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APPLICATION OF THE ARTIFICIAL INTELLIGENCE ALGORITHMS FOR SYSTEM ANALYSIS OF MULTI DIMENSION PHYSIOLOGICAL DATA FOR DEVELOPING POLYPARAMETRIC INFORMATION SYSTEM OF PUBLIC HEALTH DIAGNOSTICS

Nina Dmitrieva, Oleg Glazachev

Abstract: The polyparametric intelligence information system for diagnostics human functional state in medicine and public health is developed. The essence of the system consists in polyparametric describing of human functional state with the unified set of physiological parameters and using the polyparametric cognitive model developed as the tool for a system analysis of multitude data and diagnostics of a human functional state. The model is developed on the basis of general principles geometry and symmetry by algorithms of artificial intelligence systems. The architecture of the system is represented. The model allows analyzing traditional signs - absolute values of electrophysiological parameters and new signs generated by the model – relationships of ones. The classification of physiological multidimensional data is made with a transformer of the model. The results are presented to a physician in a form of visual graph – a pattern individual functional state. This graph allows performing clinical syndrome analysis. A level of human functional state is defined in the case of the developed standard ("ideal") functional state. The complete formalization of results makes it possible to accumulate physiological data and to analyze them by mathematics methods.

ACM Classification Keywords: J.3 Life and Medical Sciences: Health. Medical information systems. I.3.5 Computational Geometry and Object Modeling. I.5.1 Models Geometric.

Introduction

One of problems of the contemporary preventive medicine is the development of an informational system of health diagnostics, which could enable to conduct a system analysis of multitude data, while could be comparable with existing clinical functional diagnostics and corresponding to the modern requirements to medical information systems [Hummel et al. 2000]. The experience obtained by us through the use of the visualized patterns and graphic modeling of functional states of an organism under activity of physiological substances [Dmitrieva et al. 1982] created the basis for development of the polyparametric method for evaluation of a human functional state in terms of the pattern recognition theory [Dmitrieva et al. 1989]. Patient data are presented in graphical formats as visual patterns, which permit to interpret these data in clinical-physiological terms. According to the recommendations of the Word Health Organization we have conducted the comparative research of a health state of students by polyparametric and clinical physiological methods [Dmitrieva, Glazachev, 2000]. These results demonstrated advantages and disadvantages of polyparametric method and lead us to development of new model on the basis of an artificial intelligence algorithms to improve one [Pospelov,1992; Zenkin, 1991].

Case-Based Reasoning

The gist of the polyparametric method for diagnostics of a human functional state consists in polygraphic recording (0.5 minutes) and data processing of objective physiological characteristics (electrocardiogram, electromiogram, electrovasogram and others), parameterization of analog signals, polyparametric description of a functional state with the unified set of the time - amplitude parameters, using artificial intelligence algorithms and graphical modeling and methods of pattern recognition for an analysis of multi dimension data on line mode. Necessity and sufficiency of the set of parameters for a description of functional state have been grounded earlier. The novelty of the new variant of the polyparametric method contains in the original polyparametric cognitive model presenting the intelligence image system as the tool for the system analysis of multi dimension data.

The Intelligence Image model. Absolute values of the unified set of physiological parameters mentioned above are represented as vectors in the system of polar coordinate (Fig.1). Each parameter has its own scale determined by modal level (middle circle). The contour limited with external and internal circumferences (maximal and minimal values of the parameters without pathognomonic signs) is the intelligence transformer performing analysis and classification of every parameter and whole shape, for example nosologic diagnosis. The active part of the intelligence transformer provides relationships of parameters as additional new signs generating new knowledge about a subject.

The changes of sympathetic or parasympathetic regulation are reflected in a displacement of a pattern (dotted circumference on fig.1) to the left and to the right correspondingly.

The model of "ideal functional state" is characterized by the invariant relationships of all parameters (fig.2, left top). This model and patterns of individual functional states are constructed on the basis of the general intelligence model.

