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MATLAB Toolbox for the Comprehension of Acoustic Measurements and Signal Processing

Motivation

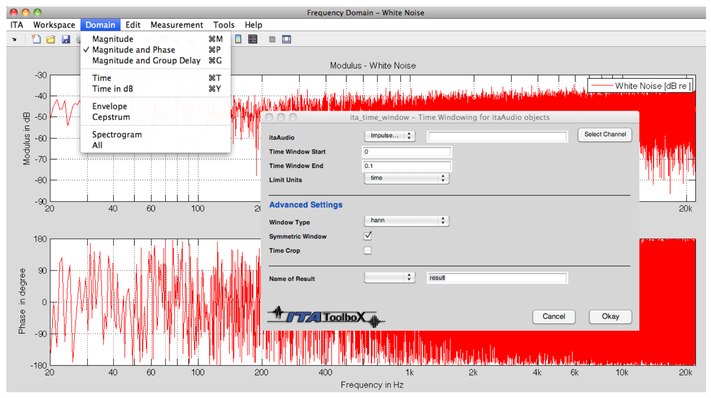
A platform-independent MATLAB toolbox called *ITA-Toolbox* is presented that offers functionality for a wide range of acoustic measurement and signal processing tasks. Students have access to the source code of most functions which enables them to follow and comprehend all parts of the signal processing chain [3]. Using MATLAB scripts based on the *ITA-Toolbox* functions, signal processing tasks can be fully automated. This allows students to easily measure directivities or to calculate reverberation times or acoustic source power. Meta data (physical units, channel names, sampling rates) are always kept consistent.

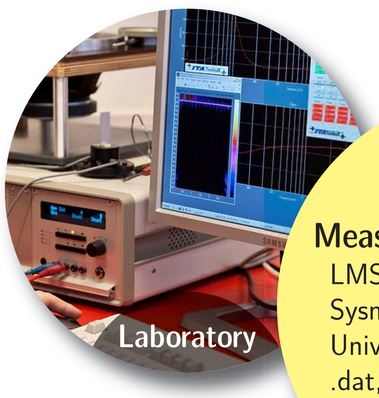
Object-Oriented Programming

To make MATLAB code generation as easy as possible, the *ITA-Toolbox* is designed to provide an intuitive handling using MATLAB's new object-oriented possibilities. Encapsulated class objects *(audio data, measurement settings, spatial information)* provide intelligent behavior.Common built-in routines and operators of MATLAB can be overloaded [1]. Specific operators are redefined for time and frequency domain (`*`, `/`, `^` frequency domain, `.*`, `./`, `.^` time domain), as well as well-known MATLAB function names (such as `plot`, `mean`, `conj`) for various kind of objects.

Graphical User Interface

Graphic frontends for the *command line* functions lighten the first steps with MATLAB, the *ITA-Toolbox*, and signal processing. The GUI uses variables in the MATLAB workspace providing a seamlessly combined usage of both approaches.





Import
Measurement/Simulation
LMS Virtual Lab, BK Pulse
Sysnoise, MonkeyForest
Universal File Format; ASCII
.dat, .spk, .mat, .csv,
.uff, .unv, .wav

Export
Data/Results/Geometry
Universal File Format, CSV,
Wave, mp3, PDF (3D),
native MATLAB
[Measurement Reports]

Synthesis
Signals/TP/Coordinates
Excitation Signals:Sweep/MLS
Impedances:Loudspeaker,Plate
Two-Port:Mass-Spring-Damper
Room Impulse Responses
Geometry/Mesh

Filtering/Windowing
Fractional Octaves
Zero/Minimum-Phase
Shelving/Low-High-Pass

Transformation
normalized FFT
Cepstrum, Hilbert

Kernel
Operators
Classes
Units

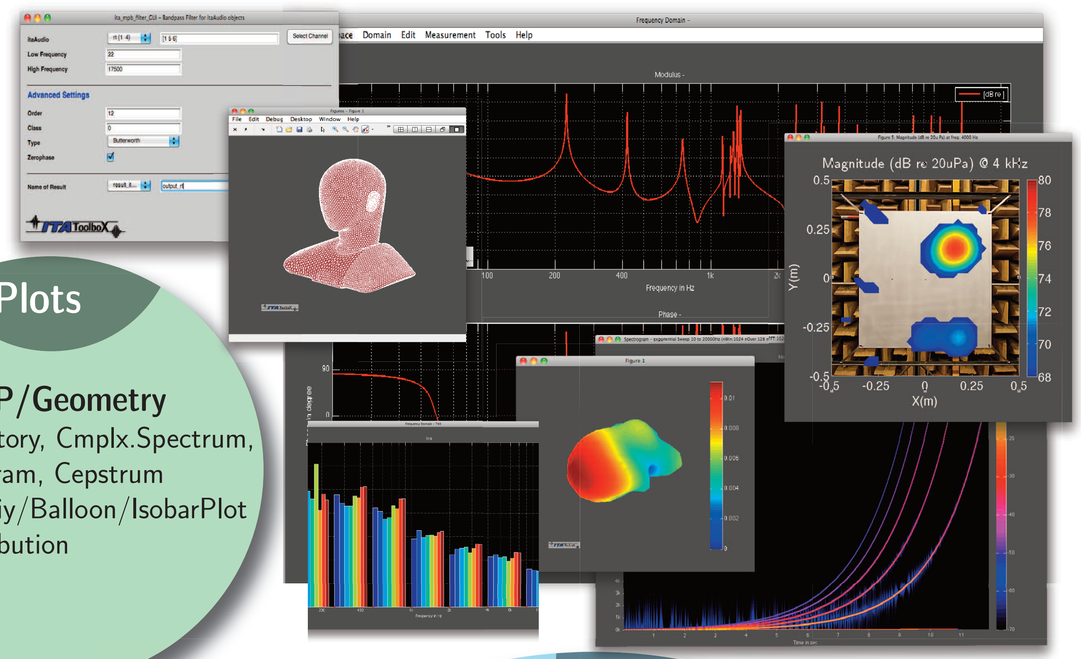
Level/Shaping
Loudness
dB(A)/dB(C)

