TWO DATASETS OF ROOM IMPULSE RESPONSES FOR NAVIGATION IN SIX DEGREES-OF-FREEDOM: A SYMPHONIC CONCERT HALL AND A FORMER PLANETARIUM

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ABSTRACT

This paper presents two datasets of room impulse responses (RIRs) for navigable virtual acoustics. The first is a set of 240 mono and Ambisonic RIRs recorded at the Maison Symphonique, a symphonic concert hall in Montreal renowned for its great acoustic characteristics. The second is a set of 67 third-order Ambisonic RIRs which was recorded in the former planetarium of Montreal (currently known as the *Centech*), a space where the room acoustic includes an acoustic focal point where extreme reverberation times occur. The article first describes the two datasets and the methods that were used to capture them. A use case for these RIRs is then presented: an audio rendering of scene navigation using interpolation among RIRs.

1. VIRTUAL ACOUSTIC: REPRODUCTION AND SIMULATION

Recent progress in virtual acoustics has made possible the simulation of interactive navigation in acoustic spaces. This navigation can be done with the help of 3D game engines by rendering a virtual model of the space [1] while informing the source and listener positions to a real-time reverberation engine. This type of navigation is qualified as "6 DoF", for 6 degrees-of-freedom, since the experience enables the listener to navigate along 3 translation and 3 rotation axes. Research about (live) virtual acoustics is active, covering a large application scope, including cultural heritage [2, 3], video-games [4], and spatial audio immersive experiences [1].

For 6 DoF acoustic navigation, several geometrical acoustic techniques that have been described in the past [5] can be used to find acoustic paths between a source-listener pair, such as the image-source method, ray tracing and beam tracing. These paths, along with a directional specification of the delays and the power of the reverberations, constitute what is called the impulse response (IR) of the location for the listener-sound source pair. More precisely, we are interested in real-time auralization, i.e., the process of making audible, by physical or mathematical modelling, the sound field of a sound source in a geometrical space for a specific listener position [6]. This auralization strategy has already been experimented and presented in literature [7, 5]. The strategy is usually based on live computation of room impulse responses (RIRs) used to live feed a convolution reverberation.

Even though there is a research effort to improve the synthesis of complex sound scenes [8, 9], several challenges remain when applied to various use cases that involve a simulation of existing places:

1. Annotation of 3D architectural models [2] with acoustic parameters. This task requires tedious manual measurements and intervention in order to provide an accurate simulation, but may benefit from automated annotation informed by actual measurements.
2. The reproduction of existing places as 3D models. The accuracy of the model geometry affects the sound propagation during simulation. However, architectural photogrammetry faces challenges such as semantic segmentation of point clouds or 3D meshes [10], a mechanism that would ease the automation of surface annotations with acoustical parameters. Accordingly, 3D model-based acoustical simulations use models created manually [3, 11]. Moreover, it has been shown that manually built and calibrated 3D models can reliably provide plausible results comparable to those of the original space [11, 2].
3. Simulation of 6DoF navigation in acoustic spaces can be done using interpolation based on multiple RIRs, in which sound sources are virtually added. We provide an example in Section 4.

Addressing these challenges requires the availability of datasets with both 3D architectural models of existing places having singular acoustics, and captured acoustics in several source/listener positions. Accordingly, the datasets we provide here offer a critical opportunity for validation and comparison of algorithms for 6DoF navigation based on RIR interpolation and automated annotation of acoustic parameters into 3D architectural models.

To our knowledge, three datasets of higher-order Ambisonic impulse responses have recently been published. Motus [12] is a dataset of higher-order Ambisonic RIRs and 3D models measured in a room with varying furniture. It targets reverberation time analysis and its relation with furniture placement in a middle-sized room (4.9 m x 4.4 m x 2.9 m). Another dataset of dedicated to 6 DoF navigation in the Finnish National Opera and Ballet (Helsinki) is analyzed [13], and more specifically evaluates the directional decay properties that characterize a directional feedback delay network. Finally, the dataset of spatial RIRs in a variable acoustics room [14] enables 6 DoF rendering of SRIR interpolation methods and spatial dereverberation techniques as possible applications. Unfortunately, the dataset makes no mention of the geometrical 3D model of the opera and is not made available publicly for research.

(a) Loudspeaker with one of the calibrated microphones used during measurements at the Maison Symphonique.