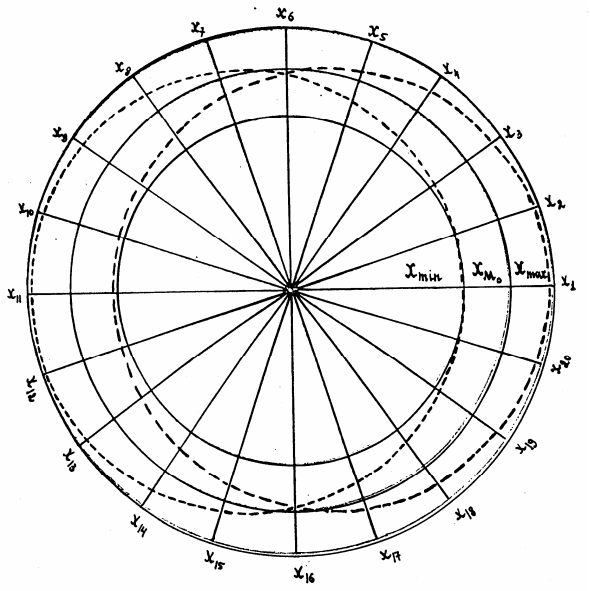

Fig.1. Artificial intelligence image model for analysis of physiological sings.
(Vectors X_1 – X_{20} are physiological parameters;
the method of construction is described in the text).

The results of the polyparametric examination are presented to physician in tabular form and as a pattern of functional state. On fig.2 there are 4 protocols of polyparametric examination patients with different functional sate: the first column is the list of physiological parameters and theirs values (in physical dimensions), the second column represents the relationships of parameters giving as the values of deviation (percents) from the invariant, visual graph (the pattern) of individual functional state enables performing clinical analysis of multiple data in interactive mode.

The polyparametric method allows evaluating level of a functional state in on-line mode during 3-5 minutes.The main characteristic of satisfactory state class is relationships of parameters closed to invariant: deviation is less than 5-7% whereas the absolute values of parameters can be in wide range between maximal and minimal rings. Thus the pattern of satisfactory functional state has a round form or similar to it. The deeper the adaptation syndrome the greater the misbalance of parameters is become. The pattern state assumes an irregular form of a different kind (Fig.2). It means that parameter relationships of the vital physiological functions are supplementary

diagnostics signs of changes of human functional states. This is the new knowledge about information connections of physiological functions.

The state patterns are classified on decision rules in the PC programs and graded into four classes according to the main stages of adaptation processes development The results of the polyparametric examination according to the classes of functional state were controlled by criterion χ^2 (by program "S-Plus 2000 professional") and discriminative analysis (table 1).

