ASH

User Guide

Table of Contents

1 License

2 Introduction

ASH is short for Audio Spatialisation for Headphones. It is an impulse response dataset that can be used for binaural synthesis of spatial audio systems on headphones. It includes binaural room impulse responses (BRIRs), headphone compensation filters (HPCFs) and configuration files for Equalizer APO.

The dataset features:

- A comprehensive set of colouration-free BRIRs that have been compensated for both circumaural and in ear headphones
- Individual compensation filters for over 35 headphones that can be used to equalise the listener's headphones to the diffuse field target
- Configuration files that can be used to convolve BRIRs and HPCFs in Equalizer APO

Details of the contents of the dataset and instructions on how to use them are provided in this user guide.

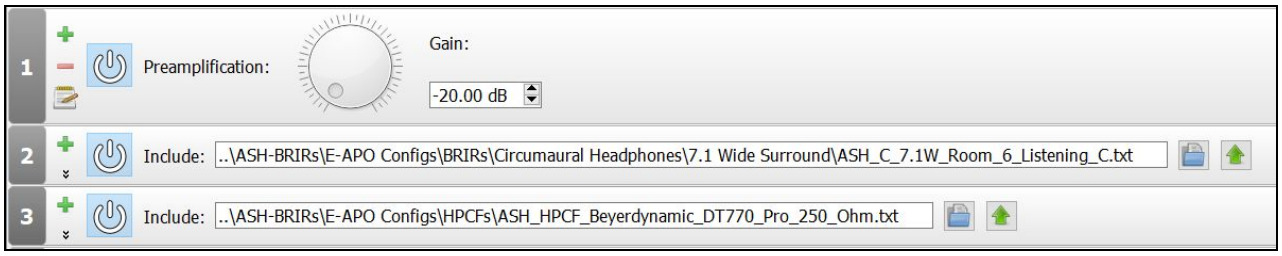
3 Equalizer APO Configuration

3.1 Overview

The dataset can be used with Equalizer APO, an Audio Processing Object (APO) for windows featuring convolution capabilities.

BRIR convolution configuration files have been provided for each room, speaker configuration and headphone type in the dataset. Configurations for the HPCFs have also been provided. Simply include these in your 'config.txt' configuration file.

Example config.txt in the configuration editor:



3.2 Installation steps

- Download Equalizer APO.
- Follow the installation tutorial.
- Download the ASH impulse response dataset.
- Extract the dataset to the location of your choosing. It is recommended to place the 'ASH-BRIRs' folder in the following location: C:\Program Files\EqualizerAPO.
- In the configuration editor add a new 'include' control to your 'config.txt' file.
- Navigate to the 'E-APO configs' folder and select the desired configuration file.

3.3 Troubleshooting

The BRIRs and HPCFs have been sampled at 44100Hz so the sample rate of the playback device must be set to 44100Hz. The sample rate of the file must match the sample rate of the device.

If your audio device does not support a 7.1 surround channel configuration, a virtual audio device such as VB-Audio Virtual Cable or Voicemeeter can be used for audio processing in place of your regular audio playback device.

4 BRIRs

4.1 Overview

BRIRs are measurements that capture the spectral filtering properties of the head and ears of the listener as well as any room reverberation present in the measurement. Measurements are typically made in reverberant rooms using dummy heads that are rotated above their torso to capture multiple head orientations for a number of source locations.

BRIRs can be used to synthesise spatial audio over headphones. Convolution of an audio signal with a BRIR converts the audio to that which would be heard by the listener if it had been played at the source location.

This dataset contains BRIRs derived from a range of freely available datasets. The BRIRs were measured in a wide variety of rooms each containing unique acoustical properties. So far 13 rooms have been included in the dataset. The frequency response of each BRIR has been compensated to remove sources of colouration and allow for accurate binaural synthesis of acoustic environments. Further details of the BRIRs can be found in the sections below.

4.2 Frequency Response Compensation

Sources of colouration present in the uncompensated BRIRs such as loudspeakers, microphones, room modes and ear canal resonances have been removed from the compensated BRIRs. This was achieved by equalising the BRIRs with compensation filters.

Colouration that would be introduced from the listener's headphone to their ear canal has also been removed from the BRIRs while taking into consideration the type of headphone used. Separate BRIRs are available for circumaural headphones and in ear headphones making the dataset compatible with both headphone types.

The frequency response compensation technique described above was used to minimise colouration, improve externalisation and improve localisation of sounds within the acoustic environments reconstructed by the BRIRs.

Note that it is assumed the listener's headphones are diffuse field calibrated and the effectiveness of the BRIRs depends on how closely the headphones match the diffuse field target frequency response. Individual headphone compensation filters have been included for some commonly used headphones. The filters can be used to equalise the listener's headphones to the diffuse field target.

