannot obtain the original sense of localization if you play back using speakers.)

Functions provided

- Object-based spatial audio processing function
  - mono in / stereo out
  - Supports only 48 kHz sampling frequency
  - The number of sound sources that can be processed depends on the processing power of the CPU.
- High Order Ambisonics (HOA) playback function
  - Supports 1st to 5th order Ambisonics. (4/9/16/25/36 channels)
  - Supports B-Format (AmbiX) ambisonic format. (.wav file format)
  - Supports only 48 kHz sampling frequency
  - Supports only PCM format, 16 bits and 24 bits bit depth
- This package supports Assembly Definition.

Setup procedure

1. If Unity is not installed, access the Unity official website and install it.
2. Create a new Unity project or open an existing project.
3. Appropriately set Platform in Build Settings and change the target Platform in Switch Platform.
4. From the UnityEditor menu, select 'Assets' > 'Import Package' > 'Custom Package.....'
5. When the Import Package... dialog box opens, select SoundxRCore.unitypackage.
6. When the Import Unity Package dialog box opens, check the contents to import and press the Import button.
7. When the import has completed, the SoundXR directory is added directly under Assets in the Project tree.
8. If the console displays “Sound xR: License Key in not activated.”, you need to activate the plugin.
   (If this message does not appear, activation is not required)
   - Select ‘Sound xR’ > ‘Activation’ > ‘Activate License Key’ and load the provided license key to activate.

Configuration

```
SoundxRCore.unitypackage
   ├─ Assets
        ├─SoundXR
             ├─ Common            : Common use program
             ├─ Docs
             |   ├─ Readme_jp.pdf : This file
             ├─ Effect            : Effect processing program
             |   ├─ Spatializer   : Spatial audio processing
             ├─ Examples          : Samples scenes, Scripts
```

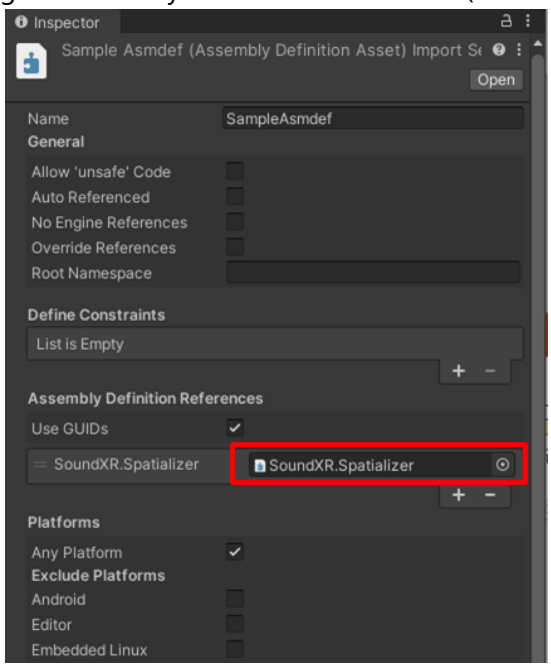
How to use (convert audio source into spatialized audio)

Sound xR Core Unity Plug-in can convert audio source to be spatialized.

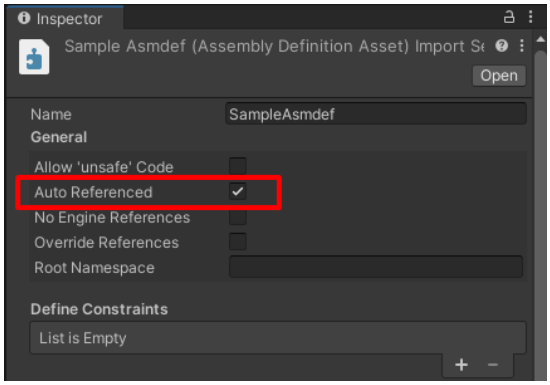
1. Activate Spatializer Plugin.
    - Select 'Edit' > 'Project Settings' > 'Audio' and choose 'Sound xR Core' in the Spatializer Plugin.

