A Database on Musicians' Movements During Musical Performances

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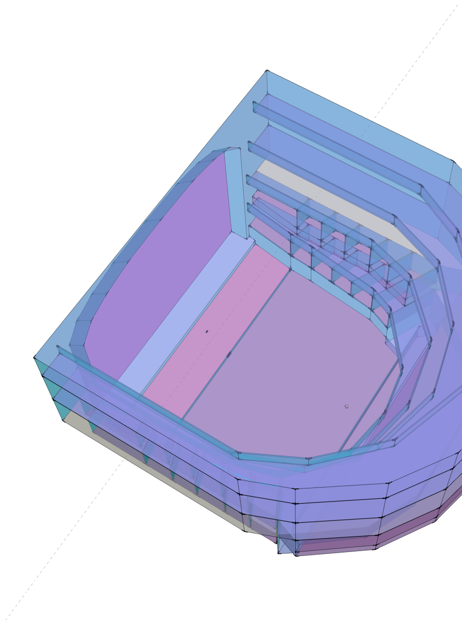

General Information

The following document describes a data base on the movements that musicians make during musical performances. It is provided under a Creative Commons BY-NC-SA licence, giving you the freedom to redistribute it under the same license and edit the database for non-commercial purposes .
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The documentation is focused on the structure and content of the data base. More information on the generation and processing can be found in the *Is Supplement To* entry on the DepositeOnce download page. If you use this database please cite it according to the mentioned entry.

Database description

The movements of 20 musicians playing 11 different musical instruments (Table 1), including all standard orchestral instruments, were captured during solo performances by means of a motion capturing system under concert-like conditions. The recordings were made in the Curt-Sachs-Saal (Tiergartenstraße 1, 10785 Berlin), a chamber music hall for an audience of 250.

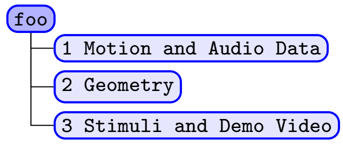

Figure 1: Data structure of the database.

Instrument	Quantity	Group
Violin	2	Strings
Viola	2	
Cello	2	
Double Bass	1	
Flute	2	Woodwinds
Oboe	2	
Clarinet	2	
Bassoon	2	
Trumpet	2	Brass
French Horn	2	
Trombone	1	

Table 1: Orchestra instruments invited for the motion capturing of different musical performances.

The movements of the musical instruments during the performance were captured with an optical motion tracking system (OptiTrack) and the associated Motive software. The system consisted of eight cameras and reflective markers. Each instrument was equipped with several markers, so that they were always visible by at least two of the cameras for reliable tracking. The positions of the instruments are provided by the software in cartesian coordinates and the orientation in quaternions in 120 Hz temporal resolution.

The CAD Software SketchUp was used to create 3D room models. Acoustical simulations were executed using the room simulation software RAVEN [1].

All simulations were done in third octave resolution, with the hybrid simulation algorithm using image sources up to third order and ray tracing using 86000 rays.

1 Motion and Audio Data

Each instrument was played by two different professional musicians, with the exception of bass and trombone that were played by only one. Each musician played three different music pieces of his or her own choice (Table 2), one time standing and one time sitting, except for the cello, that is usually played in a sitting position, and the double bass, that is usually played standing.
For each musician the tracked position data and the tracked rotation data are made available as comma-separated files and stored in the folders `1 Position` and `2 Rotation`. The recorded audio is provided in the *Free Lossless Audio Codec* (`.flac`) format at a sample rate of 44.1 kHz and stored in the folder `3 Audio`.

All files are named according to the scheme:

`instrument_content_playingPositionNr`

For example `Bassoon1_pos_standing1.csv` (Figure 4) defines the position data (`pos`) for `Bassoon 1` while playing piece number `1` (*E. Bozza - Pieces Breves, No. 1*, Table 2) in `standing` position. The position data is represented in cartesian coordinates in the three axes `x` (column 2), `y` (column 3) and `z` (column 4) according to the axis convention shown in Figure 3 in meter. Column 1 of the comma-separated file represents the corresponding time stamp in seconds.

