RBA Toolbox

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github.com/RBAtoolbox

Abstract

The RBA Toolbox provides the necesarry building blocks to perform room acoustic measurements using a computer running MATLAB. It has been developed as an alternative to existing room acoustics measurement software, to provide more flexibility and control of the measurement chain and post-processing.
Measurements performed using the RBA Toolbox has been compared with measurements performed with Dirac. The measurements validated that reliable measurements can be performed using RBA Toolbox [1].

Motivation

The **Room and Building Acoustics Toolbox** (RBA Toolbox) for MATLAB has been developed in order to integrate the measurement procedure and post-processing of data in MATLAB. Commercially available software such as Dirac and Pulse can be used standalone for measurements and post-processing, but require cumbersome export procedures if the user wishes to perform data analysis on other platforms or software. The RBA Toolbox makes the complete measurement chain accessible within MATLAB. The RBA Toolbox aims to provide

- a flexible, platform-independent, and easy-to-use measurement procedure that comply with ISO-3382,
- a basic set of tools for common operations regarding post-processing of data,
- a framework for ongoing development and code sharing.

Functionality

The complete measurement chain can be divided into four elements:

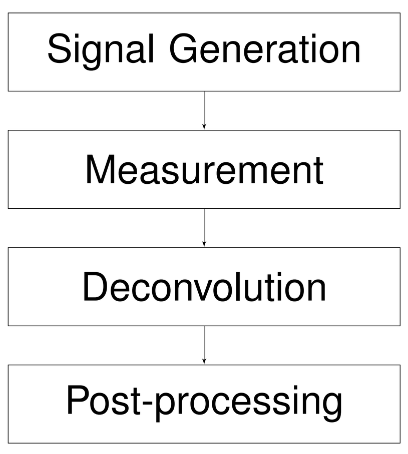

Figure 1: *Measurement chain*

Each segment can be controlled and manipulated individually thereby providing a flexible interface for many purposes. Some of the functionalties are

Signal Generation Generate excitation signals such as linear and log sweeps and MLS.

Measurement Perform measurements while processing data real-time by using *Psychophysics Toolbox* [2].

Deconvolution Extract impulse response from measurements of sweeps or MLS.

Post-Processing Calculate decay curves and room acoustic parameters such as reverberation time, clarity and definition.

Usage

To show how simple the RBA Toolbox is to use, some Matlab code example are given. Some steps of the measurement procedure and post processing of data, are given as a guide.

Performing a measurement

The script below generates a logarithmic sine sweep and applies a time window, before performing an actual measurement, deconvolving and plotting a spectrogram of the measurement and the obtained impulse response (see Figure 2):

```
fs = 48000;       % Sampling frequency
fLow = 1;         % Lower sweeping freq
fUp = 22000;      % Upper sweeping freq
T = 5;            % Duration of sweep [s]
type = 'logsin'; % excitation type
f1 = 20;          % Lower frequency
f2 = 20000;       % Upper frequency

[sweep,t] = rbaGenerateSignal(...
type,fs,fLow,fUp,T);
% Apply window
L = length(sweep);
win = sweepwin(L,fLow,fUp,f1,f2,type);

% Start measurement
RT = 1;       % Estimated T60 [s]
N = 6;        % Number of sweeps
y = rbaMeasurement(sweep,fs,N,RT);

% Compute impulse response
h = sweepdeconv(sweep,y,f1,f2,fs);

% Plot results
specgram(y,min(256,length(y)),fs)
title('Spectrogram')
plot(0:1/fs:(length(h)-1)/fs,h)
title('Impulse response')
xlabel('Time / s')
ylabel('Impulse response')
```

Visualizing results

The impulse response obtained from deconvolution of the measurement should be cropped before further processing in order to produce the most reliable results. The cropping procedure is shown in Figure 2. The RBA Toolbox provides an iterative method, Lundeby's method [3], for determining the knee-point between sound decay and background noise. The necessity of a correct cropping is clearly seen on the derived decay curves in Figure 3.