(b) Loudspeaker with one Ambisonic microphone used during measurements at the Centech.

Figure 1: Spherical loudspeakers used as sound sources during our measurements.

In the first part of this paper, we present and make publicly available two datasets of room impulse responses from large spaces with unique acoustics: the Montreal *Maison Symphonique* concert hall and the former Montreal planetarium. Both datasets are provided with an accompanying geometrical model. The datasets are available under a creative commons license (CC BY-NC-SA 4.0) on `archive.org`[1].

The second and third section of this article provide a the method used for RIR capture and description of the dataset for the Maison Symphonique and the repurposed planetarium respectively. The fourth section demonstrates how the datasets can be used for 6 DoF navigation.

2. ACOUSTIC CAPTURE OF THE MAISON SYMPHONIQUE CONCERT HALL

We provide here a description of source-listener measurements made in the Maison Symphonique, a classical concert hall in Montreal. As illustrated in Figure 1, we used spherical loudspeakers as sound sources with mono and Ambisonic microphones as listener locations. In the configuration we describe hereafter, we provide measures for all relevant locations as well as a 3D model of the room.

2.1. Software tools for measurement

Our acoustic capture method consists of RIR measurements using Exponential Sine Sweeps (ESS), as described by [15] and further refined with [16] [17]. The recording pipeline generates a 20-second ESS at a sampling rate of 48kHz. The raw recording is then convolved with the ESS reverse filter. We used both mono calibrated microphones[2] and an Ambisonic microphone[3].

All conversions from ESS to RIR were done using pyAmbir [4], our Python module that implements ESS generation, computation of RIRs based on recorded ESS and conversion to 3rd order Ambisonic B-format (Ambix [18]). It also offers reverberation time computation utilities that are used in Section 3.4.

2.2. Maison Symphonique

This set of impulse responses was recorded in the Maison Symphonique of Montreal[5], a concert hall designed for symphonic orchestras. It is composed of mono (omnidirectional) and Ambisonic (3rd order) impulse responses. The sound source that was used is a custom-made omnidirectional loudspeaker. It was set in 11 different positions as shown in Figure 2 for every recording session.

2.2.1. *Impulse responses*

The recording of the impulse responses took place over three sessions, with the same 11 loudspeaker positions every time. Seven microphone positions were used for each session. When merged, these three sessions provide a larger number of source-listener positions, as presented in Figure 2. Precise locations and distances are provided in Table 1 and Table 2 respectively. The first session focuses on the stage, the second on the seating area (parterre) and the third on the first floor (corbeille and loge).

The files in the dataset are named using the following convention:

- `SX` indicates the source numbered `X`
- `LX` indicates the mono listener numbered `X`
- `LAX` indicates the Ambisonic listener numbered `X`

3. ACOUSTIC CAPTURE OF A PLANETARIUM DOME

Similar to what was done in the previous section, we provide here a description of source-listener measurements made in the Centech, the repurposed planetarium dome. As illustrated in Figure 1, we

[1] `https://archive.org/details/savr_rir_dataset_202204`. All URLs in this paper have been accessed in June 2022.