4.3 Room Information

The BRIRs were measured in 13 rooms each containing unique acoustical properties such as reverberation time. A summary of the acoustical properties of each of the rooms is provided in the table below. The rooms have been sorted by reverb time in ascending order.

ID	Room Name	Dimensions (l x w x h) (m)	Floor Area (m^2)	Volume (m^3)	RT60 (s)
1	Listening Room A	5.00 x 5.50 x3.00	27.50	83.00	0.170
2	Control Room A	6.85 x 5.48 X 2.47	37.57	92.79	0.232
3	Listening Room B	5.80 x 6.60 X 2.70	38.28	103.36	0.261
4	Control Room B	7.26 x 8.26 X 2.90	59.97	167.91	0.266
5	Listening Room C (with absorbers)	4.50 x 5.50	24.75	N/A	0.369
6	Seminar Room A	5.00 x 5.00	25.00	N/A	0.474
7	Conference Room A	10.31 x 5.76 x 3.10	59.39	184.10	0.575
8	Conference Room B	5.50 x 4.50	24.75	N/A	0.808
9	Apartment	4.00 x 8.00	32.00	N/A	0.704
10	Seminar Room B	10.00 x 9.00	90.00	N/A	0.784
11	Studio	17.33 x 11.07 x 6.2	191.84	815.33	0.969
12	Listening Room C (without absorbers)	4.50 x 5.50	24.75	N/A	1.107
13	Stairway	N/A	N/A	N/A	1.119

4.4 Measurement Setups

The BRIRs were measured using a variety of dummy heads and head and torso simulators (HATS). A summary of the measurement setups for each of the rooms is provided in the table below.

ID	Room Name	Listener	Azimuth Resolution	Source Distance (m)	Source Azimuth Range	Source Elevation
1	Listening Room A	KEMAR 45BA	Nearest 5°	2.00	±180°	0°
2	Control Room A	Neumann KU100	Nearest 5°	2.80	±180°	0°
3	Listening Room B	B&K HATS Type 4100	Nearest 5°	2.10	±180°	0°
4	Control Room B	Neumann KU100	Nearest 5°	3.00	±180°	0°
5	Listening Room C (with absorbers)	KEMAR 45BA	Nearest 5°	2.14	±180°	0°
6	Seminar Room A	KEMAR	Nearest 5°	3.35	±180°	0°
7	Conference Room A	KEMAR 45BA	Nearest 5°	2.50	±180°	0°
8	Conference Room B	KEMAR 45BA	Nearest 30°	2.00	±120°	0°
9	Apartment	KEMAR 45BB-4	Nearest 30°	2.50	±180°	-20°
10	Seminar Room B	KEMAR	Nearest 15°	4.00	±180°	0°
11	Studio	Neumann KU100	Nearest 5°	6.94	±180°	0°
12	Listening Room C (without absorbers)	KEMAR 45BA	Nearest 5°	2.52	±180°	0°
13	Stairway	Neumann KU100	Nearest 15°	3.00	±90°	0°

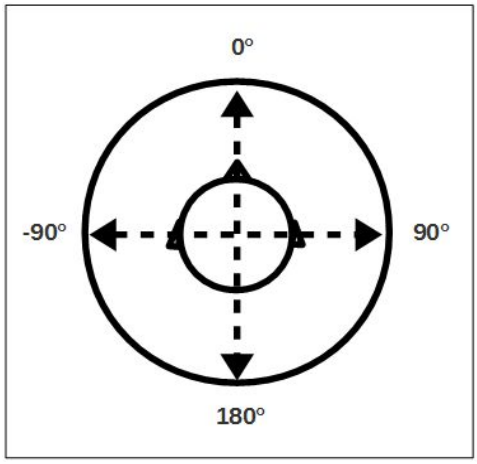
4.5 File information

The BRIRs are provided as 24 bit stereo wav files at a sampling rate of 44100Hz. The following information can be used to locate the desired wav files within the dataset. The file names follow the coding below. Possible options for each field are listed in the table.

ASH_BRIR_<headphone type>_<room>_<elevation>_<azimuth>.WAV

Field	**Options**
Headphone type	C: Circumaural Headphone IE: In Ear Headphone
Room	R1: Listening Room A R2: Control Room A R3: Listening Room B R4: Control Room B R5: Listening Room C (with absorbers) R6: Seminar Room A R7: Conference Room A R8: Conference Room B R9: Apartment R10: Seminar Room B R11: Studio R12: Listening Room C (without absorbers) R13: Stairway
Elevation	E0: Elevation angle between source and listener
Azimuth	A-180 to A180: Azimuth angle between the source and listener

Azimuth angles between the source and the listener's head can be found using the diagram below.