Calibration
Measurement Chains
Pistonphone/Sensors
Broadband/Latency
Actuator Compensation

Platforms
Windows,Linux,
Mac OS X

Directivity
spherical/cylindrical
harmonic calculation

Plots
Audio/TP/Geometry
Time History, Cmplx.Spectrum,
Spectrogram, Cepstrum
Directivitiy/Balloon/IsobarPlot
2D-Distribution
WebCam



GUI
Parametric GUI concept:
Modular Enhancement of
Command-Line Functions
Main Window:
Connecting Modular GUIs
and Plot Routines

Audio IO
PortAudio/PortMedia
ASIO/CoreAudio/ALSA
Measurement/Stimulus
Continious Level Meter

Remote
Hardware/Motor Control
RS232 Communication:
Turntable/Arm, X-Y-Bench
BK Nexus, Laser Vibrometer
MIDI Communication:
Preamp/Amp/ModulITA

developer
user

Applications

Loudspeaker
el.Impedance/Two-Port
Thiele-Small Parameters
Equivalent Circuit Diagram

Room Acoustics
ISO 3382, Reverberation Time
Clarity, Definition, IACC

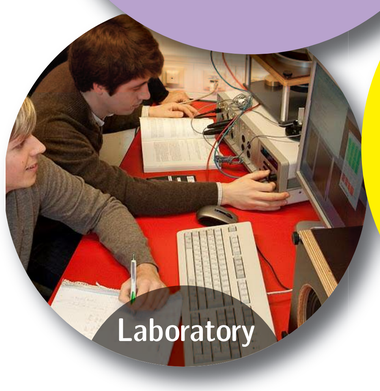
Source Localization
Beamforming, NAH
Surface Velocity

Sound Power
Free-Field
Reverberation Chamber

Laboratory on Acoustics
Scripts to be completed
by students:
Sound Power Calculation
3 Microphone Kundt's Tube
Filter Design/CTC

Acoustic Impedance
Kundt's Tube
In-Situ: p-u/p-p

Binaural Processing
Auditory Model
HRTF, CTC



ITA Toolbox
www.akustik.rwth-aachen.de/toolbox

Laboratory

Since MATLAB code does not require compilation, the *ITA-Toolbox* is a very comfortable framework to provide students with scripts missing important parts, e.g. for *crosstalk cancellation filters*, *Kundt's tube* and *sound isolation*. Students must first complete the codes for data processing, gaining a broader knowledge about the subject under study, to then use it for the tasks required in the courses.

Script Example

```
%% building excitation signal
sweep = ita_generate('sweep',16,[40 18000]);

%% measurement
result = ita_portaudio(sweep,'inputChannel',1,'outputChannel',1);

%% deconvolution
RIR = (result/sweep).';

%% Filter and Window
RIR = ita_filter(RIR,[40 18000]);
RIR = ita_time_window(RIR,[0.8 1.2],'time','crop');

%% Plot
plot(RIR);

%% Room Acoustics ISO 3382
parameters = ita_roomacoustics(RIR);
bar(parameters.RT);
```

Acknowledgment

The authors would like to thank Prof. Michael Vorländer and Dr. Gottfried Behler for their support and Dr. Swen Müller [2] for his coorporation. PortMusic and playRec were used to realize stable audio data acquisition with MATLAB. Thanks to all users for their constructive feedback.

References

[1] Register, A. H.: A Guide to MATLAB Object-Oriented Programming. Chapman & Hall/CRC, 2007

[2] Müller, S. and Massarani, P.: Transfer-Function Measurement with Sweeps. Journal of the Audio Engineering Society, 2001

[3] Fingerhuth, S.; Dietrich, P. and Kaldenbach, R.: Mess-'Blackbox' zum Verständnis des Übertragungs-verhaltens und der akustischen Messtechnik, Fortschritte der Akustik - DAGA, 2010