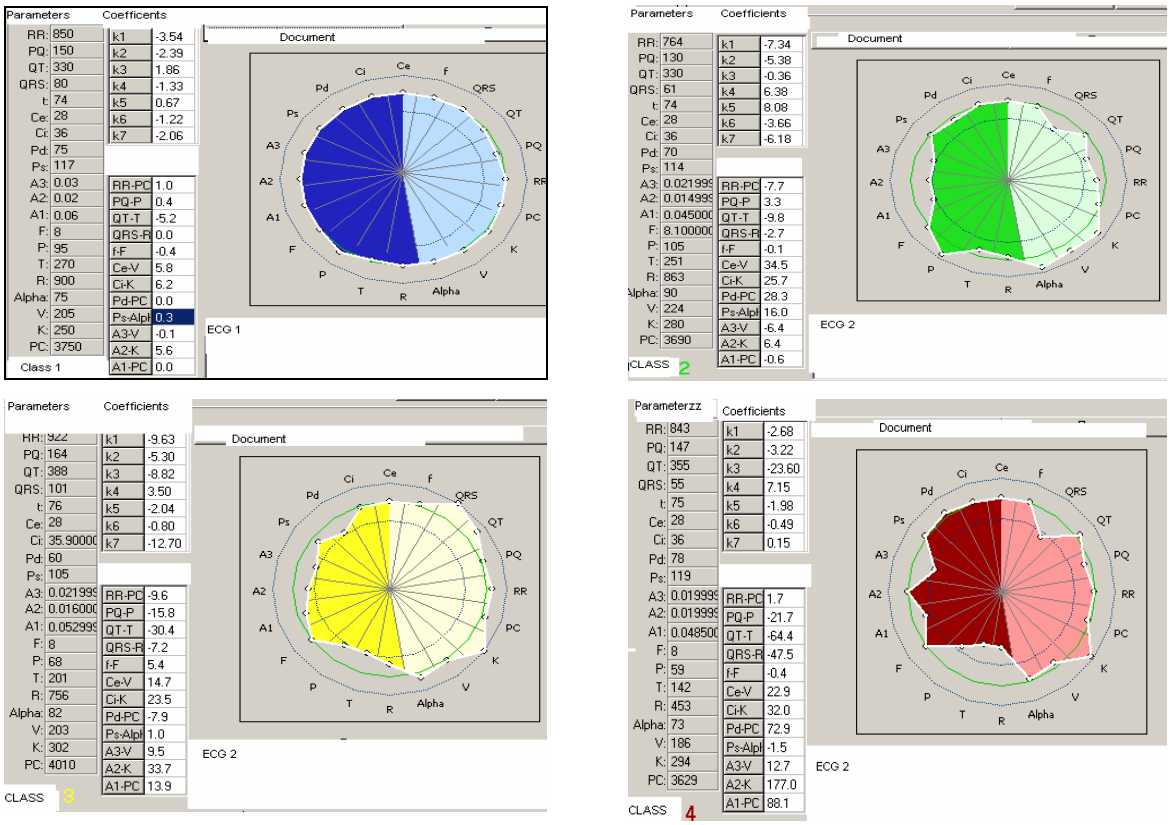

Fig.2. Patterns of different functional states. (1– satisfactory functional state, 2 – strained functional state, 3 – overstrained functional state, 4 – stress. Description of structure is in text)

Table1. Differences between functional classes by criterion χ^2 (by program "S-Plus 2000 professional")

Classes	4-1	4-2	4-3	3-1	3-2	2-1
Criteria	113.6	82.5	33.95	44.86	26.35	97.2
Mean	0.001	0.001	0.0034	0.001	0.034	0.009

Thus, with χ^2 criterions the main stages of adaptation process have objective differences between classes of functional states.

The discriminative analysis of the polyparametric data has confirmed their subdivision into 4 prescribed classes of functional states with satisfactory differences (under 9%).

As using parameters allow characterizing the autonomic regulation, the patterns of functional states can be considered as syndrome of autonomic status [Veyn, 1998]. For a definition of autonomic regulation every time parameter in the pattern marked with light color and amplitude parameters are darkened. This gives possibility for a physician to definite autonomic status ease and quickly [Dmitrieva, 1999].

Special investigations were found out significant individual differences of the patterns. The results of statistical analysis (mean values, mode, standard deviation and coefficient of variation) of polyparametric data demonstrated highly variable of some parameters for different people. It means the number of combinations of the changed signs can be high. The research of individual variations revealed that they can be satisfactorily systematized into major classes of states in respect of the standard model.

In support of that the polyparametric data were analyzed with the cluster method by the strategy of Word. On the Fig.3 the results of cluster analysis of polyparametric documents (on left) and statistic refined data (on right) are represented.

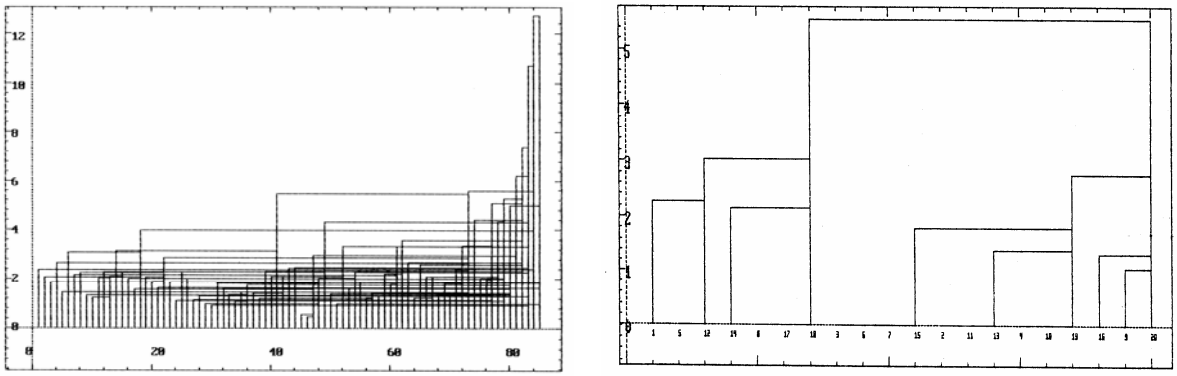

Fig3. Cluster analysis of documents of polyparametric examinations of students (axis X –individual documents, axis Y –cluster ranges).