[2] `https://www.acopacific.com/mics.html`

[3] `https://www.zylia.co/zylia-zm-1-microphone.html`

[4] `https://gitlab.com/sat-metalab/pyambir`

[5] `https://placedesarts.com/en/venue/maison-symphonique`

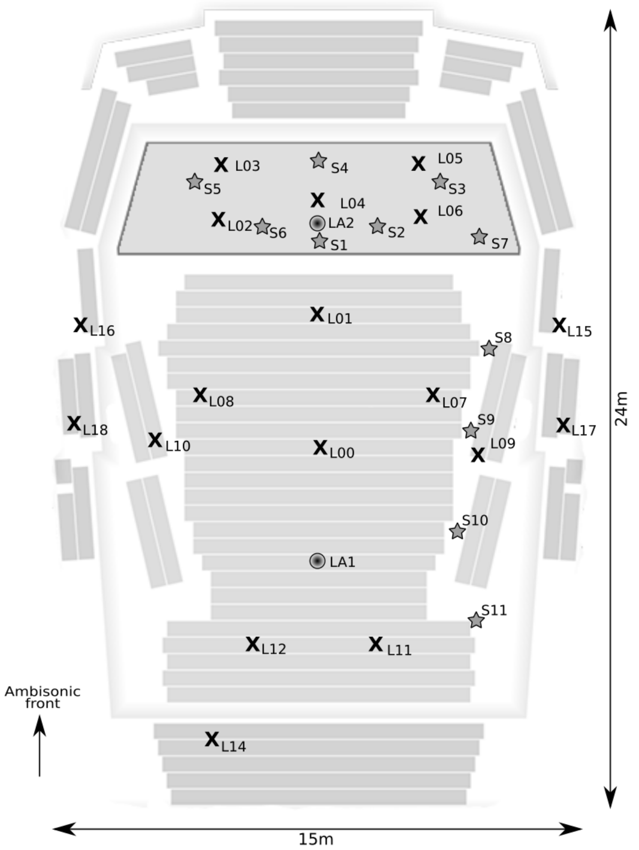


Figure 2: Sources and listeners' positions for the Maison Symphonique impulse response recordings. Each Source and listener couple are available in the dataset. Sources positions are indicated with a star, Ambisonic listener with a circle and monophonic listener with a cross (X). Maximal dimensions are provided here, for detailed geometry of the room please refer to the 3D model provided with this dataset.

	X	Y	Z
LA1	-0.4	-23.8	0.13
LA2	0	0	0
S1	0.24	-2.73	-0.11
S2	3.79	-0.98	-0.11
S3	5.4	4.23	-0.11
S4	0.21	6.15	-0.11
S5	-4.38	4.14	-0.11
S6	-3.4	-0.98	-0.11
S7	8.56	-3.58	-0.11
S8	8.41	-11.96	-0.45
S9	7.76	-19.5	-0.08
S10	7.49	-25.05	0.09
S11	9.09	-28.84	0.03
L00	-0.8	-18.51	-0.24
L01	-0.8	-7.05	-0.96
L02	-5.65	-1.75	-0.11
L03	-5.78	6.68	-0.11
L04	-0.43	2.36	-0.11
L05	5.66	6.42	-0.11
L08	-7.6	-15.11	-0.49
L09	10.33	-17.35	-0.37
L10	-10.32	-17.36	-0.32
L11	3.07	-29.67	0.04
L12	-3.11	-29.67	0.04
L14	-4.69	-31.96	3.53
L15	11.31	-6.3	3.07
L16	-11.51	-6.07	3.08
L17	11.31	-16.85	3.2
L18	-11.51	-16.74	3.25

Table 1: Positions of sources and listeners (metres) in the Maison Symphonique. Axes are defined relative to a person facing the scene; X - left/right, Y - Back/Front, Z - Low/High.

used spherical loudspeakers as sound sources and Ambisonic microphones exlusively for listener locations. In the several configurations we describe hereafter, we provide measures for all relevant locations as well as a 3D model of the room.

The software tools used for measurement are the same as those used for the Centech described in Section 2.1.

3.1. Transformed planetarium

The Centech dome is the former planetarium of Montreal. It was renovated to become a start-up accelerator, converting the projection dome into an empty space for events. Geometrically, the space is a half-sphere concrete dome on top of a concrete cylinder. This geometry leads to a particular acoustic signature where the RT30 (measure of the time after the sound source ceases that it takes for the sound pressure level to reduce by 30 dB) goes up to 10 seconds in the centre of the dome, with a prominent and fast echo. Figure 3 shows a top view of the room where measurements were recorded.

3.2. Capture strategy and methodology

Ambisonic recordings were done with a third-order order Ambisonic microphone (Zylia ZM-1). The loudspeaker used is an Audiodice - a dodecahedron-shaped loudspeaker with the ability to control each of its 12 drivers (one for each face) individually or at the same time as an omnidirectional loudspeaker.

We considered three specific scenarios: coupled source/listener, acoustic attenuation and the whispering gallery effect.

Positions are given in polar coordinates, and both loudspeakers and microphones were set at a height of 1.5 m. We mainly used the Audiodice as an omnidirectional loudspeaker—playing the same ESS in all 12 drivers—except for the whispering gallery effect where we recorded one set of 12 measurements, one driver at a time, to observe the impact of directivity on the effect. For

