ΨΗΦΙΑΚΗ ΤΕΧΝΟΛΟΓΙΑ ΗΧΟΥ

Εργασία: Ισοστάθμιση ακουστικών

Project: Headphone equalization

Aims

The goal of this project to familiarize with headphone response equalization [1]. You will be given different headphone measurements in the form of Impulse Responses (IRs) [2], which you will have to equalize. You will also be given the response Targets [3], which describe through a Magnitude Response the desired result of the equalization process.

Outcome

The students will present comparisons between different equalization methods as well as methods to evaluate their effectiveness.

Tasks

1. Plot the magnitude responses in dB of the given headphones and compare them with the given Targets. Each headphone should be on a separate figure, along with the given Targets. On each figure the MSE [4] and RMSE [5], between the headphone responses and each of the Targets should be indicated. Do not forget to include the units of the error metrics.
2. Create a filter that achieves the desired Target response in the frequency domain and plot the results (before, after, target and the filter).
3. Create an FIR filter that achieves the Target response through convolution with the original headphone response. Plot the results as above.
4. Try reducing the number of FIR coefficients and compare the results.
5. Create a function that creates a parametric equalizer. The function should be based on Second Order Filters (SOS), with the user specifying the filter Center Frequencies W_o, and their Quality Factors Q. The function should return an array of second order filters. The number of filters included in the parametric equalizer should be variable, e.g. the function should be called like so: sos = design_parametric($[W_{01}, W_{02}]$, $[Q_1, Q_2]$) but also like so: $\text{sos} = \text{design\_parametric}([W_{01}, W_{02}, W_{03}], [Q_1, Q_2, Q_3])$. The information found in the following links may be useful for this task [6], [7].
6. Use the above function to create a filter such that when it is convolved with the headphone response a response as close to the Target as possible is achieved.
7. Create an automatic fully parametric equalizer using the function created for 6. The user should provide the headphone response and the Target, the output should be the filter that achieves the target with the lowest error. You can choose whatever method you prefer, either through adaptive optimization (e.g. stochastic descent), or via brute force. For this task you can set a predetermined number of SOS filters (16 is a good number).

The optimal solution should calculate the number of required filters without user intervention.

Bibliography - Links

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[3] S. E. Olive, T. Welti, and E. McMullin, “Listener Preference For Different Headphone Target Response Curves,” 2013.

[4] “Mean squared error,” *Wikipedia*. Feb. 14, 2024. Accessed: Feb. 22, 2024. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Mean_squared_error&oldid=1207422018

[5] “Root-mean-square deviation,” *Wikipedia*. Feb. 07, 2024. Accessed: Feb. 22, 2024. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Root-mean-square_deviation&oldid=1204670839

[6] “Parametric Equalizer Design - MATLAB & Simulink.” Accessed: Feb. 22, 2024. [Online]. Available: https://www.mathworks.com/help/audio/ug/parametric-equalizer-design.html

[7] “Signal processing (scipy.signal) — SciPy v1.12.0 Manual.” Accessed: Feb. 22, 2024. [Online]. Available: https://docs.scipy.org/doc/scipy/reference/signal.html