Whereas `Bassoon1_rot_sitting3.csv` (Figure 5) defines the rotation data (`rot`) for `Bassoon 1` while playing piece number `3` (*I. Stravinsky - The Firebird*, Table 2) in `sitting` position. The rotation data is represented in the quaternions `a` (column 2), `b` (column 3), `c` (column 4) and `d` (column 5). Column 1 of the comma-separated file represents the corresponding time stamp in seconds.

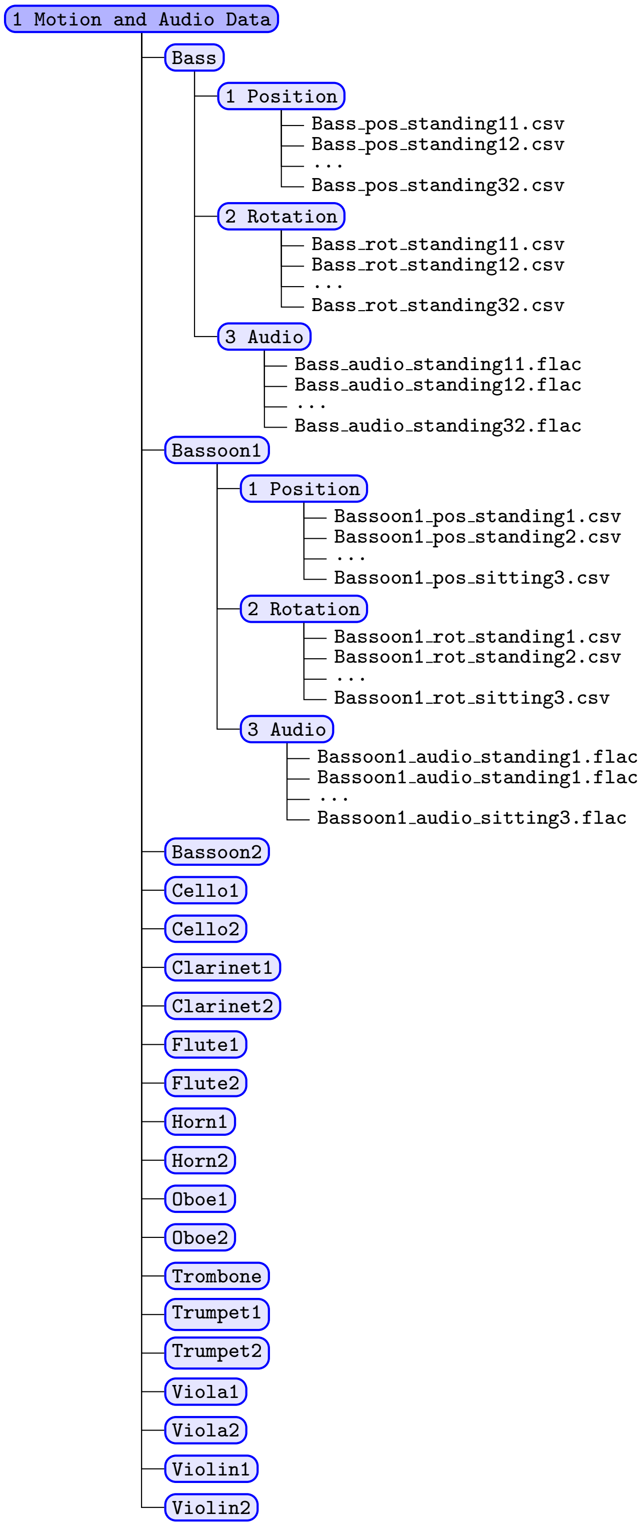

Figure 2: Data structure of the Motion and Audio Data folder.

