**TEXTURE ANALYZER Software**

L. Beranek, in his book “Concert and Opera Halls, how They Sound” (1996), defined the acoustic texture as “the subjective impression the listeners derive from the patterns in which the sequence of early sound reflections arrive at their ears. In an excellent hall those reflections that arrive soon after the direct sound follow in a more-or-less uniform sequence. In other halls there may be a considerable interval between the first and following reflections. Good texture requires a large number of early reflections, uniformly but not precisely spaced apart, and with no single reflection dominating the others”.

The microscopic parameters of the acoustic texture also offer information, at least partially, about Listener Envelopment, LEV, Acoustic Glare, Immediacy of Response, Freedom from Echo, Extraneous effects on tonal quality and temporal acoustic diffusion. Furthermore, a good acoustic texture will be the result of the absorption coefficient of the room, the arrangement of diffusing surfaces, their efficiency, the interior volume and the degree of uniformity of the distribution of the acoustic coatings on the interior surface.

The main parameter of the acoustic texture is the nOD (normalized Ordinal Distance). This is calculated by the sum of the ordinal differences between the accumulated energy curve of the early reflections as a function of time (*real edf*) and its ideal equivalent (*ideal edf*), between t = 0 and Tt. Finally this sum is divided by the length of the ideal curve, which results in the parameter nOD. For the above it is essential to define and find the transition time. Tt [ms] corresponds to the last instant in which the energy difference between the impulse response of stochastic reflections and the impulse response of early reflections is -10 dB.

An ideal neutral texture corresponds to an **nOD** value equal to zero, but in real cases with **nOD** values less than 1.5 may be considered “sufficiently acoustically neutral”. Higher values reflect lower degrees of acoustic neutrality in the analyzed room impulse response, RIR; that is, the lower the neutrality, the greater the coloration it generates and the shift in the localization of the sound source, at the measuring point.

The software is based on the processing of the early reflections that all RIR has, reducing the number of parameters previously presented by this author in various scientific meetings and re-defining them. The *ideal* texture values, that is, those that present less coloration on the direct sound, show a uniform distribution of reflections over time and a smooth decay of their amplitudes, were extracted from the analysis of synthetic RIRs generated with exponentially decaying white Gaussian noise.

Thanks to the normalization of the ordinal distance, OD, parameter per unit of length of the *ideal edf* curve, **nOD**, it is possible to compare the acoustic textures between different RIRs within a room, and of RIRs from different rooms. The software is offered as a **freely distributed acoustic analysis tool**, and it is intended to be useful for education on Architectural Acoustics, for the diagnosis of venues, for the evaluation of locations and quantities of acoustic coatings to be applied (e.g.: acoustic diffusers), for research, among other possible uses.

You are invited to distribute among colleagues the QR code that you have received to access the software. If you need just the QR, it is located in the same folder the software is stored. You are allowed to copy and distribute it.

If you use this calculation tool in research or acoustic analysis work, I would appreciate it if you could include the name of the software and its author in the documentation.

**INSTALLING Texture\_analyzer\_v12.app**

The Texture Analyzer App was developed and compiled on Mac and Windows to be standalone, that is, it can run without having MatlabTM installed.

Depending on your working environment, MAC OS or WindowsTM, once you receive the link to the software folder, choose the zipped version of the software corresponding to your operative system. In both cases, the installing process is the same:

1. Unzip the folder that contains the App.

2. Inside the generated folder is the file ‘MyAppInstaller\_web.app’.

3. Double click on ‘MyAppInstaller\_web.app’. This will launch the app installer. You will need an internet connection so that the installation process can download the necessary components.

4. The installer will guide the user through the installation process, and at the end, the standalone application will be installed on your system. This may take a while.