2. Set up of Assembly Definition
    - Create an .asmdef file in the appropriate folder with 'Create' > 'Assembly Definition'.
    - Set 'SoundXR.Spatilizer' in the 'Assembly Definition References' (recommended) OR turn on the 'Auto Referenced' check box. (See below)

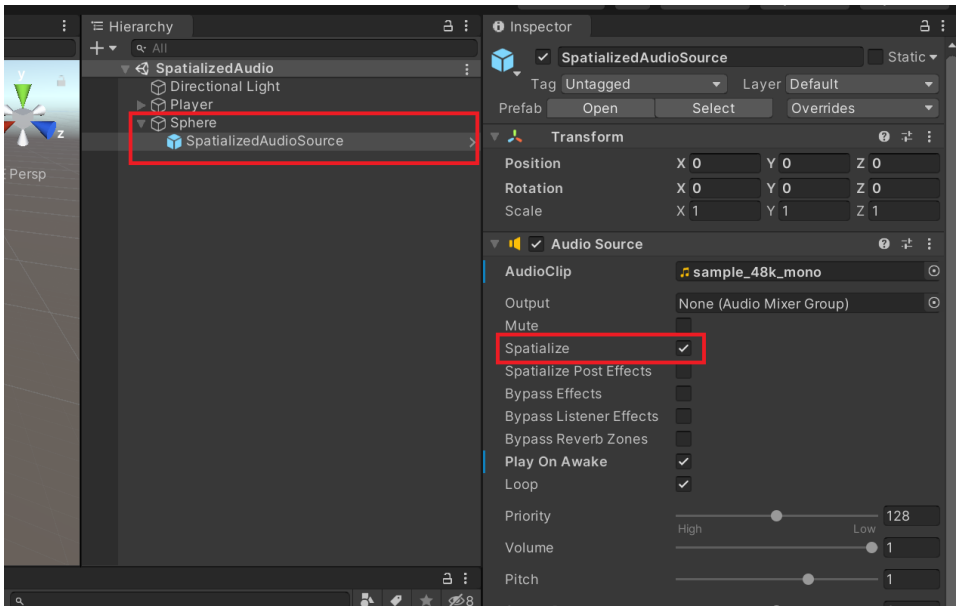
ex. setting of 'Assembly Definition References' (recommended)



ex. setting of 'Auto Referenced'



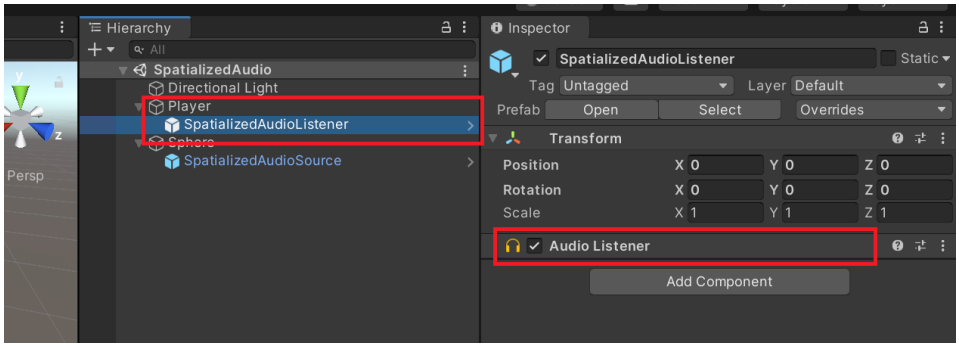
3. Select the Spatialize check box for each audio source (AudioSource) to be converted to spatial audio.



In this image, the audio source of the Sphere object is converted into spatialized audio.

4. For each AudioSource, add SpatializedAudioSource component from Add Component by selecting Sound xR > Effect > Spatializer.

5. Set the listening position (AudioListener).

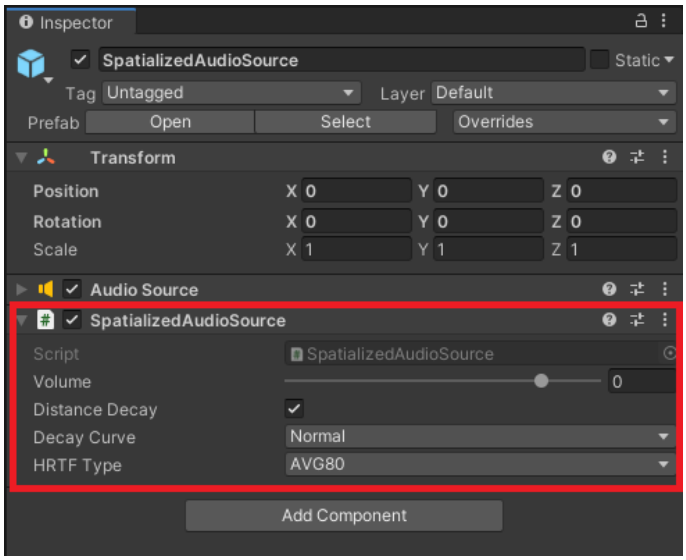


In this image, Audio Listener is set using Player as the listening position.
(The listener-side does not need to be specially set.)