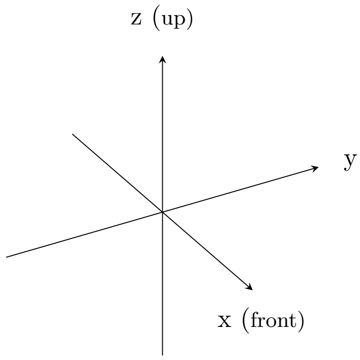

Figure 3: Axis convention

Quaternions are generally represented in the form:

$$a + b\mathbf{i} + c\mathbf{j} + d\mathbf{k} \tag{1}$$

where a, b, c, and d are real numbers, and $\mathbf{i}$, $\mathbf{j}$, and $\mathbf{k}$ are the fundamental quaternion units and

$$\mathbf{i}^2 = \mathbf{j}^2 = \mathbf{k}^2 = \mathbf{ijk} = -1. \tag{2}$$

`Bassoon1_audio_sitting3.flac` defines the audio data (`audio`) for `Bassoon 1` while playing piece number `3` (*Stravinsky - Firebird*, Table 2) in `sitting` position.

An exception here is the cello, that was played only in a sitting position, and the double bass, that was played only standing. `Bass_pos_standing11.csv` defines the position data (`pos`) for `Bass` while playing piece number `1` (*Karl Ditters von Dittersdorf - concerto No. 2, 2nd movement*, Table 2) in `standing` position the first time, Whereas `Bass_pos_standing12.csv` defines the position data (`pos`) for `Bass` while playing piece number `1` (*Karl Ditters von Dittersdorf - concerto No. 2, 2nd movement*, Table 2) in `standing` position the second time.

```
Time in s,   x,            y,            z,
0.0000,      -0.04305446,  -0.02393479,  -0.04310548,
0.0083,      -0.04375851,  -0.02484681,  -0.04387516,
⋮
48.5833,     -0.00863266,  0.05415662,   -0.01451498,
48.5917,     -0.00954914,  0.05206001,   -0.01563459,
```

Figure 4: `Bassoon1_pos_standing1.csv` data format.

```
Time in s,   a,            b,            c,            d,
0.0000,      0.99902866,   0.02498498,   -0.01191384,  0.03428635,
0.0083,      0.99902082,   0.02554117,   -0.01274068,  0.03380426,
⋮
103.9667,    0.99983150,   -0.01319223,  -0.00163341,  0.01265947,
103.9750,    0.99982086,   -0.01314478,  -0.00153958,  0.01353109,
```

Figure 5: `Bassoon1_rot_sitting3.csv` data format.

Table 2: Recorded music pieces

Instrument	Piece 1	Piece 2	Piece 3
Violin 1	J. S. Bach - Sonata No. 1 in G minor BWV 1001, 1. Adagio	F. Mendelssohn Bartholdy - Violin Concerto in E minor op. 64, 2. Andante	F. Mendelssohn Bartholdy Violin Concerto in E minor op. 64, 3. Allegretto
Violin 2	J. Sibelius - Violin Concerto, 1. Allegro	W. A. Mozart - Violin Concerto No. 5, 1. Allegro	J. S. Bach - Sonata No. 1 BWV 1001, 1. Adagio
Viola 1	I. Stravinsky - Elegie for solo viola	Eleni Karaindrou - Der Blick des Odysseus	J. S. Bach - Partita No. 3 BWV 1006, Gigue
Viola 2	J. S. Bach - Suite No. 5 BWV 1011, Gigue	J. Stamitz - Viola Concerto, 1st movement	J. Brahms - Viola Sonata op. 120 No. 2 E flat major, 1st movement
Cello 1	P. Hindemith - Sonata No. 3 op. 25, 1st movement	P. Hindemith - Sonata No. 3 op. 25, 2nd movement	P. Hindemith - Sonata No. 3 op. 25, 3rd movement
Cello 2	J. S. Bach - Suite No. 6 D major BWV 1012, Prelude	L. Boccherini - Sonata A major, G.4, 1st movement	L. Boccherini - Sonata A major, G.4, 2nd movement
Bass	Karl Ditters von Dittersdorf - concerto No. 2, 2nd movement	S. Koussevitzky - Concerto No. 1, 1st movement	J. S. Bach - Suite No. 2 BWV 1008, Prelude
Flute 1	A. Casella - Sicilienne op. 23	A. Casella - Burlesque op. 23	J. S. Bach - Partita A minor BWV 1013, Allemande
Flute 2	C. Debussy - Syrinx	E. Varese - Density 21.5	J.S. Bach - Partita A minor BWV 1013, Bourree angloise
Oboe 1	W. A. Mozart - Concerto for Oboe KV 314, 1st movement	W. A. Mozart - Concerto for Oboe KV 314, 2nd movement	G. Ph. Telemann - Fantasia for Oboe Solo No. 8 Largo
Oboe 2	C. Ph. E. Bach, Sonata for Oboe and BC G minor WQ 135	W. A. Mozart - Concerto for Oboe KV 314	V. Martini - Concerto for Oboe and Orchestra
Clarinet 1	C. Rose - Adagio	W. Osborne - Rhapsody	C. Rose - Etude Nr. 1
Clarinet 2	B. Kovacs - Hommage a Manuel De Falla	D. Häusler - Bazooka	D. Häusler - Pimpel da Besch
Bassoon 1	E. Bozza - Pieces Breves, No. 1	D. Shostakovich - Symphony No. 9, 4th movement	I. Stravinsky - The Firebird
Bassoon 2	B. Kovacs - Hommage a Manuel De Falla	G. Ph. Telemann - Fantasia No. 7 A minor, Andante	G. Ph. Telemann - Fantasia No. 9 F major, Presto
Trumpet 1	S. Rachmaninoff - Vocalise op. 34, No. 14	J.-B. Lully - Marche	O. Ketting - Intrada (1958)
Trumpet 2	P. Hindemith - Sonata, 1st movement	J. Haydn - Concerto E flat major, 2nd movement	P. Hindemith - Sonata, 3rd movement
Horn 1	W. A. Mozart - Horn Concerto No. 4 KV 495, 1st movement, Exposition	R. Schumann - Adagio and Allegro op. 70 (Excerpt from the Adagio)	R. Schumann: Adagio and Allegro op. 70 (Excerpt from the Allegro)
Horn 2	M. Haydn - Concerto in D, 1. Larghetto	M. Haydn - Concerto in D, 2. Allegro non troppo	D. Schnyder - Le monde miniscule, 2. Le petit Americain
Trombone	F. David - Concertino E flat major, 1st movement	F. David - Concertino E flat major, 2nd movement	Grøndahl - Concerto for trombone