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
LA1	21.08	23.2	28.62	29.96	28.22	23.02	22.12	14.77	9.23	7.99	10.75
LA2	2.74	3.92	6.86	6.15	6.03	3.54	9.28	14.63	20.99	26.15	30.24
L00	15.81	18.12	23.57	24.68	22.93	17.72	17.62	11.3	8.62	10.56	14.3
L01	4.52	7.66	12.9	13.27	11.78	6.66	10.02	10.45	15.13	19.85	23.95
L02	5.97	9.47	12.56	9.84	6.03	2.38	14.33	17.38	22.25	26.75	30.84
L03	11.17	12.26	11.45	6.01	2.9	8.02	17.63	23.43	29.47	34.39	38.51
L04	5.13	5.38	6.12	3.84	4.33	4.47	10.78	16.83	23.34	28.53	32.62
L05	10.63	7.63	2.21	5.46	10.3	11.7	10.41	18.59	26	31.52	35.43
L06	5.43	1.89	5.87	9.45	11.5	8.98	3.57	10.71	18	23.49	27.43
L07	14.29	14.58	19.44	22.43	22.55	17.76	11.6	3.32	4.43	9.96	13.85
L08	14.66	18.15	23.31	22.65	19.52	14.75	19.86	16.32	15.98	18.08	21.62
L09	17.77	17.63	22.14	25.59	26.04	21.37	13.89	5.72	3.36	8.22	11.56
L10	18.04	21.62	26.71	25.76	22.31	17.78	23.37	19.49	18.21	19.4	22.55
L11	27.09	28.7	33.98	35.93	34.62	29.41	26.66	18.5	11.2	6.39	6.08
L12	27.15	29.51	34.95	35.97	33.83	28.69	28.58	21.13	14.89	11.56	12.23
L14	29.87	32.33	37.75	38.6	36.28	31.22	31.53	24.24	17.98	14.42	14.56
L15	12.06	9.75	12.49	16.98	19.11	15.96	5.01	7.27	14.03	19.37	22.85
L16	12.63	16.44	20.06	17.23	12.86	10.09	20.47	21.07	23.7	27.02	30.86
L17	18.24	17.87	22.14	25.75	26.41	21.89	13.95	6.76	5.51	9.57	12.6
L18	18.59	22.22	27.15	25.93	22.32	18.04	24.23	20.82	19.75	20.98	24.11

Table 2: Distances between sources and listeners in the Maison Symphonique (in meters).

every recording, a 20 seconds exponential sine sweep was played, with an extra 19 seconds of recording after the end of the sweep to take into account some extreme reverberation cases.

Like most loudspeakers, note that the Audiodice are not calibrated, i.e., the full range of the frequency spectrum is not represented equally. As a result of the ESS technique, the non-linearities generated by the playback (Digital-to-Analog Converter, amplifiers and loudspeakers) are not taken into account after the convolution. Furthermore, we are currently in the process of calibrating the Audiodices, and we plan on providing corrected recordings in the future.

3.3. Coupled source/listener

For this recording session, we coupled the loudspeaker with the microphone and moved it around to simulate 2 people speaking in different spots under the dome. We measured 19 points, covering nearly a quarter of the dome, and presented in Table 3.

This session's aim is to give a good overview of how the room sounds without specifically targeting special acoustic phenomena caused by the dome. This recording session covered only one-quarter of the room rather than its entirety because of the symmetry of the dome, which makes all four quarters very comparable in their acoustic response.

RIR files are named with the polar coordinates of the coupled loudspeaker mic pair, as `RIR_aXX_PYYm.wav`, where `XX` is the angle, and `YY` the distance in meters. For angles 0°, 72°and -72°we measured 7 distances (0 m, 1 m, 2 m, 3 m, 4 m, 6 m, 8 m). For angles 18°and 52°, we measured 2 distances (6 m, 8 m). For angles 35°, we measured 2 distances (4 m, 8 m).

We observed that the variability of the RT30 is strongly related to the distance of the source and microphone couple to the centre of the room. The closer we get to the centre, the longer the RT30 measurement is (from 0.9 seconds at 8 metres to 12 seconds at the centre). All measurments that feature same radius relative to the center of the room will share the same RT30 duration. This is also illustrated in the Centech video demonstration described in Section 4.

