APPLICATION OF THE ARTIFICIAL INTELLIGENCE ALGORITHMS WITH A COGNITIVE GRAPHIC AS A TOOL FOR A SYSTEM ANALYSIS OF ELECTROPHYSIOLOGICAL PROCESSES

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Abstract: Summarizing the accumulated experience for a long time in the polyparametric cognitive modeling of different physiological processes (electrocardiogram, electroencephalogram, electroreovasogram and others) and the development on this basis some diagnostics methods give ground for formulating a new methodology of the system analysis in biology. The gist of the methodology consists of parametrization of fractals of electrophysiological processes, matrix description of functional state of an object with a unified set of parameters, construction of the polyparametric cognitive geometric model with artificial intelligence algorithms. The geometry model enables to display the parameter relationships are adequate to requirements of the system approach. The objective character of the elements of the models and high degree of formalization which facilitate the use of the mathematical methods are advantages of these models. At the same time the geometric images are easily interpreted in physiological and clinical terms. The polyparametric modeling is an object oriented tool possessed advances functional facilities and some principal features.

Introduction

It is known, the existent methods of analysis of electrophysiological processes give little information about early dysfunctions and development of a principally new approach to an analysis of complicate oscillation processes is an actual task [Fedotchev and others.2003]. To decide this task the most perspective approach is a system approach with the use intelligence tools [Pospelov D.A., 1982; Zenkin A.A., 1991; Gorodeckiy V.I.,2002; Workshop on Autonomous Intelligent Systems,2007]. In this aspect the description of analog processes and their analysis are considered as a cell of classification and decision-making with management elements [Fominach 1998; Yachno and others, 2004].

Case-Based Reasoning

From our point of view the relationships of parameters of system have a more significant expression because they are determined in geometric model as the information connections [Dmitrieva N.V., 1990, 2005].WE have to say that the class such phenomena as information connections of physiological processes can not be observed by modern means of physiological experiments. The decision way consists of a polyparametric cognitive modeling of oscillation processes. On this methodological basis we have developed earlier some cognitive models for system analysis of electrocardiogram, electroencephalogram, electroreovasogram and also of functional state of the whole organism for medical diagnostics [Dmitrieva N.V., 1990,2003, 2005]. Such diagnostics have deal with a multitude of parameters of a system and it is polyparametric diagnostics. There are some summaries of the accumulated experience in development of cognitive models for the system analysis of electrophysiological processes.

Short description of a general structure algorithm of intelligence models for system analysis of electrophysiological processes.

The principal structure and function of cognitive models of different electrophysiological processes are unified therefore it is rational considering it as a general structure. For a model construction it is used a set of amplitude and time parameters of electrophysiological processes, which are equidimensional but have different scale. Similarity and nesting of parameters are observed in all electrophysiological systems. The objective parameters are only used in the absolute value, the models of separate electrophysiological processes are constructed on a different scale. This generates model variations, which are some set of models having a unified algorithm of the structure of an artificial intelligence system. Quality difference of such models consists not only of there scale but also of forming of a standard ("ideal") functional state of physiological system which is served for a relative estimation of real processes. For the construction of such a standard there are used parameter modes of every electrophysiological system (ECG, EEG, and others) and maximal and minimal values of parameters without pathognomonic meaning. The structure of model is very simple: parameter values (Mo, maximal and minimal) of individual oscillation processes are represented in two-axis system. Every leg has its own dimension. The totality of parameters is enclosed in the counter of right triangle. The legs of a triangle are vectors of time and amplitude parameters.

Thus it is created a range of parameter changing which have not meaning for clinic but have significance for an evaluation of functional state of physiological system and organism as a whole. The general counter limited maximal and minimal values (external and internal triangle counters) is an intelligence transformer, its work is based on a structure-algorithm of artificial intelligence system. The transformer makes permanent analysis of a character of behavior in the absolute values and classification (for example transfer of a patient in clinical diagnosis). The result is a visualized pattern and quantitative expression of intersystem connection of parameters, which are defined by geometry and symmetry of the model structure. Absolute values of a person's health are inter square limited by external and internal triangles, i.e. in significant range, as at the same time the relationships of parameters are rested near the invariant value [Dmitrieva N.V., 2004].

Summarizing the accumulated experience in the polyparametric cognitive modeling of different physiological processes (electrocardiogram, electroencephalogram, electroreovasogram and others) and developing on this basis of some diagnostic methods (9 patents in Russia) led us to formulating a methodology of polyparametric cognitive modeling. The gist of the methodology is in marking of fractals of electrophysiological processes, the paramerization of its, description of functional state of an object with a unified set of parameters; construction of the cognitive geometric model of fractal with artificial intelligence system algorithms, using of methods of image recognitions for the analysis of multi-dimension data. Such models present the instrument to analyze multidimensional data, performing knowledge engineering and data mining. The geometry model enables displaying relationships adequacy to require of the system approach. Principal singularities of this methodology: full objective elements of models (physical values of parameters); strict geometry structure of model high degree of formalization easing use of mathematical methods. At the same time the geometric images are easy interpreted in physiological and clinical terms making this model preferable [17, 18].

As an examples the polyparametric analysis of ECG and EEG on a basis of polyparametric cognitive modeling are presented.

The polyparametric intelligence model of electrocardiogram **(ECG)** (fig,1) is intended for a system analysis and preclinical diagnostics of early cardiodysfuntions. Elements of the model are commonly accepted amplitude and time parameters of ECG-cycle such as P, T, R, QRS, QT, RR, which are represented in two-axis system Methods of projective geometry and general principles of symmetry are used to define relationships between elements of the model (know-how of the method). The model gives possibility to get meaningful and useful relationships of parameters, which are new diagnostics signs, classify multidimensional data, and to interpret data in commonly used clinical and physiological terms. The model was implemented in a software package.

