Acoustic Suite – User Guide

A: Obtaining Impulse Response of a space

The first function of the program allows you to obtain the acoustic characteristic of the desired room, represented as an Impulse Response. This is done by playing a Sine Sweep into the acoustic space, which is then recorded and analysed. MATLAB saves the sound files as 16-bit. Different options are provided to adjust the Sine Sweep for optimal measurements, including with/without pre-equalization and mono/stereo mode of measurement.

A1: System setup

The program requires the following to operate:

1. A computer system with MATLAB
2. Loudspeakers
3. 1 microphone for mono mode, 2 microphones for stereo mode

Loudspeakers and microphones are connected to the audio output and input of the computer, respectively. They should then be placed at specific locations where the pair of loudspeakers and microphones simulate the natural source and receiver of sound, respectively, e.g. placing the loudspeakers on a stage while the microphones on the seats to simulate the experience of listening to a concert.

A2: Obtaining your impulse response

A2.1: The following instructions apply to mono or stereo mode <u>without pre-equalization</u>.

1. Open MATLAB.
2. Ensure AS.m and all other related files of the program are placed in the current directory of MATLAB. Then run AS.m
3. Ensure box for pre-equalization is unticked, then select *"Obtain Impulse Response"*. (See part A2.2 for applying pre-equalization)
4. Adjust settings of the SineSweep:
    i. Select *"logarithmic"* or *"linear"* sweep.
    (Note: For linear, harmonic distortions appear everywhere on the time axis while for logarithmic, harmonic distortions appear before the impulse response)
    ii. Enter the file name of the generated sine sweep wav file.
    iii. Set Initial Frequency.
    iv. Set Final Frequency.
    v. Set Duration of Sweep.
    vi. Set Number of Desired Averages.
    (Note: Higher number of sweeps may remove unwanted noise, which improves signal-to-noise ratio)
    vii. Set Duration of Silence after each Sweep.
    (Note: Longer duration of silence may prevent time-aliasing problems in highly reverberant acoustic spaces)

viii. Select “mono” or “stereo” accordingly for recording mode.
ix. Set Sampling Frequency.
5. Press “OK” to confirm or “Cancel” to return.
6. Confirm the settings shown in the Command Window of MATLAB are correct, then press any key to initiate the sweep.
7. The Sweep will then be generated, then be played and recorded simultaneously. (Note: Do not interrupt system or create noises until the message *“Average carried out successfully”* is shown since the program could still be recording.)
8. Frequency Response, Phase Response and Group Delay will then be plotted in Figure 1.
    i. Click *“Plot Impulse Response”* to obtain a plot of the Impulse Response of the generated sine sweep and the details of the sinesweep settings.
    (Use “**irinfo.m**” to obtain information about the sweep setting of an impulse response anytime.)
    ii. Click “*Plot Distortion Data”* to obtain the data for the fundamental frequency, 2nd harmonic, 3rd harmonic and 4th harmonic
    iii. Click “Plot Waterfall” to obtain the waterfall plot displaying how the frequency content of the IR changes over
        i. Enter the number of slices desired per second (1-200). (Higher number of slices increases the resolution of the signal)
9. The frequency response with psychoacoustic smoothing, 1/3 Octave smoothing and ERB smoothing will be plotted in Figure 2
10. Select “Close” to close the current figure and return to the main screen

A2.2: The following instructions apply to mono or stereo mode <u>with pre-equalization</u>.

1. Open MATLAB.
2. Ensure AS.m and all other related files of the program are placed in the current directory of MATLAB. Then run AS.m
3. Ensure box for pre-equalization is ticked, then select *“Obtain Impulse Response”*.
4. Adjust settings of the SineSweep:
    i. Select *“logarithmic”* or *“linear”* sweep.
    (Note: For linear, harmonic distortions appear everywhere on the time axis while for logarithmic, harmonic distortions appear before the impulse response)
    ii. Enter the file name of the generated sinesweep wav file.
    iii. Set Initial Frequency.
    iv. Set Final Frequency.
    v. Set Duration of Sweep.
    vi. Set Number of Desired Averages.
    (Note: Higher number of sweeps may remove unwanted noise, which improves signal-to-noise ratio)

vii. Set Duration of Silence after each Sweep.
(Note: Longer duration of silence may prevent time-aliasing problems in highly reverberant acoustic spaces)

viii. Select "mono" or "stereo" accordingly for recording mode.

ix. Set Sampling Frequency.