Parameter operation

You can operate the following parameters from the Inspector window.

Name	Description	Value
Volume	Set the audio source output volume. The default is 0 dB.	-96 to 0 dB
Distance Decay	Set whether or not to decay the audio source volume by distance. This check box is not selected by default. If the Unity standard's distance decay function is also used, both distance decay functions are applied.	ON/OFF
Decay Curve	Set the degree of distance decay for the audio source. The default is Normal. At the same distance, the amount of decay decreases with Slow and increases with Fast.	Slow/Normal/Fast
HRTF Type	Select an HRTF characteristic set (described below). The default is AVG80.	AVG80/TC4



About HRTF characteristic sets

You can select the HRTF (head-related transfer function) characteristic set used for spatial audio processing from the following two types.

HRTF Type	Feature
AVG80	A natural sense of localization is obtained in all directions. Widely suitable for AR/MR applications.
TC4	When the audio object is in front, there is no spatial effect, and when the audio object is away from the front, the original sense of localization is applied. This feature, which is used for a VR application including video, is effective when you want to suppress changes in the sound quality of the audio object located in front.

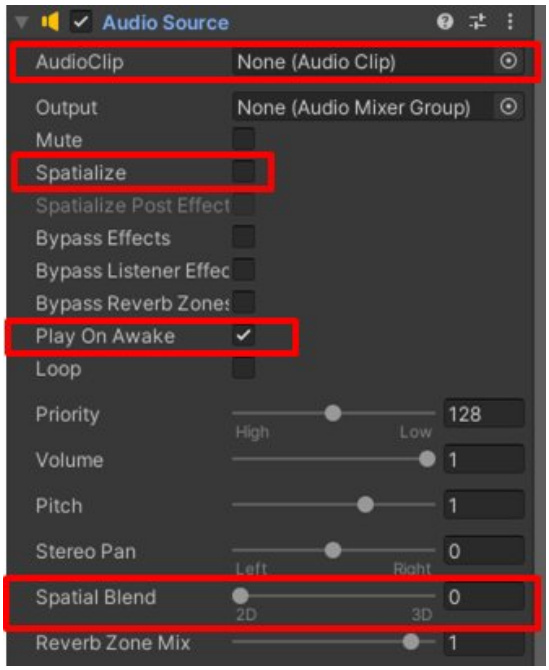
Sample scene - Spatial audio function

- This package contains a spatial audio playback sample scene. Use it as a reference.
- From the project window, view Assets\SoundXR\Examples\SpatializedAudio\Scenes\SpatializedAudio .
- When you start the preview, the audio object will start moving and playing sample voice.

How to use (HOA playback function)

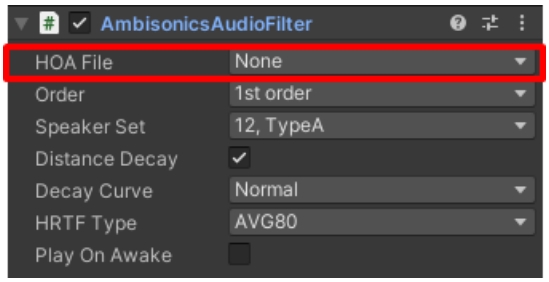
Sound xR Core Unity Plug-in can play an HOA file.

1. Activate Sound xR Plug-in.
    - Select Edit > Project Settings > Audio > Spatializer Plugin > Sound xR Core.
2. Set up of Assembly Definition
    - Create an .asmdef file in the appropriate folder with 'Create' > 'Assembly Definition'.
    - Set 'SoundXR.Spatilizer' in the 'Assembly Definition References' (recommended) OR turn on the 'Auto Referenced' check box.
3. Audio source-side settings (1)
    - Prepare an object to be used as the HOA audio source, assign AudioSource to it, and make the following settings.
        - Select the Play On Awake check box.
        - Set Spatial Blend of AudioSource to 2D.
        - You do not need to specify AudioClip of AudioSource and select the Spatialize check box.



