The Change-point Detection in Rhythmocardiosignal by Neyman-Pearson Criterion

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Abstract – **Rhythmocardiosignal (RCS) as the periodically correlated stochastic sequence is presented. Neyman-Pearson criterion was applied for the change-point detection in RCS.**

Keywords – **rhythmocardiosignal change-point, detection, periodically correlated stochastic sequence, the Neyman-Pearson criterion.**

INTRODUCTION

Organism adaptation to the environment causes the change of heart rate - that is cause of RCS change-point. Duration of this change-point is the important diagnostic parameter that shows the stress resistance of organism. [1]. Stochastic character of RCS change-point appearance requires construction of methods of its detection.

1. THE MATHEMATICAL MODEL OF RCS

The central and vegetative nervous systems provide permanent influence on the heart rhythm with adaptation purpose those cause the RCS nonstationarity with variation of the statistical characteristics in time. So we'll consider RCS as nonstationary periodically correlated stochastic sequence with mean $m_{\xi}(t) = m_{\xi}(t+T_K)$ and with correlation $r_{\xi}(t,s) = r_{\xi}(t+T_K, s+T_K)$, where T_K – correlation period.

When the change-point appears, we'll put that the model of RCS will be changed from periodically correlated to nonstationary in the instant of time τ:

$$\xi(t) = \eta(t) + \theta(t)\cdot\zeta(t), \quad \theta(t) = \begin{cases} 0, & 0 \le t < \tau \\ 1, & \tau \le t \le T_R \end{cases} \qquad (1)$$

where $\eta(t)$ – periodically correlated stochastic component; $\zeta(t)$– nonstationary RCS; θ– unknown parameter that denotes an appearance of RCS change-point (when $\theta=0$ (RCS is periodically correlated, event H_0), and when $\theta=1$ (RCS is nonstationary, event H_1)); τ – RCS change-point occurrence; T_R – observation period.

2. THE RCS CHANGE-POINT DETECTION METHOD

The decision-making about change-point in RCS is based on the statistical criterion of Neyman-Pearson that provides maximum probability of correct RCS change-point detection with specified probability of false RCS change-point detection p_f [2]. According to this criterion value of threshold h picks from the specified probability of false detection

$$L = \frac{W_1(q)}{W_0(q)} = \frac{\exp\left\{-\frac{1}{N}\int_0^T [\xi(t)-\zeta(t)]^2 dt\right\}}{\exp\left\{-\frac{1}{N}\int_0^T \xi^2(t)dt\right\}} \underset{H_0}{\overset{H_1}{\gtrless}} h \qquad (2)$$

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where, $W_1(q)$ – the distribution function of spectral components values of nonstationary RCS, $W_0(q)$– the distribution function of spectral components values of periodically correlated RCS, N – the power spectral density of spectral components of periodically correlated RCS. The spectral components were obtained by coherent method.

The decision about the RCS change-point makes whereas the relation L exceeds the threshold h.

$$h = \sqrt{D_0}\,\Phi^{-1}(1-p_f) + m_0 \qquad (3)$$

where $\Phi(\bullet)$ – probability integral; h – threshold, which determined by the power spectral density of periodically correlated RCS.

Resolved decision about change-point in RCS is represented by information about parameter $\theta=1$, fig.1, with different probabilities of false RCS change-point detection p_f.

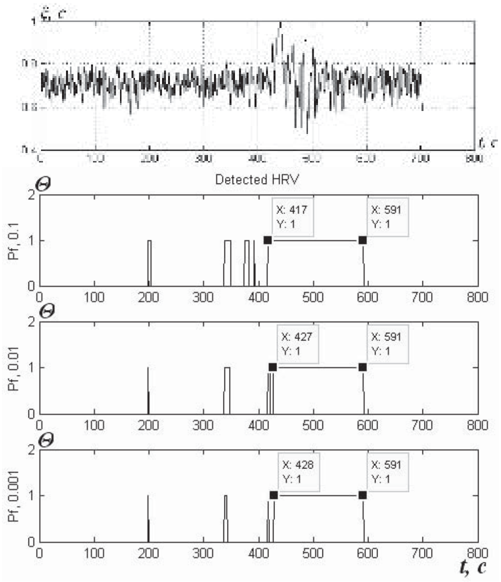

Fig. 1 Result of RCS change-point detection

CONCLUSION

The developed method were certified with test RCS. It was also received the assessment of its confidence of RCS change-point detection by applying of coherent method to obtain the spectral components. The application of others methods to obtain spectral components requires further researches.

REFERENCES

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