Coupled source/listener

	Angle (deg)	Distance (m)
RIR_a0_p0m	0	0
RIR_a0_p1m	0	1
RIR_a0_p2m	0	2
RIR_a0_p3m	0	3
RIR_a0_p4m	0	4
RIR_a0_p6m	0	6
RIR_a0_p8m	0	8
RIR_a18_p6m	18	6
RIR_a18_p8m	18	8
RIR_a35_p4m	35	4
RIR_a35_p8m	35	8
RIR_a52_p6m	52	6
RIR_a52_p8m	52	8
RIR_a72_p1m	72	1
RIR_a72_p2m	72	2
RIR_a72_p3m	72	3
RIR_a72_p4m	72	4
RIR_a72_p6m	72	6
RIR_a72_p8m	72	8
RIR_a-72_p1m	-72	1
RIR_a-72_p2m	-72	2
RIR_a-72_p3m	-72	3
RIR_a-72_p4m	-72	4
RIR_a-72_p6m	-72	6
RIR_a-72_p8m	-72	8

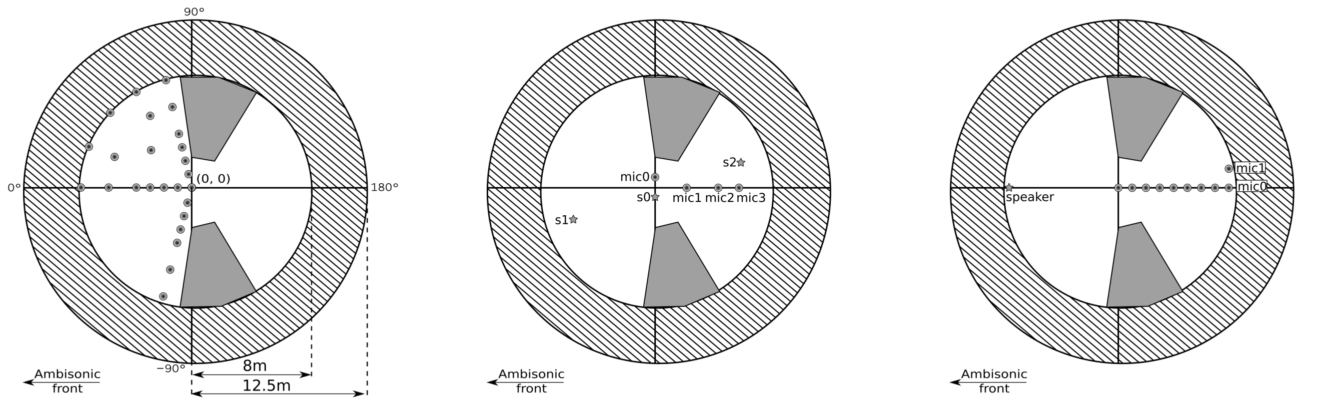
Acoustic attenuation

	Angle (deg)	Distance (m)
S0	-90	0.5
S1	-15	6
S2	165	5
mic0	90	0.5
mic1	180	2
mic2	180	4
mic3	180	5

Whispering gallery effect

	Angle (deg)	Distance (m)
Loudspeaker	0	8
p0	180	0
p1	180	1
p2	180	2
p3	180	3
p4	180	4
p5	180	5
p6	180	6
p7	180	7
p8	180	8
mic0	180	8
mic1	165.5	8

Table 3: Positions for the Centech configurations.



(a) Coupled source/listener configuration. (b) Furniture attenuation configuration. (c) Whispering gallery effect configuration.

Figure 3: Microphones and loudspeakers locations for the three configurations of RIRs captures at the transformed planetarium. The hatched area is the ground floor. The white area is the platform where all measurements were done. This platform is 4 m above the ground floor. The grey triangles are staircases from the ground floor to the platform.

	S0	S1	S2
mic0	1	6.15	4.89
mic1	2.06	7.95	3.11
mic2	4.03	9.92	1.54
mic3	5.02	10.91	1.31

Table 4: Distances between sources and microphones for the acoustic attenuation configuration (meter).

3.4. Acoustic attenuation

As we are under a concrete dome, the sound tends to focus to a precise point in the room, its centre. We decided to use available furniture and position it on the focal point of the dome to test possible attenuation scenarios.

We were particularly interested in this scenario as the Centech administration aims to use this room to host events, or as a workspace. However, given the peculiar and very significant acoustic response of the room, it doesn't lend itself to that very well. We were therefore very interested in figuring out how much furniture configuration could help mitigate this situation. As furniture positioned in the centre of the dome has the greatest effect on the acoustic response of the room, this is the scenario we decided on making measurements for.

The furniture used is a cylindrical seat with a diameter of 1.01 metres and a 0.45 metres height. It is mostly made of foam and wood and is covered in fabric.

