Contribution to the design of modulated filter banks for arbitrary subsampling rates
Beiträge zum Entwurf modulierter Filterbänke für verschiedene Teilbandabtastraten

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ABSTRACT

This work discusses the design of modulated filter banks, where besides some results from filter bank theory also applications like subband coding and subband filtering are considered. We furthermore restrict us to modulated filter banks with the generalized discrete Fourier transform (GDFT) and the generalized discrete cosine transform (GDCT). Firstly, we talk about the classical almost perfect reconstruction case, where a novel systematic investigation of the filter bank properties for all integer subsampling rates is carried out. For applications like subband based spectral modification (as echo compensation, noise reduction or equalization), where oversampled filter banks are used, GDFT filter banks should be preferred, since even when linear subband filtering is present, the aliasing components can be suppressed fairly well. For subband coding applications with critically subsampled filter banks it turns out that the DCT-IV-based filter bank has a higher coding gain than the modified DFT filter bank. Furthermore we present a novel description for integer subsampled perfect reconstruction (PR) GDFT and GDCT filter banks with arbitrary system delay, which contains the PR conditions known from literature as special cases. We show that we have additional design freedom in the oversampled case, which can be exploited in the design process. Additionally, the PR conditions become less restrictive with increased oversampling, since the number of conditions to be satisfied by the prototype coefficients is reduced. A further novel result of this work is the relation between PR and almost PR prototypes. PR prototypes, which are designed for a certain subband subsampling rate yield an almost PR solution, when they are applied to filter banks with higher subband subsampling rates. In the special case of a non-subsampled filter bank the equivalence between the PR conditions and the classical Nyquist condition can be shown. On the other hand we prove that almost PR prototypes approximately satisfy the PR conditions. After that we present some novel methods for the design of prototype lowpass filters with an least squares error criterion in the stopband. The design results for PR prototypes show that additional oversampling indeed leads to an increased prototype selectivity. For an almost PR design three new design approaches are proposed and compared to each other. Another important point is the influence of the prototype parameters on the filter bank performance in different applications. In subband coding with a critical subsampled filter bank we loose the PR property completely when decreasing the word length in the subbands. For very low bit rates the main aliasing components in the linear filter bank subsystem are not compensated anymore, since the subband quantization errors will become signal dependent. These aliasing components can only be compensated by prototypes with narrow transition bands and sufficient stopband attenuation. In the oversampled GDFT-case we can exploit the additional design freedom, when we design a synthesis prototype with ”don’t care” bands in the stopband region. This leads to a further reduction of the aliasing power in the reconstructed signal.