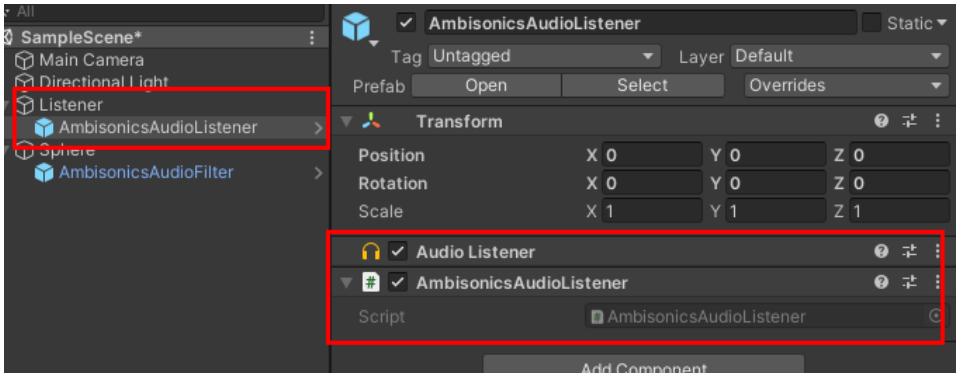
4. Audio source-side settings (2)

- From 'Add Component', add AmbisonicsAudioFilter component to the object to be used as the HOA audio source by selecting Sound xR > Effect > Spatializer.
- Place the HOA file in the Assets\StreamingAssets folder. If the StreamingAssets folder does not exist, please create it.
- From Inspector, specify the HOA file you want to play in 'HOA File' of AmbisonicsAudioFilter.
- For other settings, set the necessary items by referring to "Parameter operation" described below.



4. Listener-side settings

- Prepare an object to be used in the listener side. At this time, be sure to observe the following items.
  - Be sure to select different objects for the HOA audio source object and the listener-side object. If you use the same object, the audio source also rotates when the listening direction rotates, which results in the sound not changing even if the listening direction is changed.
  - The listener-side object's Position must be the same as the HOA audio source object's Position. If either one moves, be sure that both move together. Abnormal playback sound will be generated.
- Assign AudioListener to the listener-side object.
  - (No particular setting is required for AudioListener.)
- From Add Component, add AmbisonicsAudioListener component to the listener-side object by selecting Sound xR > Effect > Spatializer.
  - (No particular setting is required for AmbisonicsAudioListener.)



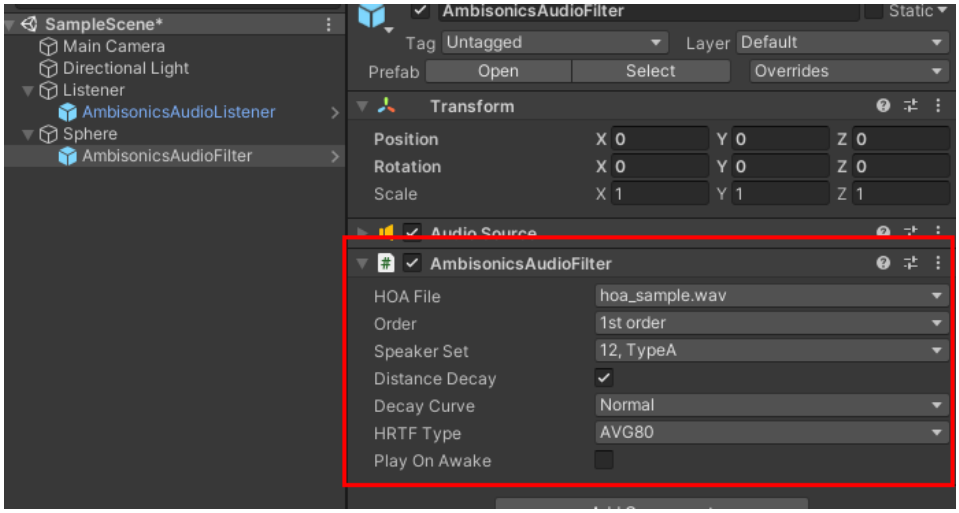
In this image, Audio Listener is set using Listener as the listening position.