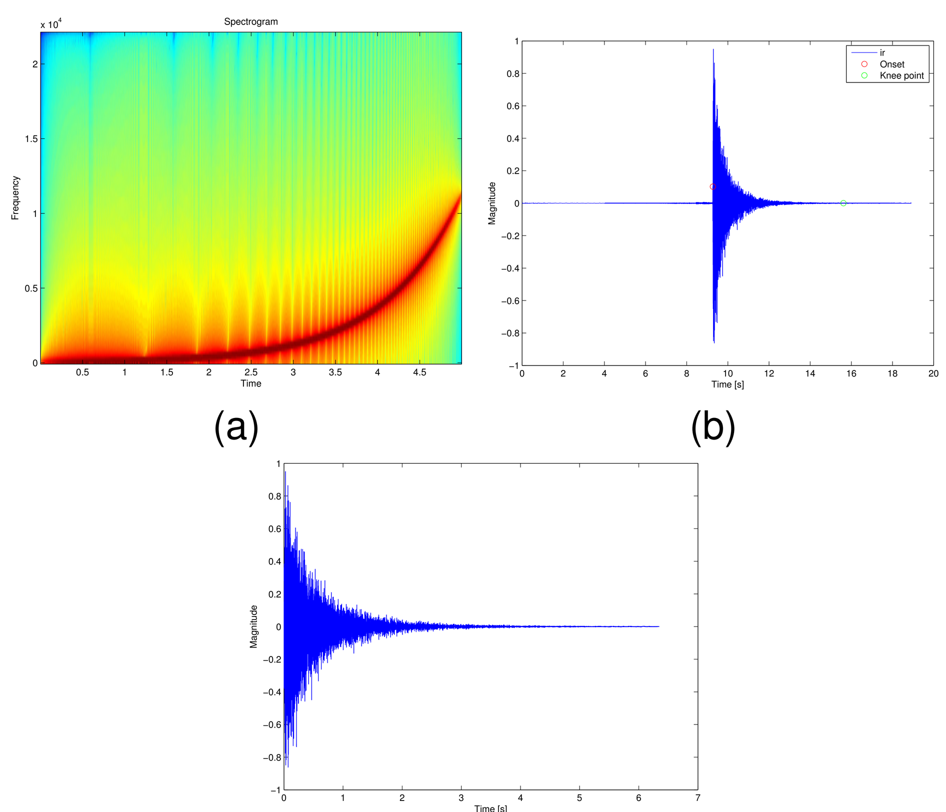

Figure 2: *Spectrogram of excitation signal (a), the resulting measured impulse response (b) and the cropped impulse response (c)*

Post processing

Common ISO-3382 parameters can easily be derived from the impulse response with the supplied functions. Decay curves are derived by Schröders backwards integration method which is dependent on the chosen cropping procedure of the impulse response - see Figure 3.

