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SEGMENTATION METHODS FOR IMPROVEMENT OF THE PRONY'S METHOD RELIABILITY FOR NOISY SIGNALS

A lot of signal processing problems call for the spectral analysis of the signal, which is usually done with the help of the Discrete Fourier Transform (DFT). The main problem of this approach is the fact that it often distorts the spectrum peaks, widening them [1, p. 341]. Such peaks can sometimes overlap and, in the most extreme cases, even merge into a single shape. Thus, a need for alternative methods arises. Parametric spectral methods such as the Prony's method can be used instead. These methods fit the predetermined model to the analyzed signal and can precisely estimate any frequency as long as it is lower than the Nyquist frequency, but they suffer greatly in the presence of noise. In this paper, the method of signal segmentation is explored as a possible method for the improvement of the reliability of the Prony's method, which uses a complex exponential signal model [2, p. 2].

Due to the probabilistic nature of the noise, some parts of the signal may be more influenced than the others. It would be logical to give the parts of the signal where the noise is less prominent a higher ability to influence the parameter estimate values. One possible way of implementing such an idea is to represent the signal as a sequence of its segments, which may overlap. After this, an already well-established method is applied to each of the segments. Along with this, an algorithm is used to estimate the segment's relative noise level. The final estimate is then given as the weighted average of the segment's estimates with the normalized relative noise levels used as the weight parameters. In order to estimate the noise level of the segment, the estimated autocorrelation matrix's spectral decomposition can be used. This approach can also be used to estimate the values of the linear prediction vector, which is essential for the Prony's method.

The method was tested on a sine signal with the normalized frequency being varied from 0.1 to 0.4 with a signal to noise ratio of 20 dB which is considered significant. Each time the experiment was repeated 1000 times. As can be seen in Fig. 1, such method can improve the results of the estimation for a notable range of frequencies in comparison with the classic Moore-Penrose approach and the usual eigenvector approach.

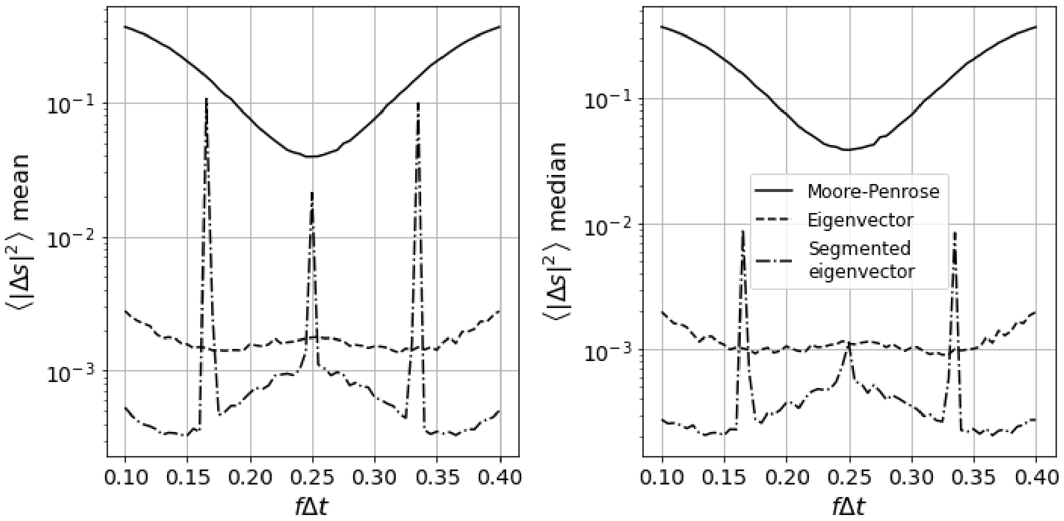

Fig. 1 – Plots of mean (left) and median (right) of the error power for each of the frequencies

The computational experiment has demonstrated that the method has merit if the places where the error spikes occur are taken into consideration. In most cases the proposed method shows better results than the eigenvector and Moore-Penrose method. For some normalized frequencies the precision is improved by almost and order of magnitude.

REFERENCES

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2. Fernández R. A. et al. Coding Prony's method in MATLAB and applying it to biomedical signal filtering. *BMC Bioinformatics*. 2018. Vol. 19, no 1. P. 451.