We measured, for both scenarios (with and without furniture), 4 microphone positions (named mic0, mic1, mic2, mic3) and 3 loudspeaker positions (named s0, s1 s2). Distances between sources and listeners are provided in Table 4 As shown in Figure 3b. RIR files are named as follows: `RIR_micX_sY.wav`, where `X` is the mic number (0 to 3) and `Y` is the loudspeaker number (from 0 to 2). There is a total of 24 measurements, 12 of which were recorded with furniture on the focal point of the room, while the other 12 were recorded without it present.

Figure 4 shows Reverberation time at 30dB with and without absorbing furniture. Measurements are grouped by loudspeaker positions, then by microphone positions from the centre position to the outer edge.

We can see that the centre position (`mic_0`) always gives the longest RT30 for any given position of the loudspeaker. This is mostly because this room has a distinct and prominent focal point due to its dome and cylindrical shape.

Positioning absorbent material at the focal point helps greatly to reduce RT30 measurements across the entire space, especially around the focal point. The RT30 is more evenly distributed and below 3 seconds everywhere.

3.5. Whispering gallery effect

The geometry of this space allows sound waves to travel along with the cylinder and the dome, creating a whispering gallery effect: words can be whispered at one side of the room and heard very intelligibly at its opposite end.

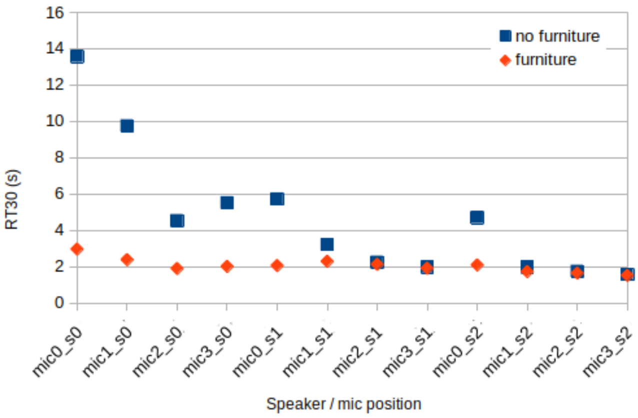
This is a very interesting and peculiar acoustic phenomenon that is unique to rooms of a circular or spherical shape. It also isn't covered by the previous recordings. Therefore, we dedicated a specific recording session to this effect.

We took advantage of the Audiodices and their ability to control all 12 drivers individually to analyze the impact of directivity on this effect. We set one loudspeaker at one end of the dome, one microphone located at the opposite of the room (named mic0) and another one 2 meters to its right (named mic1), as shown in Figure 3c. ESS was played once on every driver, recorded by 2 microphones.

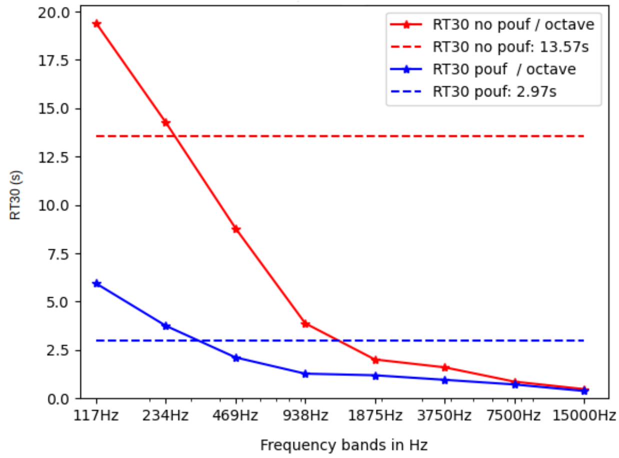
Recorded RIRs are named as follows: `RIR_micX_dYY.wav` where `X` is the microphone number (0 or 1) and `YY` is the driver number (from 1 to 12). There is a total of 24 measurements. One of the Audiodice drivers (number 7) was facing the microphones. More details about the Audiodice driver placements are provided in the Audiodice specification webpage.[6]

We also measured how far the effect extends along the diameter of the room. We used a loudspeaker at one end of the dome in omnidirectional mode and microphones in nine positions along the diameter. Along this axis, we observe that as the direct sound weakens as we move further from the source, the first

[6] https://gitlab.com/sat-metalab/hardware/audiodice



(a) Reverberation time (RT30).



