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Mental Disorder Diagnostic System Based on Logical-Combinatorial Methods of Pattern Recognition *

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Abstract

The authors describe mental disorder diagnostic system based on logical-combinatorial methods of pattern recognition called as the intelligent system DIAPROD-LOG. The system is designed for diagnostics and prevention of depression. The mathematical apparatus for creation of the proposed system based on a matrix model of data and knowledge representation, as well as various kinds of regularities in data and knowledge are presented. The description of the system is given.

Keywords: intelligent system, logical-combinatorial methods of pattern recognition, diagnostic tests, intelligent instrumental software IMSLOG, depression.

1 Introduction

Creation of intelligent systems (ISs) for various semistructured areas, such as medicine, psychology, geology, etc. and development of algorithms underlying this ISs is very relevant [1, 2]. Mathematical apparatus of a number of ISs for above-mentioned problem areas is based on logical-combinatorial methods of test pattern recognition [2-4]. Currently, investigation in practical public health, viz. revealing mental and behavioral disorders is very important. However, the problem of

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ISs creation for revealing regularities of various kinds, high quality and timely diagnostic and prevention of these disorders is still open. Unlike created intelligent systems [5, 6] for revealing mental and behavioral disorders in an inspected person which are based on a small number of scales and / or questionnaires, in our proposed mental disorders diagnostic system a diagnostic criteria of the international classification of diseases, tenth revision (ICD-10) [7] and 8 clinical-psychological scales and questionnaires [8-15] are used.

In Laboratory of Intelligent Systems at Tomsk State University of Architecture and Building by chief A.E. Yankovskaya have been developed ISs for revealing regularities and diagnostic and organizational-management decision-making, for example IS for revealing social-psychological factors in communicative stress conditions in learning process [16]; the IS DIOS [17] designed for express-diagnostics and intervention (correction) of organizational stress and the IS DIAPROD [18] designed for express-diagnostics and prevention of depression.

Unlike the IS express-diagnostics DIAPROD [18] using threshold and fuzzy logic for decision-making, the IS "Intelligent Decision Support System for Depression Diagnosis Based on Neuro-Fuzzy-CBR Hybrid" [5] using neural networks and fuzzy logic and the IS "Beck Depression Inventory Test Assessment Using Fuzzy Inference System" [6] using fuzzy logic, the proposed further IS DIAPROD-LOG is based on logical-combinatorial methods of test pattern recognition.

2 Basis of mathematical apparatus of creation of intelligent system DIAPROD-LOG

The mathematical apparatus of the IS DIAPROD-LOG is based on logical-combinatorial methods of test pattern recognition [3, 4]. For the data and knowledge representation in the IS DIAPROD-LOG a matrix model [4] is used.

The model includes an integer description matrix ($\mathbf{Q}$) that describes objects in the space of characteristic features $z_1, z_2, \ldots, z_m$ and an integer distinction matrix ($\mathbf{R}$) that partitions objects into equivalence

classes for each classification mechanism. A dash ("–") in the element of the matrix **Q** shows that the value of the feature is not significant to the object. We give the interval of values for each feature z_j ($j \in \{1, 2, \ldots, m\}$).

We mean under the pattern a subset of objects of knowledge base with matching values classification features.

A diagnostic test (DT) [4] is a set of features that distinguishes any pair of objects that belongs to different patterns.

A diagnostic test is called "irredundant" (dead-end [3]) if it includes an irredundant amount of features.

An irredundant unconditional diagnostic test (IUDT) is characterized by simultaneous presentation of all features of the object under investigation included in test, while decision-making.

Regularities [4] are 1) subsets of features with particular, easy-to-interpret properties that influence on the distinguishability of objects from different patterns that are stably observed for objects from the learning sample and are manifested in other objects of the same nature; 2) weight coefficients of features that characterize their individual contribution [19] to the distinguishability of objects and 3) the information weight given, unlike [20], on the subset of tests used for a final decision-making. The regularities can include constant (taking the same value for all patterns), stable (constant inside a pattern, but non-constant), non-informative (not distinguishing any pair of objects), alternative (in the sense of their inclusion in DT), dependent (in the sense of the inclusion of subsets of distinguishable pairs of objects), unessential (not included in any irredundant DT), obligatory (included in all irredundant DT), pseudo-obligatory (which are not obligatory, but included in all IUDT involved in decision-making) features and signal features, as well as all minimal and all (or part, for a large feature space) irredundant distinguishing subsets of features that are essentially minimal and irredundant DTs, respectively and tolerant to measurement (entry) errors IUDTs [21]. The weight coefficients of characteristic features calculated by different algorithms are also included in regularities [4].