The model makes it possible to forecast preclinical changes in heart activity. The model was verified in clinical study with participation of 101 volunteers. Simultaneously independent diagnostics of cardiovascular system of the volunteers were performed by using clinical physiological analysis of ECG in 12 deviations [Dmitrieva, 1989]. This method of system analysis of ECG can be particularly useful for preventive medicine.

Short description of cognitive model of system analysis of rhythms of a human electroencephalogram.

Elements of model are commonly accepted amplitude and time parameters of a human electroencephalogram according to recommendation of the International Federation of Encephalography and Clinical Neurophysiology [1984]. Amplitude and time parameters are presented on legs of two right triangulates presenting left and right cerebral hemispheres.

The totality of parameters of the whole brain are enclosed in counter of isosceles triangle with superposition of legs of the right triangles. Hypotenuses of every triangles are commonly accepted in clinic indexes of rhythms of each hemisphere expressed in per cent for 10 sec epoch. Each hemisphere has its own intelligence transformer of system realizing algorithm of functions of model and making classification. Relationships between elements of the model are defined with projective geometry and general principles of symmetry (know-how of the method). For standard model ("ideal functional state) and for health people these relationships are invariant (W≈1.309).

This visualized model presents the strict characteristic of electrical processes and gives possibility to the following math development and at the same time it may be very easily interpreted in clinical- physiological terms.

Discussion

Evidently electrophysiological processes possess a fractal auto organization by principals of scale-invariant similarity and proportion of parameters is an order of ones. On the basis of such model the totality of bioelectrical generators can be rationality presented as a level-based model of hierarchy systems of connected nonlinear endogen electrical generators with different frequency of order presented in evolutionary coordinated code. It is new knowledge allowing presenting of a set of oscillation processes as a unified complicated system.
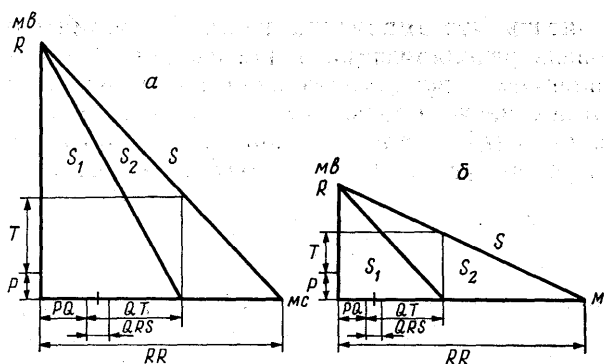

Fig.1.
The model of ECG of the health people (a)
and patient with the hypertonic diseases (b).
(R, T, P- amplitude, QRS, PQ, QT, time parameters,
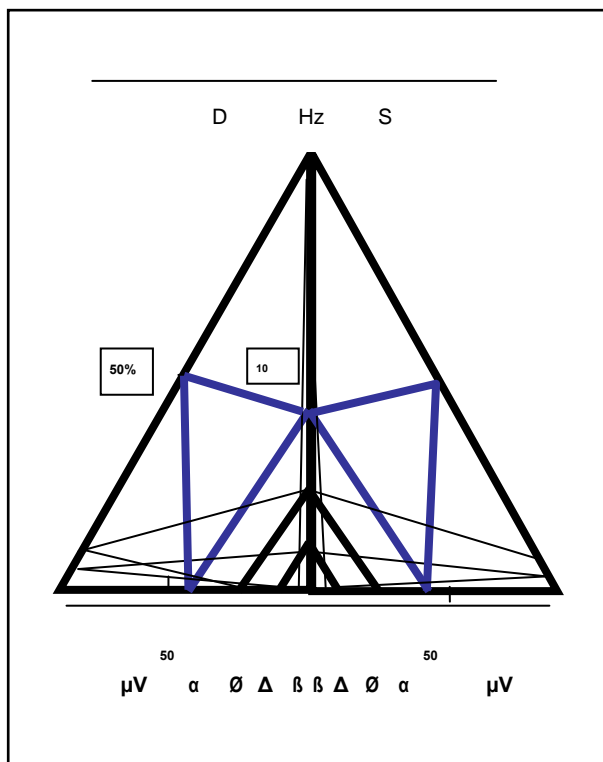S_1 and S_2 _Systolic and Diastolic parts of cardio circle).

Fig. 2 The model of a structure of rhythms of EEG.
(S- left hemisphere, D-right hemisphere of brain.
Method of construction is in the text.).

Development of the theory of informatics for the last years drew the attention researchers of living systems to comprehension of code connections of elements of systems [System. Harmony. Symmetry. 1988]. The special interest in research of regularity of code relationships in different systems presents a conception computer' cognitive graphic based on general principals of symmetry and methodology of artificial intelligence systems [Zenkin A.A., 1991]. Interpretation of our results on the basis of symmetry allows characterizing the maintenance of object on the whole and its changes, i.e. optimality and functional (code) balance of object [System. Harmony. Symmetry.1988]. Without doubt it is shown on a principal basis of functional order as a time organization of physiological processes.

Uniform schemes of description of patterns are open possibilities for using of an algebraically approach to their analysis [Gurevich and others, 1999], which is perspective for supporting diagnostics decisions.

Conclusion

The new polyparametric methodology for a system analysis of electrophysiological processes by modelling ones with application of artificial intelligence algorithms with general principals of geometry and symmetry is proposed. The polyparametric models possess system attribute, data mining and knowledge discovery exhibiting information connection between parameters of processes as elements of physiological systems. Models offered composition, classification properties, characterizing quality and quantity as the whole object as parts one.

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