(b) Reverberation time (RT30) per octave for the source-listener location where the echo is perceived the most (mic0,s0).

Figure 4: Reverberation time according to source-listener location, when the absorbing furniture is present or not in the centre of the transformed planetarium.

reflection gets comparatively louder. The first reflection starts getting louder than the direct sound 5 metres away from the centre. Figure 3c shows the loudspeaker and microphone placements. Recorded RIRs are named as follows: `RIR_PXXm.wav` where `XX` is the microphone distance in metres from the centre.

4. 6 DOF NAVIGATION

In this section, we present an application of these recorded RIRs: 6 DoF navigation using interpolation among RIRs. We produced two accompanying videos, one with the Centech RIRs[7] and one with the Maison Symphonique[8]. These videos are also included in the dataset.

We used an algorithm that has been developed to compute intermediate RIRs between these recordings by interpolating the closest measured RIRs to a given point. This allows the simulation of the room acoustics and enables an immersive experience from a set of recorded RIRs by generating data where no measures have been recorded. We used pyAmbir [9] for interpolating RIRs, our Python module that implements multiple multiple tools related to Ambisonics and RIRs. We will first discuss the method used to interpolate RIRs, then we will present two examples of navigation using RIRs recorded at the Maison Symphonique and Centech (see Section 3).

We follow the approach presented in [19], using a method to interpolate RIRs using Dynamic Time Warping (DTW). The first step is to select the RIRs that are going to be used for the interpolation. We select the three closest measures to the given point and then verify whether the point lies between these three measures. If not, we swap one of the selected measures with the next closest one to the target point and verify the same condition. We then compute a weight for each of them using barycentric coordinates.

[7] Centech demonstration: `https://vimeo.com/697114857`
[8] Maison Symphonique demonstration: `https://vimeo.com/697118976`
[9] `https://gitlab.com/sat-metalab/pyambir`

The second step is to divide each selected RIR into two distinct regions: early reflections and tail.

For the early reflections, a dynamic time warping (DTW) algorithm is used to align each RIR. In the case of Ambisonic RIRs, the DTW is computed channel by channel. A simple frame-by-frame linear interpolation is then used to interpolate the warped early reflections and the tails of the selected RIRs, taking into consideration the weights of each RIR. This method provides a smooth reproduction of the RIR in between the measured RIRs.

Two navigation examples presented in the demonstration videos were generated in the Maison Symphonique and the Centech (see Figure 5 and Figure 6). We define a navigation as a path of interpolated points (in the figures, black points). Before the interpolation, each measured RIR was assigned two coordinates in space. These have been measured during the recording sessions on-site using a laser pointer for the Maison Symphonique and a direct measurement (polar angle and radius) for Centech.

In order to generate the audio for these navigation examples, we operate a pipeline using various tools to correctly simulate the wanted acoustics. First, we generate all interpolated RIRs in the navigation using the method described above. The next step includes [1], a real-time auraliser that can convolve multichannel RIRs in real-time and update them. We update the RIR used by vaRays at a regular interval to travel in the acoustic response of the room. In the case of mono or stereo recordings, this pipeline is sufficient. If we deal with multichannel RIRs, we use [20], an audio spatializer that we use to convert the Ambisonic auralisation to binaural audio.

In the Maison Symphonique navigation, one source is located at the front of the scene (S01) and 13 microphones are located on the stage and in the public. One key property of the Maison Symphonique that we would like to reproduce is the damped and diffuse sound when in the back seats that gets brighter as we move toward the scene. In the Centech, all recordings are based on loudspeaker/microphone couples, so we can witness the varying echo of the room acoustic response at different locations. The key property of this room is the gradual increase of a significant echo as

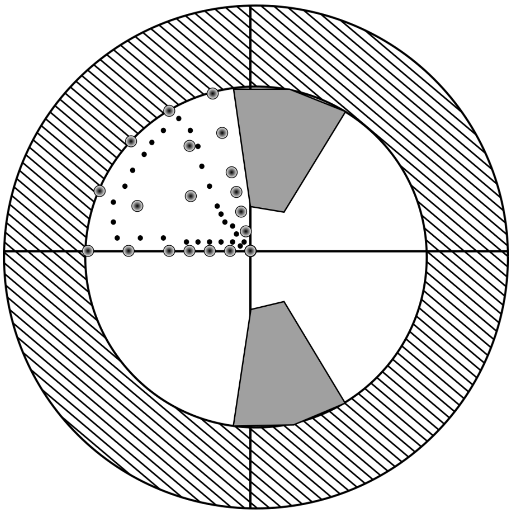


Figure 5: The trajectory of the navigation in the Centech using the coupled source/listener configuration. The position of the black filled points indicates interpolated RIRs computed to provide a 6 DoF acoustical navigation.