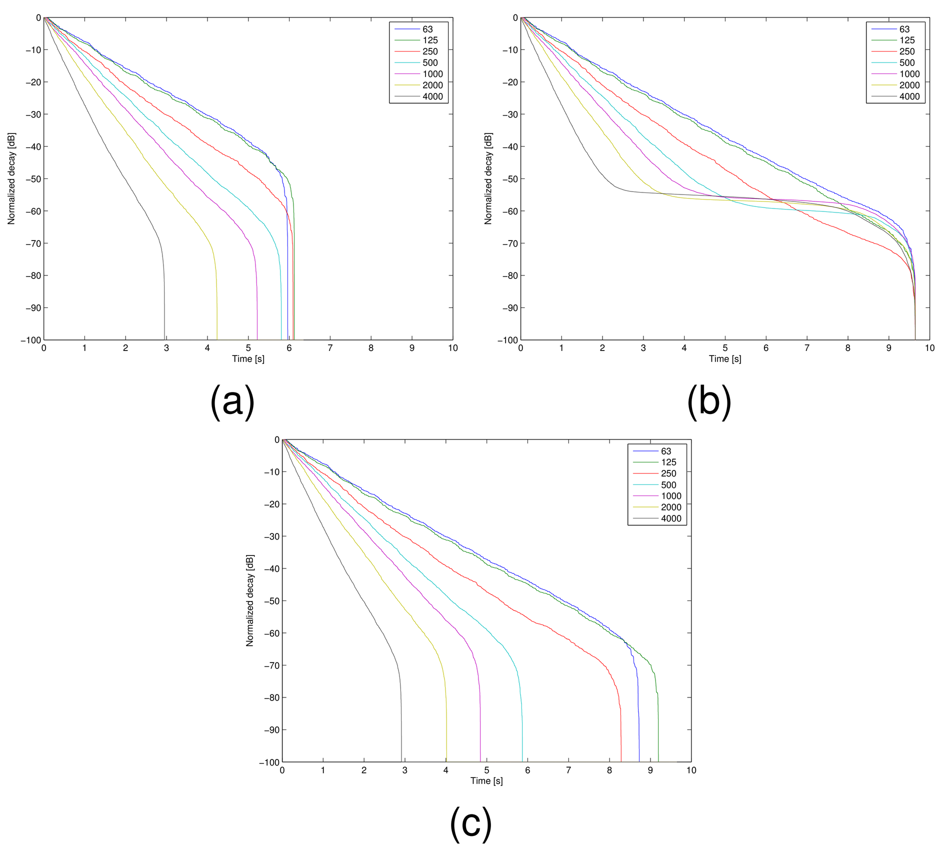

Figure 3: *Differences between cropping procedures at different stages of the data treatment. a) Cropping onset and at knee-point, b) no cropping and c) only cropping at onset.*

The following example shows how to derive Reverberation time, EDT, Clarity and Definition from a broadband impulse response.

```
% Crop Impulse Response h at onset
[hCrop,t] = rbaCropIR(h,fs,'onset');
BandsPerOct = 1;
% Get octave band frequencies
freqs = rbaGetFreqs(63,8000,BandsPerOct);
% Filter IR into octave bands
H = rbaIR2OctaveBands(hCrop,fs,freqs(1),...
  freqs(end),BandsPerOct);
% Compute common ISO 3382-1 parameters
C = rbaClarity(H,fs);
D = rbaDefinition(H,fs);
% T60 requires decomposition into decay curves
% Compute decay curves
R = rbaSchroeder(H,fs);
RT = rbaReverberationTime(R,t,'best');
```

Validation

Measurements were performed with RBA and Dirac in the large reverberation chamber at DTU and the resulting T_{30} values are shown in Table 1 for comparison.

[Hz]	63	125	250	500	1000	2000	4000	8000
RBA	7.51	7.43	6.11	5.01	4.33	3.51	2.38	1.43
Std.Dev	0.41	0.35	0.07	0.08	0.07	0.08	0.06	0.04
Dirac	7.42	7.36	5.97	4.98	4.31	3.36	2.35	1.41

Table 1: *Parameter output values from script example.*

Perspectives

The RBA toolbox is freely available and everyone interested is invited to join the further development of additional functionality on:

github.com/RBAtoolbox

where bug reports and feature request can be submitted. It has been shown that the most common procedures in room acoustics can be done exclusively in MATLAB, more complicated procedures, such as working with microphone and loudspeaker arrays, have not been implemented yet. It is believed, however, that the combination of the RBA Toolbox and the Psychophysics Toolbox is capable of providing the necessary environment for more complicated setups.

References

[1] Lylloff O, Nielsen M and Duhalde D. The RBA Toolbox. *Acoustic Technology*, DTU, 2012. Report available at github.com/RBAtoolbox.
[2] Kleiner M, Brainard D, Pelli D. What's new in Psychtoolbox-3? *Perception 36 ECVP Abstract Supplement*, 2007. http://psychtoolbox.org/
[3] Lundeby, A, T E Vigran, H Bietz, and M Vorlander. Uncertainties of Measurements in Room Acoustics. *Acta Acustica United with Acustica 81 (4): 344355, 1995*