Parameter operation

You can operate the following parameters from the Inspector window.

Name	Description	Value
HOA File	Specify the HOA file you want to play. The files placed in Assets\StreamingAssets are displayed in a list format. (Create the StreamingAssets folder if it does not exist.)	
Order	Set the HOA order. The default is 1st order. The higher the order is, the more detailed sound image localization can be expressed, however, the computational load increases. If the order set here is different from the order of the HOA file actually loaded, the smaller order is applied.	1st/2nd/3rd/4th/5th order
Speaker Set	Set the number of "virtual speakers" used for internal processing when playing back in the Ambisonics format. The default is 12ch: 12,	12/20/32/42, TypeA

Name	Description	Value
	TypeA (Only TypeA is currently supported as Type). The more virtual speakers there are, the more detailed the sound image localization can be expressed, however, the computational load increases. If the order of the HOA file to be played is low, even if there is a large number of virtual speakers, no effect is obtained.	
Volume	Set the audio source output volume. The default is 0 dB.	-96 to 0 dB
Distance Decay	Set whether or not to decay the audio source by distance. This check box is selected by default. When this check box is selected, the volume is decayed depending on the Scale of the object to which the AmbisonicsAudioFilter.cs component is added. The higher the Scale is, the greater the volume decay becomes.	ON/OFF
Decay Curve	Set the degree of distance decay for the audio source. The default is Normal. At the same Scale, the amount of decay decreases with Slow and increases with Fast.	Slow/Normal/Fast
HRTF Type	Select an HRTF characteristic set. The default is AVG80.	AVG80/TC4
Play On Awake	When this check box is selected, the HOA audio source starts playing at the same time the application starts. This check box is not selected by default.	ON/OFF



Tips

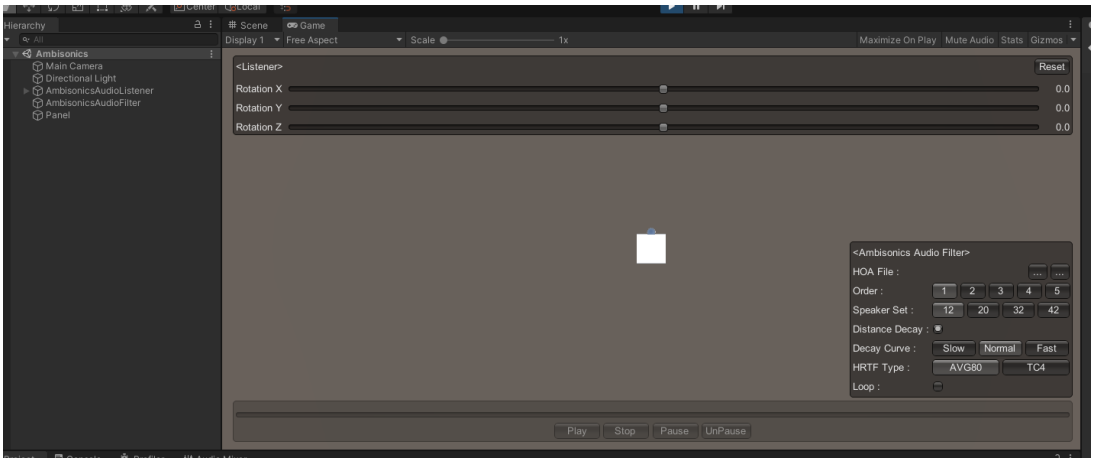
- HOA files must meet the following specifications
    - 1st to 5th order Ambisonics. (4/9/16/25/36 channels)
    - B-Format (AmbiX) ambisonic format. (.wav file format)
    - 48 kHz sampling frequency
    - PCM format, 16 bits and 24 bits bit depth
- If you load an unsupported HOA file, the following error log will be displayed in Console. Error codes are described later.

```
Ambisonics SetWaveFile() rc = 2
```

- If the Play On Awake check box of AmbisonicsAudioFIlter.cs is not selected, Play() of AmbisonicsAudioFilter.cs is called to start a playback.
- The Volume/Loop settings of the AudioSource with the AmbisonicsAudioFileter.cs component added are applied to each channel of the virtual speakers.
- Distance Decay, Decay Curve, and HRTF Type are the same as of the SpatializedAudioSource.cs component. These settings are applied to the audio output from each channel of the virtual speaker.
- The HOA file is expanded to the virtual speakers focusing around the position of the object to which AudioSource is assigned, and played. Therefore, place AudioListener and AudioSource at the same Position.
    - It is recommended that you fix the Position and change the AudioListener direction by Rotation for trial listening.