4.6 References

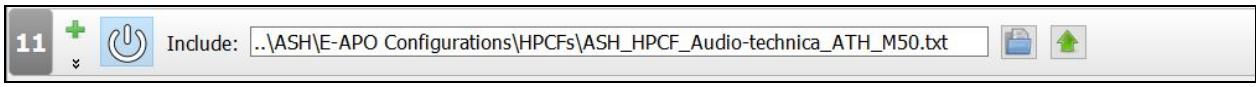
The original BRIR measurements were sourced from the datasets referenced in the table below. The licenses of the datasets have been included. Additional information about the licenses or measurements can be found by clicking the links in the table.

Room	**Reference**	**License**
Control Room A	"A Spatial Audio Impulse Response Compilation Captured at the WDR Broadcast Studios". Audio Group Downloads, 11-Jan-2013.	Creative Commons (CC BY-SA 3.0)
Control Room B	"A Spatial Audio Impulse Response Compilation Captured at the WDR Broadcast Studios". Audio Group Downloads, 11-Jan-2013.	Creative Commons (CC BY-SA 3.0)
Listening Room A	Wierstorf, Hagen, "Binaural room impulse responses of a 5.0 surround setup for different listening positions". Zenodo, 14-Oct-2016.	Creative Commons (CC BY 4.0)
Listening Room B	F. Melchior, D. Marston, C. Pike, D. Satongar and Y. Lam, "The Salford BBC Spatially-sampled Binaural Room Impulse Response dataset". University of Salford, 26 Feb 2014.	Creative Commons (CC BY-NC-SA 4.0)
Listening Room C	Erbes, Vera, "Single-channel and binaural room impulse responses of a 64-channel loudspeaker array for different room configurations". depositonce, 21-Apr-2015.	Creative Commons (CC BY 4.0)
Conference Room A	Neidhardt, Annika, "Binaural room impulse responses: Same listener-source-setup at different positions in the room". Zenodo, 28-Oct-2016.	Creative Commons (CC BY 4.0)
Conference Room B	Wierstorf, Hagen and Geier, Matthias, "Binaural room impulse responses recorded with KEMAR in a small meeting room". Zenodo, 14-Oct-2016.	Creative Commons (CC BY 4.0)
Apartment	F. Winter, W. Hagen, A. Podlubne, T. Forgue, J. Manhès, M. Herrb, S. Spors, A. Raake, and P. Danès, "Binaural room impulse responses of an apartment-like environment". Zenodo, 08-Apr-2016.	Creative Commons (CC BY 4.0)
Seminar Room A	Mittag, Christina, Böhme, Martina, and Werner, Stephan, "Dataset of KEMAR-BRIRs measured at several positions and head orientations in a real room". Zenodo, 16-Dec-2016.	Creative Commons (CC BY-NC 4.0)
Seminar Room B	Wierstorf, Hagen and Geier, Matthias, "Binaural room impulse responses recorded with KEMAR in a mid-size lecture hall". Zenodo, 14-Oct-2016.	Creative Commons (CC BY 4.0)
Stairway	"Aachen Impulse Response (AIR) Database". RWTH Aachen University	© 2009 RWTH Aachen University
Studio	"A Spatial Audio Impulse Response Compilation Captured at the WDR Broadcast Studios". Audio Group Downloads, 11-Jan-2013.	Creative Commons (CC BY-SA 3.0)

5 HPCFs

A set of headphone compensation filters have been included for some commonly used headphones. The filters can be used to equalise the listener's headphones to the diffuse field target response. The filters are minimum phase FIRs that are provided as mono wav files sampled at 44100Hz. Equalizer APO configuration files have also been provided.

Example usage in Equalizer APO:



Filters for the following headphones have been included in the set:

- AKG K141 MKII
- AKG K171 MKII 55 Ohm
- AKG K240 MKII
- AKG K240 Studio
- AKG K271 MKII
- AKG K401
- AKG K420
- AKG K601
- AKG K701
- AKG K702
- AKG K1000
- AKG N60nc
- AKG Q701
- Audio-technica ATH M50
- Audio-technica ATH M50x
- Beats Solo
- Beyerdynamic DT250
- Beyerdynamic DT770 Pro
- Beyerdynamic DT880 Pro
- Beyerdynamic DT990 Pro
- Beyerdynamic MMX 300
- Bose QC25
- Philips SHP2500
- Presonus HD7
- Razer Piranha
- Sennheiser HD25-I 70 Ohm
- Sennheiser HD25-II 70 Ohm
- Sennheiser HD202
- Sennheiser HD569
- Sennheiser HD599
- Sennheiser HD600
- Sennheiser HD650
- Shure SRH940
- Sony MDR7505
- Sony MDR7506
- SpeedLink Medusa NX
- STAX SRS2050 II
- Superlux HD681 EVO

The HPCFs listed above were created using headphone impulse responses sourced from the FABIAN head-related transfer function database and are licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

6 Access

Visit github.com/ShanonPearce/ASH-BRIRs to download the latest dataset.

7 Contact Information

If you have questions or suggestions, please send an email to:

Name: Shanon Pearce

Email: spearceash@gmail.com