APPLICATION OF HOS FOR HEART RATE VARIABILITY

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This work is devoted to calculation of higher order spectra (HOS) of ECG signals and comparing of results of standard spectral and statistical methods and HOS methods for heart rate variability (HRV) analysis. Heart rate variability (HRV) is a useful signal for understanding the status of the automatic nervous system.

Standard methods in signal processing are based on second-order statistics. HOS are based on averages over products of three or more samples of the signal, thus allowing nonlinear dependencies among multiple signal samples to be evaluated. Most random biosignals in practice are generally non-stationary in nature with nonlinear interaction between harmonic components of a signal. Different ways to use nonlinear methods for processing of biosignals were proposed [1]-[4].

HOS are defined to be spectral representations of high order of cumulants of a random process. The 2nd order cumulant spectrum is the power spectrum, and the 3rd cumulant spectrum is known as the bispectrum. The bispectrum is the 2D-Fourier transform of the 3rd cumulant function.

We analyzed ECG signals obtained from the MIT-BIH arrhythmia data base. Analyzing forms of bispectra we grouped the signals in 5 groups (fig.1). We concluded that results for HOS differ from results of standard methods. So, HOS analysis can be used as additional method for diagnostics of HRV.

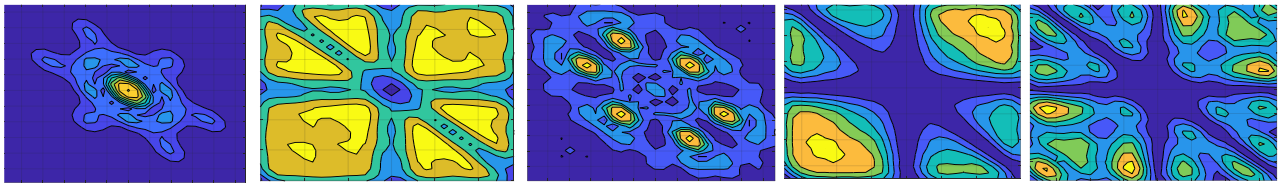

Fig.1 – Typical forms of bispectrum for HRV signals

References:

1. Топчий, В.С., Жемчужкина, Т.В., & Носова, Т.В. (2018). Статистический анализ показателей фазового портрета ЭМГ-сигнала с целью дифференцирования заболеваний опорно-двигательного аппарата. Міжвузівський збірник "Наукові нотатки", Луцьк, 64, С. 217-222.

2. Жемчужкіна, Т.В., Носова, Т.В. & Кощей, А.В. (2020) Оцінка ентропії для діагностики болю в попереку. Інформаційні технології: наука, техніка, технологія, освіта, здоров'я: тези доповідей XXVIII міжнародної науково-практичної конференції MicroCAD-2020, у 5 ч. Ч. II. Харків: НТУ «ХПІ», 341.

3. Жемчужкина, Т., & Носова, Т. (2021). О построении фазовых портретов фонокардиографических сигналов. Збірник наукових праць ΛΌГОΣ. https://doi.org/10.36074/logos-14.05.2021.v1.30.

4. Zhemchuzhkina, T.V., etc. (2019). Application of EMG-signal phase portraits for differentiation of musculoskeletal system diseases. Proc. SPIE 11176, Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments. https://doi.org/10.1117/12.2537338.