Sample scene - HOA playback

- This package contains a HOA playback control sample scene. Use it as a reference when implementing HOA file playback control.
- From the Project window, view Assets\SoundXR\Effect\Spatializer\Examples\Ambisonics\Scenes\Ambisonics.
- This package contain a sample HOA file. .
    - A sample HOA file "3rdOrderHOASample1.wav" is stored in the Assets\StreamingAssets\Hoa folder. (WAV format file, 3rd order ambisonics)



This is the screen that previews the sample scene.

File import function

- This package contains a sample of a general-purpose file import function (plug-in). This function is provided as a sample; therefore, its operation is not guaranteed.
- It supports the function to read files under Assets\StreamingAssets and the function to read files outside the application.
    - It is also used in the sample scene Ambisonics described above, so use it as a reference.
- It is necessary to either add 'SoundXR.Common' in the 'Assembly Definition References' (recommended) OR turn on the 'Auto Referenced' check box.
- Regarding usage on Android devices

    - You need to move AndroidManifest.xml and AndroidManifest.xml.meta included in Assets\SoundXR\Common\FileSystem\Plugins\Android of unitypackage of the imported Sound xR to Assets\Plugins\Android (create this folder if it does not exist).

    - If you already have AndroidManifest.xml, add the following content into the <application> tag.

      ```
      <activity android:name="com.yamaha.soundxr.ExActivity"
                  android:theme="@style/UnityThemeSelector">
          <intent-filter>
              <action android:name="android.intent.action.MAIN" />
              <category android:name="android.intent.category.LAUNCHER" />
          </intent-filter>
          <meta-data android:name="unityplayer.UnityActivity"
      android:value="true" />
      </activity>
      ```

    - You need to select Project Settings > Player > Other Setting and set the Write Permission setting to "External(SDCard)" from the Unity Editor settings.

        - When the app starts, a dialog box is displayed requesting the authority to access files in the device.
        - This authority is required to display the file selection screen and read the selected file.

Audio source playback area setting function

- This package contains components that control the area in which audio source are played.
- This component is provided as a sample; therefore, its operation is not guaranteed.

Usage

1. Place a GameObject in the scene to specify the area where the audio source can be heard.
2. Add SpatializedSoundArea component to any GameObject that has an AudioSource. SpatializedSoundArea component is located in Sound xR > Efftct > Spatializer > SpatializedSoundArea.
3. Set the GameObject prepared in step 1 in the Playback Area of the SpatializedSoundArea component.

Parameter operation

- You can operate the following parameters from the Inspector window.

Name	Description	Value
Area	Switch the audio source playback area setting function. Default is ON (enabled).	ON/OFF
Playback Area	Specify the area where the audio source is played by setting a GameObject. The playback area is determined by the Position and Scale of the GameObject you set.	-
Decay Area	Specifies the width of the region in which the Audio source gradually decays. Default is 2.0m.	0.0 - 50.0 m

About AudioSource volume

- The volume of AudioSource changes depending on the positional relationship between AudioListener and AudioSource. (See figure below)
- When one of the AudioListener and AudioSource is inside the Playback Area and the other inside the Decay Area, the volume will be attenuated.
    - If the position of the object inside the Decay Area is closer to the Playback Area, the volume will be louder, and if it is closer to the outside, the volume will be lower.
- When one of the AudioListener and AudioSource is inside the Playback Area and the other is outside, the volume will be zero.
- When AudioListener and AudioSource are in the same area, the volume is not attenuated .
- Normally, AudioSource is used by placing it inside the Playback Area.

Fig. Relation between AudioListener and AudioSource

- Summary of combinations

Position of AudioSource	**Position of AudioListener**	**Volume of AudioSource**
Playback Area	Playback Area	100%
	Decay Area	0% - 100% (Depends on AudioListener's position)
	Out of area	0%
Decay Area	Playback Area	0% - 100% (Depends on AudioSource's position)
	Decay Area	100%
	Out of area	100%
Out of area	Playback Area	0%
	Decay Area	100%
	Out of area	100%

    - The volume of the AudioSource is controlled by the SpatializedSoundArea component.

