Advanced Signal Processing Seminar
Convex Optimization in Signal Processing
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Sparse Filter Design Using Linear Programming

The complexity of discrete-time filters can be defined as the number of arithmetic operations required for their implementation. If one wants to design a discrete-time filter satisfying certain frequency-domain constraints, while simultaneously limiting the number of required arithmetic operations, then there are several methods available. Two novel methods for this purpose, based on linear programming algorithms, are presented in [1]: the authors aim to reduce the filter complexity by minimizing the number of non-zero coefficients in the impulse response $\mathbf{b}$ by (a linearly relaxed version) of the optimization problem

$$\begin{aligned} \underset{b_0,\ldots,b_M}{\text{minimize}} \quad & \|\mathbf{b}\|_0 \\ \text{s.t.} \quad & W(\omega)|A(e^{j\omega}) - H_d(e^{j\omega})|, \end{aligned} \tag{1}$$

where $\|\mathbf{b}\|_0$ denotes the number of non-zero coefficients of $\mathbf{b}$, $W(\omega)$ is a weighting function, $H_d(e^{j\omega})$ the desired frequency response and $A(e^{j\omega})$ the frequency response of the filter to be designed.

TODO

- Get familiar with the basics of linear programming such that you are able to understand the paper by Baran et al. on sparse filter design [1]. A good starting point for this could be [2].
- Present the two filter design approaches from [1]. Explain especially how a linear program relaxation is derived from problem (1).
- Implement the two presented algorithms in MATLAB. You are allowed and encouraged to use the linear program solver `linprog` shipped with MATLAB.
- Implement an equalizer for the subscriber line given by the frequency response on the website (to be published). Determine the number of nonzero coefficients required for different tolerances on the specifications. Present your results.
- Hand in your presentation slides and your code, which will be made available via our homepage.

References

[1] T. Baran, D. Wei and A.V. Oppenheim, Linear Programming Algorithms for Sparse Filter Design, *IEEE Transactions on Signal Processing*, vol. 58, 1605–1617, 2010.

[2] J. Wei, *Lecture notes on* ***Linear Programming***, 2011
`http://www.math.cuhk.edu.hk/~wei/LP11.html`