MATHEMATICAL METHODS AND INTELLIGENT COMPUTER TOOLS FOR ANALYSIS AND INTERPRETATION OF CYCLICAL SIGNALS IN DIGITAL MEDICINE

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ABSTRACT

Fundamental and applied research in engineering, biology, economics and other areas are often associated with the analysis of observed processes that are repetitive in time. Such processes generate specific signals, which are usually called cyclic in the scientific literature. Typical examples of cyclic signals are electrocardiograms, rheograms, photoplethysmograms and other biomedical signals reflecting to the cyclic nature of the work of the circulatory and respiratory systems of a living organism.

The report develops efficient mathematical methods, original computational procedures and intelligent computer tools that provide processing of cyclic signals for preventive and clinical medicine.

Proposed approaches are based on a stochastic model of generating a cyclic process according to a reference pattern that has diagnostic value which by action of internal and external disturbances is distorted from cycle to cycle. As a result of such distortions, informative fragments that characterize the regular features of the process under study can be hidden from the researcher.

The proposed mathematical methods and intelligent computer procedures are aimed at solving two problems:

1. Restoration of the form of the reference pattern of the studied cyclic process hidden by perturbations, which has diagnostic value;

2. An assessment of the dynamics of changes in the parameters characterizing the form of informative fragments from cycle to cycle.

To solve the first problem, an original computational algorithm is proposed based on the transition from a scalar signal (a discrete time sequence of the process under study) to its display on the phase plane, followed by averaging based on the Hausdorff metric.

To estimate the dynamics of the parameters characterizing the form of informative fragments of the process under study from cycle to cycle, original computational algorithms are proposed, which are based on the construction of the convex hull of the phase portrait of the permutation entropy and calculation of the Levenshtein distance.

On the basis of the proposed approach, original preventive medicine tools for home use have been developed.