Sample scene

- This package includes sample scenes for this function. Please use this sample as a reference when using this function.
- See Assets\SoundXR\Examples\SpatializedAudio\Scenes\SpatializedSoundArea.

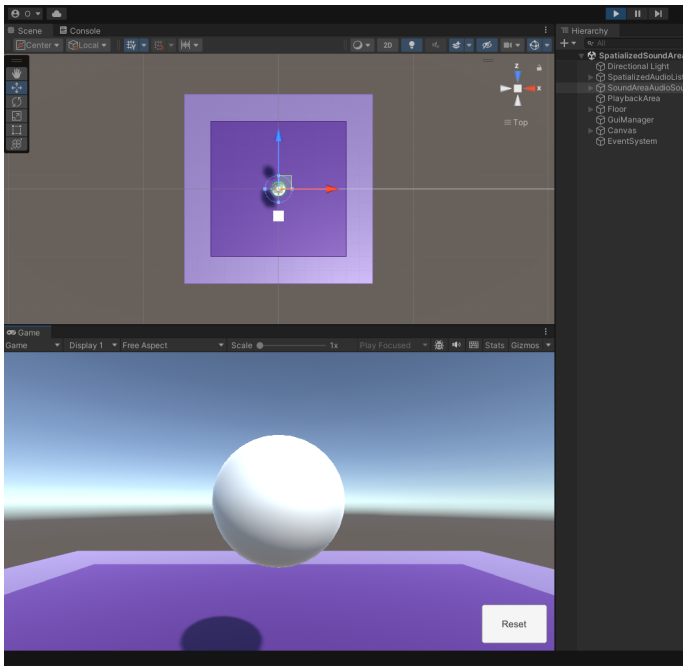


Fig. Preview of sample scene

- The floor surface is color-coded into Playback Area and Decay Area.
- By using the following keys/UI operations, the position and rotation of AudioListener can be controlled.
    - Move: ↑ / ↓ / ← / → Keys
    - Rotate: W / A / S / D Keys
    - Reset button: The position and rotation are initialized.

API Reference

This section describes details of API that this plugin provides. This plugin has two components.

- SpatializedAudioSource.cs
- AmbisonicsAudioFilter.cs

SpatializedAudioSource.cs

Description

- This component is for configuring spatialization settings.
- An AudioSource component is required to use this component.

Enum values

- DecayCurve: Value for setting the degree of distance attenuation.

```
enum DecayCurve {
    slow = 0,   /// The rate of distance attenuation is slow
    normal,     /// The rate of distance attenuation is medium
    fast        /// The rate of distance attenuation is fast
}
```

- Preset: Value for setting the HRTF characteristic. (Refer to section of About HRTF characteristic sets.)

```
enum Preset {
    AVG80,
    TC4,
}
```

Properties

Type	Name	Description
float	volume	Sets the output volume. [dB] (default: 0.0)
bool	distanceDecay	Sets whether to use the distance attenuation function of this plugin. (default: false)
DecayCurve	decayCurve	Sets the degree of distance attenuation. This value is valid when distanceDecay is true. (default: DecayCurve.normal)
Preset	HRTFType	Sets the HTRF characteristic sets. (default: Preset.AVG80)

AmbisonicsAudioFilter.cs

Description

- This component is for configuring HOA playback function.
- An AudioSource component is required to use this component.

Enum Vaules

- SpeakerSet: Value for setting the number of virtual speakers.

```
enum SpeakerSet {
    TypeA_12ch,     /// 12 ch
    TypeA_20ch,     /// 20 ch
    TypeA_32ch,     /// 32 ch
    TypeA_42ch      /// 42 ch
}
```

- DecayCurve: Value for setting the degree of distance attenuation.

```
enum DecayCurve {
    slow = 0,   /// The rate of distance attenuation is slow
    normal,     /// The rate of distance attenuation is medium
    fast        /// The rate of distance attenuation is fast
}
```

- Preset: Value for setting the HRTF characteristic. (Refer to section of About HRTF characteristic sets.)

```
enum Preset {
    AVG80,
    TC4,
}
```

Public Methods

Return Value	Function Name	Description
void	Play()	Start playing the HOA file.
void	Stop()	Stop playing the HOA file and the playback position returns to the beginning.
void	Pause()	Pause playback of the HOA file.

