Frequency estimation with spectrum interpolation and GMSD time windows - abstract

Frequency estimation is a fundamental issue in many fields of technology and is a key element in the implementation of many practical systems. The interpolated discrete Fourier transform (IpDFT) class eliminates the limitations of the classical DFT-based approach to signal analysis, which become apparent when the signal under study is out of sync with the measurement window (incoherent sampling). This paper focusses on how to obtain and analyze estimators using interpolation of the DFT spectrum for generalized maximum sidelobe decay time windows, i.e., GMSD windows. The methods proposed in this thesis eliminate the error due to the presence of interfering components in the signal: long-range leakage due to the use of GMSD time windows, and the conjugate component and the single low-order harmonic component due to the use of new interpolation formulas, even for short measurement times.

The first two chapters of the thesis outline the topic of frequency estimation in the context of using example methods in practical real-time systems. The third chapter presents the theoretical basis of DFT spectrum interpolation methods and a more detailed analysis of the available methods with an indication of the key features of the described algorithms, concluding with a qualitative summary. The fourth chapter derives the equations of the new spectrum interpolation methods: two-point, three-point and five-point GMSD methods, which allow to improve the accuracy of estimation by eliminating the influence of the presence of interfering spectral components. These are, in turn, the long-range leakage, the conjugate component, and the single low-order harmonic component. The chapter also presents an example description of the implementation of the proposed algorithms. The fifth chapter presents an analysis of the accuracy of the obtained estimators using simulation studies, along with a comparison to selected methods. The chapter includes a description of a practical system implementing the proposed algorithms along with an analysis of computational complexity and execution times. The thesis concludes with a summary in chapter six.

Adam Matusiak