5. Press "OK" to confirm or "Cancel" to return.
6. Check the settings shown in the Command Window of MATLAB are correct, then press any key to proceed.
7. Adjust values of the regularization window if necessary: "Low frequency", "High frequency", "Width of transition band of the high-pass filter" and "Width of the transition band of the low pass filter".
8. Select the impulse response of the recording system for pre-equalization.
9. A sinesweep will then be generated and recorded simultaneously.
(Note: Do not interrupt system or create noises until the message *"Average carried out successfully"* is shown since the program could still be recording.)
10. Frequency Response, Phase Response and Group Delay would then be plotted.
11. Frequency Response, Phase Response and Group Delay will then be plotted in Figure 1.
    i. Click *"Plot Impulse Response"* to obtain a plot of the Impulse Response of the generated sine sweep and the details of the sinesweep settings.
    (Use "**irinfo.m**" to obtain information about the sweep setting of an impulse response anytime.)
    ii. Click "*Plot Distortion Data"* to obtain the data for the fundamental frequency, 2nd harmonic, 3rd harmonic and 4th harmonic
    iii. Click "Plot Waterfall" to obtain the waterfall plot displaying how the frequency content of the IR changes over
        i. Enter the number of slices desired per second (1-200). (Higher number of slices increases the resolution of the signal)
11. The frequency response with psychoacoustic smoothing, 1/3 Octave smoothing and ERB smoothing will be plotted in Figure 2
12. Select "Close" to close the current figure and return to the main screen

B: Plotting Saved Data

B1: Plotting a saved Impulse Response

1. From the main screen, select "Plot saved Impulse Response"
2. Select the file generated at the time and date when the sinesweep was carried out to obtain a plot of Impulse Response and details of the sinesweep settings
3. The Impulse response will be plotted in a new figure.

B2: Plotting a saved Distortion Data

1. From the main screen, select "Plot saved Distortion Data"
2. Select the file generated at the time and date when the sinesweep was carried out to obtain a plot of the distortion data.
3. The Distortion data will be plotted in a new figure.

B3: Plotting a saved Waterfall Plot

1. From the main screen, select "Plot saved Waterfall"
2. Select the file generated at the time and date when the sinesweep was carried out to obtain the waterfall plot
3. Enter the number of slices desired per second (1-200). (Higher number of slices increases the resolution of the signal)
4. The waterfall plot will be generated in a new figure

C: Transforming Sound or Music

Using impulse responses obtained from the first part of the program, you are now able to listen to any sound or music as if you were in the room where you obtained the impulse response. You can also decide the location of the audio source using spatialized binaural impulse responses [1]. Use headphones for a better experience.

1. Open MATLAB.
2. Ensure AS.m and all other related files of the program are placed in the current directory of MATLAB. Then run AS.m
3. Select "Transform your music"
4. Select your sound or music to be transformed. Press "Browse" to search for the location of the file, "Play" to listen to the audio file without transformation, "Stop" to quit the preview.
5. Tick the box for Spatial Colouration, click "Browse" to select the Impulse Response of the target acoustic space.
6. Tick the box for Spatial Localisation, click "Select Location" and adjust sliders to set Elevation and Azimuth angles.
   i. Elevation: -45° to 0° are below your head, 0° to 90° are above your head. (Position of the yellow dot)
   ii. Azimuth: 0° is direction in front of you (Direction of green arrow), 180° is behind the head. Angles increase anticlockwise such that 0°-180° is on the left, 180° to 360° is on the right.
7. Select "OK" to select the values, with angle values displayed on the previous interface.
8. Click "Transform" to start and play the convolved sound. "Stop" to stop playing the convolved sound.
9. Select "Save" to export the transformed audio.
10. Select "Cancel" to close the current screen and return the main screen.

Acknowledgement

Spatial Binaural IR: *http://recherche.ircam.fr/equipes/salles/listen/context.html*