

Application of Modified Particle Swarm Optimization Algorithm in FIR Filter Design

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SUMMARY

In this work we present an application of Particle Swarm Optimization (PSO) algorithm as a support in the design of Finite Impulse Response (FIR) filters. The conventional PSO algorithm was not sufficient to obtain desired filter parameters for filters longer than 20 coefficients. For this reason, we used an adaptive PSO algorithm that allows for adjustment of several key parameters during the optimization process of the swarm. In comparison to existing adaptive algorithms, in which for example only the inertia coefficient was subject to change, in our approach the possibility of changing several parameters simultaneously has been introduced. In our approach we additionally modify the social and cognitive coefficients in parallel. As a result, it was possible to obtain satisfactory results for FIR filters of lengths exceeding 50. In this work, we focused in particular on examining the effect of the swarm population size on the algorithm convergence. It turned out that for FIR filters of lengths around 40-50, satisfactory results are obtained with the number of particles in the swarm at the level of 100-150.

Designing FIR filters with the use of the PSO algorithm is an alternative approach to conventional methods known since years. It requires defining an appropriate fitness function, which allows for the evaluation of differences between the theoretical and desired frequency responses. One of the assumptions of this work was to achieve a linear phase response. The design criteria may also include the passband and stopband boundaries, as well as minimizing signal distortion in the passband. The objective function can be defined in such a way as to minimize the sum of absolute errors in the passband and stopband. Optimization of such a fitness (objective) function leads to better attenuation of signals in the stopband, minimal ripples in the passband, and optimal transition width between these bands.

In this work we used the objective function that is a weighted sum of two criteria related to the accurate reconstruction of the passband and stopband of an ideal filter. Both bands are defined using cut-off frequencies. Additionally, a parameter

associated with the transition band width is introduced, which masks error accumulation within specific frequency ranges. This is because the dynamics in this band largely depends on the filter size and could mislead the algorithm.

Selected obtained results are shown in Fig. 1. In this case the filter designed using the PSO algorithm performs better in damping oscillations in the passband. However, it is characterized by a wider transition band than the filter designed using the conventional window method. Both filters offer a similar attenuation. In the case of the filter designed with the PSO algorithm a wider transition band has been obtained.

Results presented in our work are a fragment of a broader investigations on this topic. These studies show that the PSO algorithm allows for the design of a filter with a moderate length. In following stages of the project, it is planned to split filters with long impulse responses into shorter sections connected in series, and then optimize them separately. Optimizing each of such shorter sections separately would be easier due to the significantly smaller dimensions of the search space.

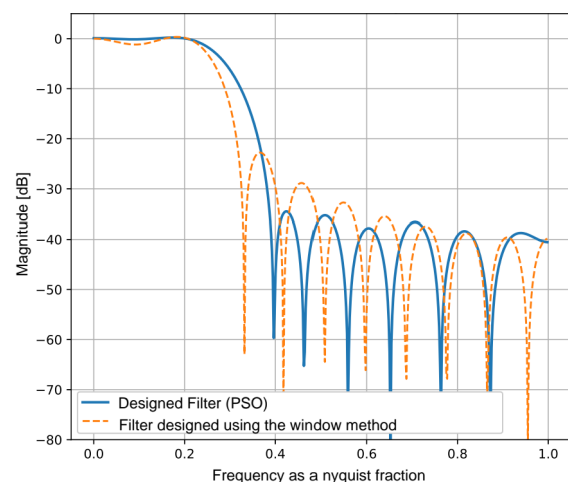


Fig. 1. Magnitude response of the low-pass FIR filter obtained using the PSO algorithm with improved parameters.