CONSTRUCTION OF BISPECTRA FOR PCG SIGNALS

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The third-order spectrum, called bispectrum, is a particular example of higher-order spectrum (HOS), which is defined as the Fourier transform of third-order cumulant sequence. The power spectrum is member of the class of higher-order spectra. In statistical theory, one long-established approach to higher-order statistics, for univariate and multivariate distributions is through the use of cumulants and joint cumulants. In time series analysis, the extension of these is to higher order spectra, for example the bispectrum and trispectrum. Phonocardiographic signals are non-Gaussian, the bispectrum of phonocardiographic signals is used to characterize the abnormalities while detecting non-linearity or non-Gaussianity in order to improve the diagnostic performance. In the comparison of the diagonal slice of the bispectrum and the power spectrum of PCG signal, the results have shown that the HOS reveal the differences in heart sound analysis indicating non-Gaussianity or non-linearity [1-2]. To construct bispectra for separate segments of PCG such as sounds and murmurs we applied segmentation method based on averaged Shannon envelope.

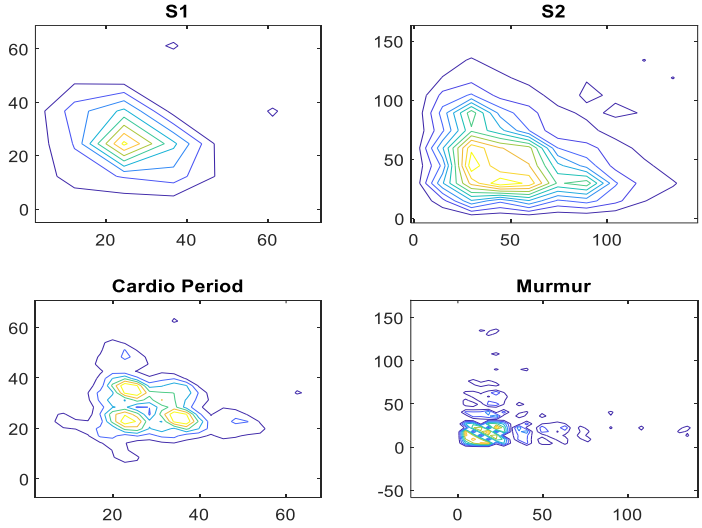

Figure 1 – Averaged bispectra of sounds, cardioperiod, murmur

We got bispectrums of sounds and murmurs for different signals: normal and pathological. It can be seen that bispectra are non-zero, so signals are non-Gaussian. There is phase coupling between each two frequencies for each bispectrum. And also, the patterns for bispectra for each person are different in all groups.

References:

1. Ahlstrom C, Liljefelt O, Hult P, Ask P Heart Sound Cancellation from Lung Sound Recordings using Recurrence Time Statistics and Nonlinear Prediction // IEEE Signal Processing Letters. – 2005. 12. – P. 812-815.

2. Павлов, С. В., Аврунін, О. Г., Злепко, С. М., Бодянський, Є. В., Колісник, П. Ф., Лисенко, О. М., Чайковський, І. А., Філатов, В. О. (2019). Інтелектуальні технології в медичній діагностиці, лікуванні та реабілітації: монографія. С. В. Павлов, О. Г. Аврунін (ред). Вінниця: ПП «ТД «Едельвейс і К».