There were singled out three main and four added clusters. The interpretation of clusters was performed by the visual analysis of individual documents. It was found out that same people examined in different time formed same clusters. Thus there were demonstrated that some syndromes are stable because of their patterns are fluctuated close to errors of a measure of parameters (± 7-8 %). Thus the reproducibility of derived parameters and their relationships has been confirmed. It was shown that a high formalization of the obtained results of the polyparametric examination makes to do systematization and mathematical analysis of multidimensional physiological data.

The patterns of typical adaptation syndromes were selected for using in the information support of physician decisions in diagnostics of a person adaptation syndrome [Seley H. 1976]. These patterns were fixed in phase 2 (Fig.4) to use them as the conceptual models of different adaptation syndromes for comparative analysis of newcomer patterns. The gist of this procedure is “data mining”. The scheme of DATA MINING of polyparametric technology is represented on fig.4.

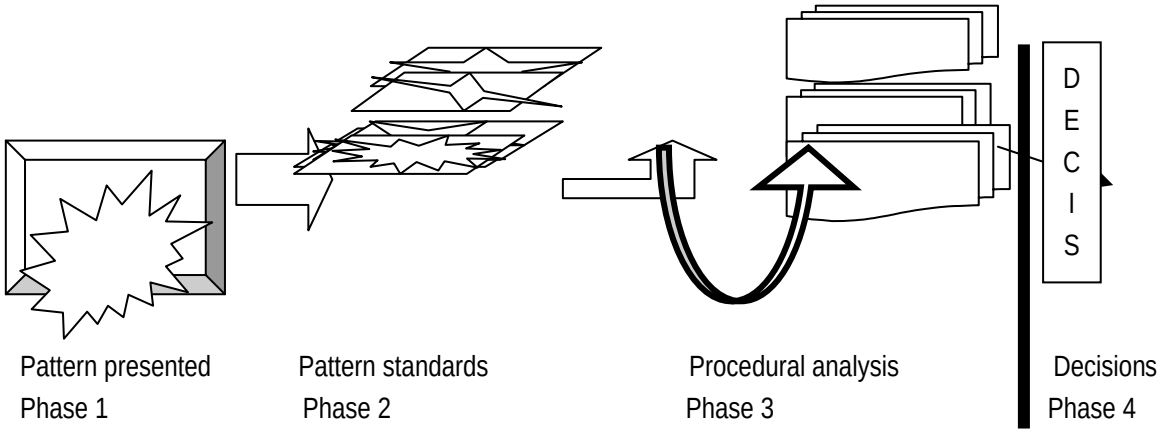

Fig.4. The scheme of polyparametric technology of diagnostics of multitude human functional states.

The phase 3 of the technology is intended for a predictable decision by using the known rules of procedure “if S then A” [Newell, Simon, 1972]. It is easy to see changes of any pattern and to interpret a dynamic of a functional state using these rules working with the model.

But the obtained results do not allow making a definite conclusion about exact role of concrete signs in the forming of pattern.

The polyparametric method and technology are open for further development and improvement based on the bank-accumulated data of polyparametric examinations and evaluations of a functional state under therapeutics and correction mode.

Application of the polyparametric method in condition of the comparative analysis of the results of examination of students with the clinical methods was conducted. The findings demonstrated that 44% of students during their term are in a state of overstrain and 40% in adaptation failure according to the classification of stages of adaptation development processes. Thus the comparative analysis showed the good correlation and correspondence.

Conclusion

The information intelligence image polyparametric system represents the instrument to analyze multidimensional data, performing knowledge engineering and data mining. It allows very quickly define level of a human functional state relatively to the developed standard of functional state. The image of functional state is very easy for interpretation. Complete formalization of the polyparametric results makes it possible to accumulate data and analyze them by math methods. This tool allows determining and evaluating relationships of electrophysiological parameters, which became a new diagnostics signs. The conceptual model of standard (“ideal”) functional state was formed. This model allows to circumvent the indefinite notions of “norm” and “ordinary man” and work out the technique for measurement of various deviations from the ”ideal functional state” as changes of the functional state.

Today the first experimental model of computer polyparametric system is installed in the Moscow State University, where the health of students has been examined for some years. The polyparametric method is open for further development of the preclinical diagnostics of functional disorders on the “training-with-a teacher” basis.

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