2 Geometry

The scene geometry and the surface properties can be found in the folder `2 Geometry` (Figure 6) and are provided as SketchUp models (free for educational purposes) and comma-separated files containing material parameters. The file `Model_Theater_An_Der_Wien.spk` defines the geometry of the room *Theater An Der Wien*.

```
2 Geometry
├── Model_Theater_An_Der_Wien.spk
├── WIE_audience.csv
├── WIE_audienceOnWood.csv
├── WIE_audienceStanding.csv
├── WIE_curtain.csv
├── WIE_floor.csv
├── WIE_orchestra.csv
├── WIE_remainingAbsorption.csv
├── WIE_upholstered.csv
└── WIE_woodenSeating.csv
```

Figure 6: Data structure of the Geometry folder.

The SketchUp file contains a 3D model of the room, the positions and orientations of the source and the receiver (Figure 8). The colors assigned to the surfaces of the 3D model specify their material. For example, the color named `WIE_audience` links to a material whose surface properties can be found in the `WIE_audience.csv` file (Figure 7) in the same folder. Absorption (column 2) and scattering (column 3) coefficients are given in third octave bands for a frequency range of 20 Hz to 20 kHz (column 1).

```
f in Hz,   absorption,   scattering,
20,        0.2,          0.3
25,        0.2,          0.3
⋮
16000,     0.67,         0.7
20000,     0.67,         0.7
```

Figure 7: `WIE_audience.csv` data format.

To view the color of a surface in SketchUp, use the *Sample Point* option of the *Paint Bucket Tool*. The degree of detail in the scene geometry has been adapted to common standards [2, p. 176].