There is no doubt that wider range of regularities considered provide a higher degree of accuracy while diagnostic decision-making.

We use a procedure for constructing the irredundant implication matrix ($\mathbf{U}'$) [4, 21] for revealing various kinds of regularities at construction of IUDTs.

The matrix $\mathbf{U}'$ is an integer matrix. The matrix $\mathbf{U}'$ defines distinguishability objects from different patterns (classes for each mechanism classification).

The regularities of various kinds are revealed on the matrix $\mathbf{U}'$ in order to reduce the feature space, determine the most important features. Also, all irredundant column coverings of the matrix $\mathbf{U}'$ [4, 21], defining essentially all IUDTs are determined with the use of logical-combinatorial algorithms. Then the choice of optimal subset of features is fulfilled. On the base of this subset ultimately the final decision-making is fulfilled.

3 Description of intelligent system DIAPROD-LOG

The intelligent system DIAPROD-LOG is included into the web–based complex of intelligent systems for psychological health prevention (http://psyhealth.tsuab.ru). The web–based complex is equipped with a Russian-language interface. The developed intelligent system DIAPROD-LOG is distributed. The first part of the system is designed for data collection and data and knowledge storage. This part is implemented as a web-application with the use of C#. For the purpose of data storage in the IS DIAPROD-LOG the relational database management system MySQL was chosen, since it has great flexibility, rich functionality and is free of charge.

An inspected person is offered to be tested with 8 questionnaires and scales: questionnaire A. Beck [8] including 21 features; Edinburgh post-partum depression scale [9] including 10 features; multivariate Freiburg personality inventory (FPI-B) [10] including 114 features; Tomsk questionnaire rigidity of G.V. Zalewski (TQRZ) [11] including 150 features; questionnaire of relationship of pregnant by I.V. Dobryakov [12] including 9 features; questionnaire about ways of coping R. Lazarus [13]

including 50 features; questionnaire symptom levels [14] including 90 features; questionnaire of determining the stress and social adaptation of Holmes and Rage [15] including 43 features.

Example of the survey of the IS DIAPROD-LOG is shown in fig. 1.

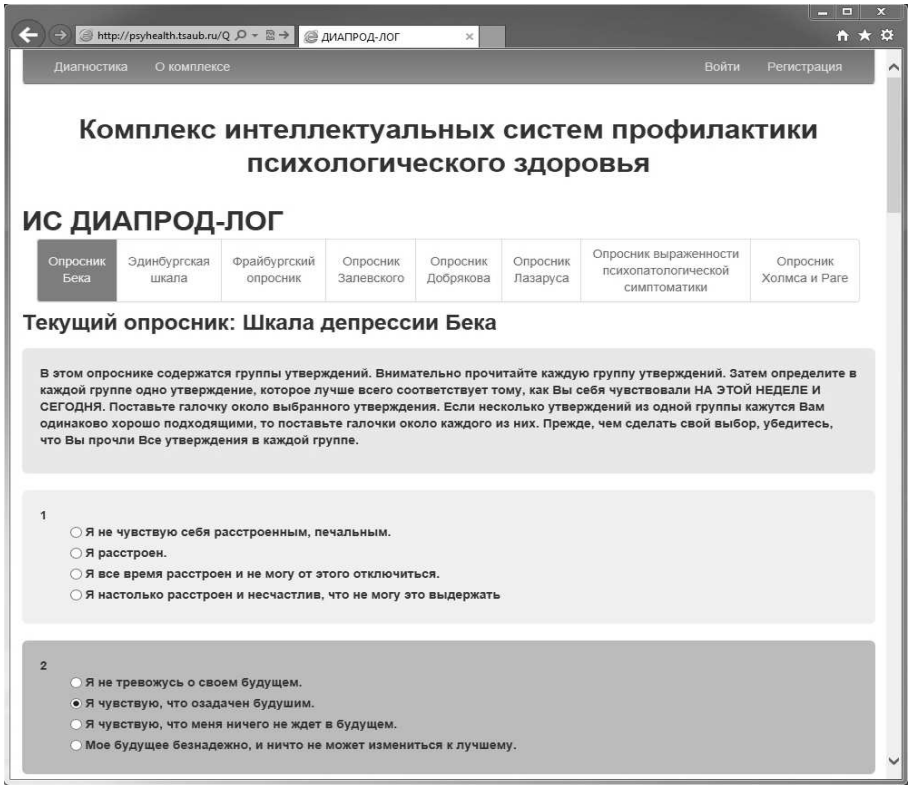

Figure 1. The survey of the IS DIAPROD-LOG

Since the inspected person confirms correctness of the entered answers, the test results are stored in the data and knowledge base.