Return Value	Function Name	Description
void	UnPause()	Resume playback of the HOA file from where it was paused.
void	OnChangedAudioListenerTransform()	Transform change notification from AmbisonicsAudioListener

Public Variables

Type	Name	Description
bool	Playing	Can get playback status of HOA file. True means playing.
bool	Paused	Can get paused status of HOA file. True means paused.
bool	validAudio	Can get whether the HOA file is set. True means that the HOA file is set.
int	audioOrder	Can get order of ambisonics of the HOA file.
float	audioLength	Can get playback length [sec] of the HOA file.
uint	audioSamples	Can get number of samples of the HOA file.

Properties

Type	Name	Description
string	audioFile	Sets the path of the HOA file.
int	order	Sets the order of ambisonics when playback HOA files. (default: 1)
SpeakerSet	speakerSet	Sets the number of virtual speakers。 (default: SpeakerSet.TypeA_12ch)
bool	distanceDecay	Sets whether to use the distance attenuation function of this plugin. (default: false)
DecayCurve	decayCurve	Sets the degree of distance attenuation. This value is valid when distanceDecay is true. (default: DecayCurve.normal)
Preset	HRTFType	Sets the HTRF characteristic sets. (default: Preset.AVG80)
bool	playOnAwake	Sets whether to start playing the HOA file when the AudioSource starts playing. (default: Off)
bool	loop	Property for loop playback setting. It automatically reflects the Loop setting of the AudioSource. So basically, please use this property as read-only.
float	time	Sets or can get the playback positinon. [sec].

Error code

- When the plugin I/F is called in the AmbisonicsAudioFilter, the following error log is displayed on the console.

```
Ambisonics SetWaveFile() rc = 2
```

- The displayed error code means the following.

Error code	Description
0	Success
1	Error: Cannot open the file
2	Error: Input file is not WAVE format file
3	Error: Input file is not PCM format
4	Error: Unsupported number of channnels
5	Error: Unsupported sampling rate
6	Error: Unsupported bit depth

Notes and restrictions

- **[Important] Do not disable the AudioSource which is attached a SpatializedAudioSource.**
    - If you have to disable the AudioSource, please disable it for each GameObject.
    - If you have to stop the sound, please use Mute(), Stop() or Pause() function.
- It is known that noise occurs under certain circumstances when starting the preview of sample scene ‘SpatializedAudio’ in Unity 2022.3.x. This noise occurs without using our plugin, and no noise occurs in the built application. We apologize for the inconvenience, but please continue to use it as is.
- This plugin only supports ARM64 for Android. A warning message ("Sound xR: Support ARM64 only.") is displayed when switch platform to Android and apk building.
- When using Unity's distance attenuation function, noise may occur when the Audio Listener moves. In that case, please use Sound xR's distance attenuation function instead of using Unity's. To do this, set Spatial Blend to 2D and enable Sound xR's Distance Decay.

Customer support

If you have any problems or questions, send an e-mail to the following address.

Department name	**e-mail**
YAMAHA Corporation Sound xR support desk	soundxr-support-ML@music.yamaha.com

Release history

Version	Release date	Modification
1.4.0	Oct. 13th, 2023	・Added audio source playback area setting function.
1.3.6	Aug. 3rd, 2023	・Fixed a bug that caused noise when connecting certain bluetooth earphones on macOS. ・Added error code and warning message.
1.3.5	Jul. 18th, 2023	・Fixed a bug that occurred when building an application with Scripting Backend set to IL2CPP. ・Changed the internal processing (No function changed)
1.3.4	May 1st, 2023	・Changed the internal processing (No function changed)
1.3.3	Mar. 14th, 2023	・Fixed a bug in the HOA playback function
1.3.2	Jan. 26th, 2023	・Added Assembly Definition File
1.3.1	Dec. 5th, 2022	・Moved the sample scene to the 'SoundXR\Example' folder ・Fixed minor bugs
1.3.0	Jun. 16th, 2022	・Added HOA playback function
1.2.1		・Fixed bug in 'SpatializedAudioSource.cs'
1.1.0		・Made the HRTF dataset swichable (AVG80 / TC4)

Manual Version: 2023.10.27