5. After installation, run Texture\_Analizer\_v11.app by double-clicking its icon in the Finder or from the Launchpad.

**RUNNING Texture\_analyzer\_v12.app**

The analysis of the acoustic texture of a room impulse response (RIR) within a bandwidth of interest allows, among many other things, to know the duration of the early sound field (Tt), to know the magnitude of the deviation of the accumulated energy of the early reflections with respect to an ideal curve, the amount of early reflections accumulated up to Tt and the decay time defined by Tt (instead of -10 dB), named Early Decay Transition time, EDTt. For this, the Texture Analyzer app was developed.

The signal-to-noise ratio of a room impulse response is called Impulse to Noise Ratio or Peak to Noise Ratio (PNR). To obtain reliable results in texture analysis it is essential to process RIRs with very good PNR, inside the analysis bandwidth. That is, the results will be reliable to the extent of having recorded an RIR with the highest signal-to-noise ratio possible. To analyze the texture of a RIR, it is recommended to use a bandwidth between 200 Hz and 5 KHz to observe the effects of reflections that effectively color the frequency responses in an room. The results of the analysis will change with different bandwidths since early reflections will be incorporated or discarded within it, and their spectral contents will be modified.

Filtering: The designed bandpass filter between fmin and fMax has a steepness of 0.85 and a stopband of 60 dB. It´s functioning applied to a pink noise file, with fm = 200 Hz and fMax = 5 KHz, can be seen in the next figure (Figure 1):



Figure 1. Bandpass filter response applied to a pink noise file.

The temporal distortion of the filter is minimized by the method of reverting the file to be processed, and a subsequent de-reverting.

Note: It is recommended to trim those portions without audio information from the room impulse responses wav files to be processed, to avoid prolonging the calculation time unnecessarily.

1. Double click in the Texture\_Analyzer icon.
2. Complete the minimum and maximum frequencies of the analysis;
3. Open the wav file corresponding to the room impulse response you want to analyze. It can be either 16 or 24 bits resolution, and any sampling frequency.
4. This can be monaural (monophonic) or binaural (stereo wav file).
5. Select the application of the weighting filter "A", according to your analysis needs.
6. If there are pre-existing figures in the graphics, it is possible to delete them with the "Clear Figures" button. If you do not delete them, the graphs resulting from the new calculation will be displayed together with the previous graphs.
7. Click on “Calculate”. In the case the software crashes, the Peak/Noise of the analyzed RIR is so low, that is not adequate (The noise increases the level of the stochastic rir, causing Tt to never be found).
8. The numerical results are distributed in two columns, one for the left channel and one for the right channel. These results will correspond to the last analysis carried out.
9. Versions 12 and higher calculate and display the P/N\_Tt value [dB]; this is the Peak – to – Noise ratio between 0 ms and Tt ms as a measure of the quality of the RIR being processed. Values larger than 6 dB assure reliable results for all texture parameters.
10. The graph below presents the x-axis in time units [ms] for better reading.
11. This version (and higher) has the possibility of exporting numerical results to an exell file (\*.xls), both for the left and right channels. The option to export to the file that is already previously loaded or to a new one is added. Every time the “save last results” button is pressed, they are exported in a new row of the exell file. The first row of the file contains the names of the exported variables. The export will continue adding rows until the “save in existing file” checkbox is unclicked. NOTE: In the case of having clicked the "save in existing file" checkbox, having opened the exel file for inspection and subsequently saved it as \*.xlsx, for the software to continue saving the results in said file without errors, the user must delete the \*.xlsx file while maintaining the \*.xls file.
12. Versions 10.b and higher have the option of displaying or not the vertical lines corresponding to ACd [ms] parameter. Just check or uncheck the “show line” box. This line will give the user a visual information about how much lasts the “direct sound package” in the frequency range selected before.
13. Versions 11 (and higher) incorporate two new parameters: the clarity in Tt (CTt) and the sound level of the late reverberant field in relation to the energy of the "direct sound package" [dB]. The latter could be helpful in quantifying an objective listener envelopment, among other calculations.

Enjoy learning and researching on acoustics!

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