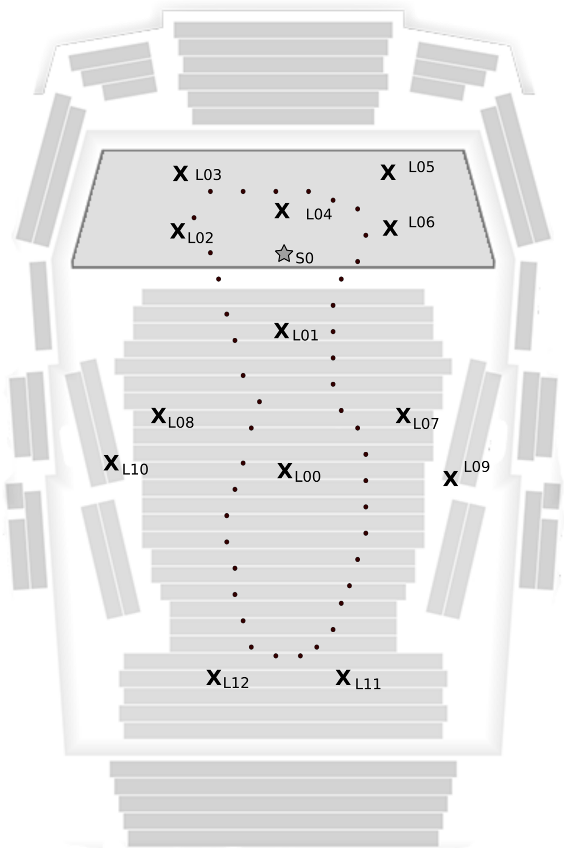


Figure 6: Trajectory of the navigation in the Maison Symphonique. Black points indicate interpolated RIRs computed to provide a 6 DoF acoustical navigation. The source is not indicated, since it is attached to the moving listener. The positions used for interpolation are indicated in the figure.

we move closer to the centre of the dome. Our interpolation techniques reproduce nicely these properties, as can be directly experienced in these two videos.

In both videos, coloured spheres are used to indicate the interpolated position currently being used (red) and the positions at which IR measurements were recorded (blue). The video for the Maison Symphonique also has another one (green) to indicate the position of the source. Orange beams are traced at each new position to indicate which IR measurements were used for interpolation. The audio is taken from anechoic recordings of symphonic music provided by Aalto University [21].

5. DISCUSSION AND CONCLUSION

In this paper, we described two datasets composed of RIRs with varying source and listener positions, along with a 3D geometrical model for each of them. One is from a large concert hall with a long reverberation time. The second of the datasets is from a dome-shaped room that features a disturbing echo when listening from its centre. The positions of the measurements allow the reproduction of 6 degrees-of-freedom navigation within the space, in which virtual sources are rendered with the room's acoustics. It also provides the opportunity for analysis of the spatial distribution of well-known acoustical parameters such as reverberation time. We provided a demonstration of 6 Dof navigation using RIR interpolation to demonstrate the feasibility of 6 DoF navigation based on the datasets.

We believe these two datasets can contribute toward resolving several research problems. Indeed, they offer:

- ground truth material for validation of late reverberation models based on geometrical models;
- input data for algorithms toward the automatic annotation of surfaces in geometrical models with acoustical parameters such as absorption and scattering;

- source material for live RIR interpolation, as required for live acoustical 6 DoF navigation;
- source material for research on acoustical metrics and their spatial distribution in the room. More particularly with echo related metrics for the Dome Dataset, but also in general for research targeting architectural design, where such analysis is critical [22];
- source material for research on the perceptual similarity between RIRs.

6. ACKNOWLEDGMENTS

We would like to thank the Orchestre Symphonique de Montréal and the Centech for their generosity during the research process, and especially for the opportunity to record impulse responses in these unique spaces. Thanks also to Marc Lavallée for his significant contribution to the capture of the Centech's dome. Finally, we thank the Ministère de l'Économie et de l'Innovation du Québec for making this project possible.

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