The second part of a system designed to create matrices $\mathbf{Q}$ and $\mathbf{R}$, to construct matrix $\mathbf{U}'$, revealing different kinds of regularities, to construct diagnostic tests, decision-making and justification of decisions, is implemented as a template of intelligent instrumental software

(IIS) IMSLOG [22] including dynamically plug-ins. The template of the intelligent system DIAPROD-LOG is given in fig. 2.

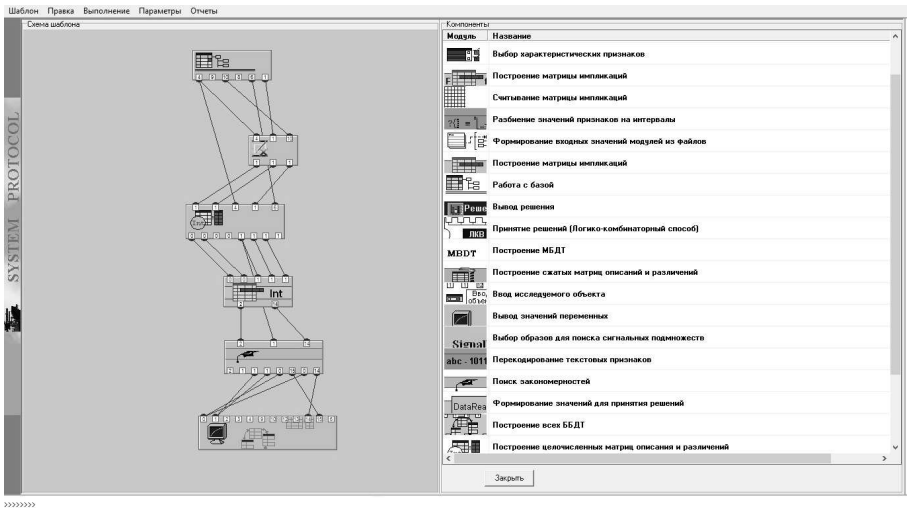

Figure 2. The template of the intelligent system DIAPROD-LOG.

The IIS IMSLOG has a module designed for data and knowledge base operation. Structure of data and knowledge base and objects of knowledge base are the input data for the module. Future selection of the necessary features for including in matrices **Q** and **R** is produced. The IS DIAPROD-LOG has characteristic features space including 28 features of the questionnaire A. Beck; the test result on Edinburgh postpartum depression scale; the test result on FPI-B; the test result on TQRZ; the test result on questionnaire of relationship of pregnant by I.V. Dobryakov; the test result on questionnaire about ways of coping R. Lazarus; the test result on questionnaire symptom levels; the test result on questionnaire of determining the stress and social adaptation of Holmes and Rage. The test results (characteristic features values) are stored in the data and knowledge base as well as classifications features values filled based on ICD-10 and highly qualified experts' knowledge in the considered problem area.

Also the IIS IMSLOG has a module designed for realizing construction of matrix $\mathbf{U}'$ using matrices $\mathbf{Q}$ and $\mathbf{R}$ with simultaneous calculating weight coefficients of characteristic features, similar to the algorithm described in [19]. In this case, the condition of tolerance to a preassigned number of measurement (entry) errors of characteristic feature values of the objects under investigation described in [19] is not implemented in this module. Then in the next module the above mentioned regularities are revealed on the basis of the matrix $\mathbf{U}'$. The next module is the construction of all irredundant column coverings of matrix $\mathbf{U}'$, defining in fact all IUDTs.

The last module fulfills the final decision-making on the diagnostic and prevention of depression in an inspected person based on voting procedure [4] on the set of tests and approaches.

4 Conclusion

The basis of the mathematical apparatus of creating intelligent system DIAPROD-LOG based on the logical-combinatorial methods of test pattern recognition, revealing various kinds of regularities, decision-making and justification decisions are suggested. The description of this system is given.

Application of the developed IS DIAPROD-LOG will allow in time diagnosing depression, making preventive decision, as well as forming the diagnostic and preventive results.

Further investigations are devoted to the intelligent system DIAPROD-LOG approbation.

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