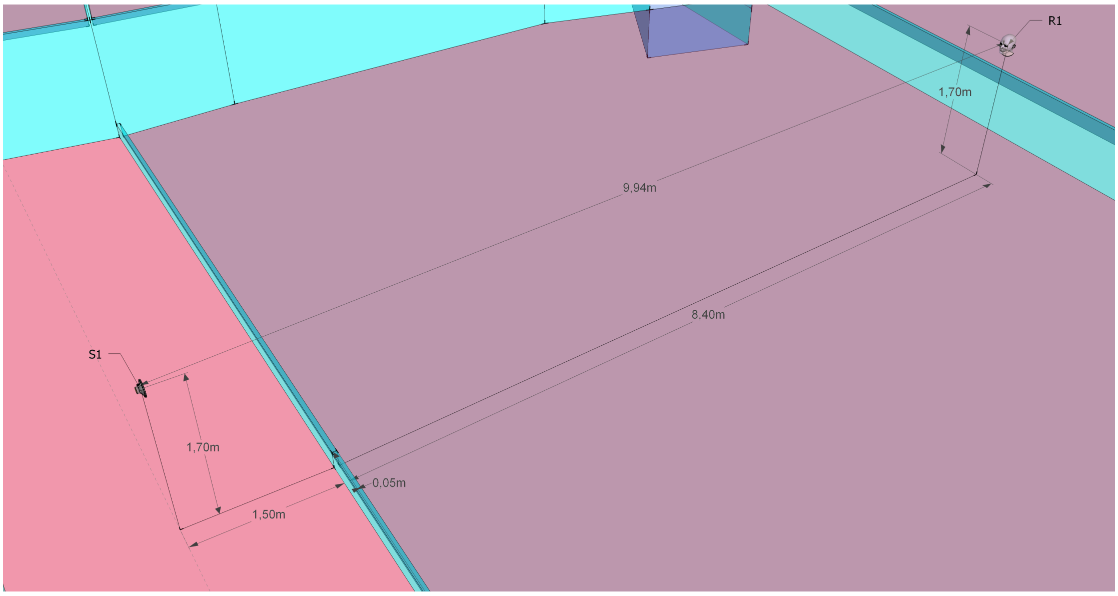

Figure 8: The positions and orientation of source (S1) and receiver (R1) in the `Model_Theater_An_Der_Wien.spk` *SketchUp* model.

3 Stimuli and Demo Video

The stimuli for the listening test were obtained by block-wise and time-variant convolution of the quasi-anechoic audio recording of these musical segments with the binaural impulse responses under both anechoic and reverberant conditions with RAVEN, using the FABIAN HRTF database [3, 4] as receiver. Auralizations of the static and dynamic sources always started with the same source orientation to make sure that no differences were audible at the beginning of a stimulus.

```
3 Stimuli and Demo Video
          ├─ Oboe1_standing1.move
          ├─ Flute1_standing1_anechoic_dynamic.flac
          ├─ Flute1_standing1_anechoic_static.flac
          ├─ Flute1_standing1_reverberant_dynamic.flac
          ├─ Flute1_standing1_reverberant_static.flac
          ├─ Trumpet2_standing3_anechoic_dynamic.flac
          ├─ Trumpet2_standing3_anechoic_static.flac
          ├─ Trumpet2_standing3_reverberant_dynamic.flac
          ├─ Trumpet2_standing3_reverberant_static.flac
          ├─ Violin1_standing2_anechoic_dynamic.flac
          ├─ Violin1_standing2_anechoic_static.flac
          ├─ Violin1_standing2_reverbarent_dynamic.flac
          └─ Violin1_standing2_reverbarent_static.flac
```

Figure 9: Data structure of the Stimuli and Demo Video folder.

References

[1] D. Schröder, M. Vorländer: RAVEN: A Real-Time Framework for the Auralization of Interactive Virtual Environments. Proc. of Forum Acusticum, Aalborg, Denmark, 2011, p. 1541–1546.

[2] M. Vorländer: Auralization. Fundamentals of acoustics, modelling, simulation, algorithms and acoustic virtual reality. Springer, Berlin, 2008.

[3] F. Brinkmann, A. Lindau, S. Weinzierl, G. Geissler, S. van de Par: A High Resolution and Full-Spherical Head-Related Transfer Function Database for Different Head-Above-Torso Orientations. J. Acoust. Soc. Am. **65(10)** (2017), p. 841–848.

[4] F. Brinkmann, A. Lindau, S. Weinzierl, G. Geissler, S. van de Par, M. Müller-Trapet, R. Opdam, M. Vorländer: The FABIAN head-related transfer function data base. http://dx.doi.org/10.14279/depositonce-5718 (2017).