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THE PARAMETRICAL COGNITIVE MODELS BLOCK FOR THE ANALYSIS OF THE EFFICIENCY OF INFORMATION EXCHANGE IN THE ADAPTIVE ENVIRONMENT OF THE AUTOMATED TRAINING

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The parametrical cognitive models block is the informational basis of the system analysis, contains the cognitive models of the subject and means of training, each from which acts as the repertoire of parameters, echeloned on a row of portraits and stratified on the several independent sets located on the two levels of the allocated hierarchy. The system analysis of the information-educational environments initiates the need of to taking into account of a wide spectrum of the different scientific fundamental and applied directions of modern science, and also causes the need of use of the innovative apparatus of research.

pic. 10. Bibliogr. 10 names.

Keywords: *the information-educational environment; the cognitive model; the automated training system; the cognitive modeling technology.*

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The introduction and statement of the problem of the system analysis of the information-educational environments

The processes of informatization of the different subject areas and the globalization of the information environment of consumption of the diverse information have a significant influence on the creation, introduction and use of information resources, products and services, and the modern level of development of the information and communication technologies allows to carry out the program realization of the adaptive systems and means of training of a new generation [1, 5].

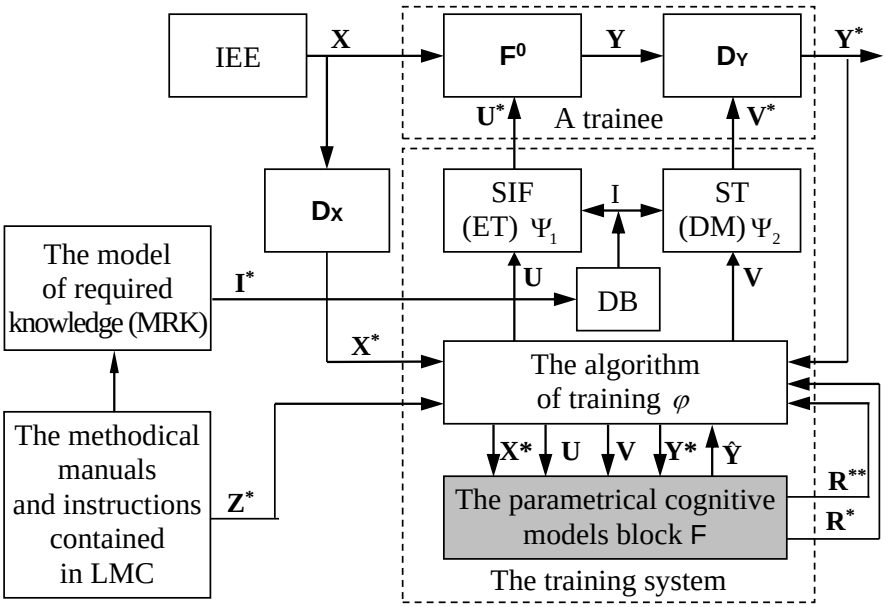
The traditional models and technologies at the basis of the automated information environments of educational establishments lose their relevance (the linear, the linear branched, the linear branched multilevel) [1-14] and initiate the emergence of the innovative: the adaptive – causes the creation, introduction and use of the contour of adaptation and parametrical models for the providing of the accounting of various factors (parameters); the individually-oriented – realizes the potential possibility of taking into account and research of the physiological, psychological, linguistic and other features of personality of the trainees [2-4].

There is a significant need of the analysis and the increasing of efficiency of the information interaction between the diverse subjects and means of difficult technological process of the automated formation of knowledge (at distance) [12-14] by means of the creating of the adaptive means and environments of training using the apparatus of cognitive informatics (R. Solso, M.L. Gik), private physiology of sensory systems (V.M. Krol, Ch.A. Izmailov), cognitive psychology (V.N. Druzhinin, M.A. Kholodnaya), applied linguistics (M.L. Gik).

The structure of the information environment of the automated training system with the properties of adaptation based on the cognitive models

The created by the author structure of the automated training system (ATS) with the properties of adaptation based on the cognitive models (CM) [3, 4, 6] presents the closed contour with the two levels of information interaction between the subjects and means of controlled process of the individually-oriented formation of knowledge of the trainees, includes the several main components, performing the different functions and tasks: the adaptive electronic textbook (ET) [3, 6, 9], the basic diagnostic module (DM) [3, 4, 6, 8] and the applied diagnostic module [3, 6], and also the parametrical CM block [2-4, 6, 7, 10].

In general the structure of the proposed adaptive ATS with the properties of adaptation based on the parametrical CM block acts as the difficult object, it is formalized by means of using of the apparatus of classical theory of control and it is presented as follows (pic. 1).



Pic. 1. The structural scheme of the training system based on the cognitive models

ATS presented on the scheme with the properties of adaptation based on the parametrical CM block functions simultaneously as the integral part and as the independent component of the innovative adaptive information-educational environment (IEE) of a new generation, the structurally decomposed on the several main elements: the training system and the trainee [3, 6].

The training system realizes the generation of a sequence of educational influences, and the level of influences of IEE is supposed to be negligible small for the purposes of certainty.

The means of training (ET) generates a sequence of information fragments, and the trainee directly studies their content, that supports the formation of knowledge.

The trainee is characterized by a certain set of various individual features of his personality (IFPST): physiological, psychological and linguistic parameters.

In the proposed structural scheme uses a row of designations in relation to the structural components of ATS with the properties of adaptation based on the parametrical CM block:

- the polynomial model (F_0) – includes the parameters and values of weight coefficients, which characterize the individual features of a certain trainee;
- the sensor D_x – provides the measurement of the level of influence of IEE, which are negligible small in relation to the educational influences of the specified means of training (ET);
- the sensor D_y – measures the estimation of resultativity of the formation of knowledge of the trainee;
- the methodical manuals – contain the instructions on the use of LMC with a structured set of ordered main and additional information fragments, which reflect the content of section, module, paragraph and page, and also assume the presence of the main and additional blocks of control questions;
- the database (DB) – contains the structured data in the given subject area for the further processing and visual displaying to the final user;
- the model of required knowledge (MRK) – reflects different requirements, tasks and purposes of training, the limitations in IEE and the structured material in a set of the subjects of studying;
- the algorithm of training (φ) – forms a sequence of returned values, containing links to training influences in DB and the parameters of their displaying (U) by means of the adaptive representation of information fragments processor in ET, and also a sequence of returned values of the links on the main and additional blocks of control questions (V), related with a certain elements of course in DM;
- the shaper of a sequence of information fragments parametric (SIF) Ψ_1 – realizes the individually-oriented visual representation of a sequence of educational influences (the information fragments) taking into account the certain links on the various information fragments and the parameters of the parametrical CM block;
- the shaper of test tasks (TF) Ψ_2 – provides the displaying of a sequence preset of the question-answers structures of test tasks taking into account of the links on the different information fragments, which reflect the content of the subject of studying;
- the parametrical CM block (F) -- contains a set of values of the repertoire of parameters of CM of the subject of training (R* $\overline{\Pi^1}$) and CM of the means of training (R** $\overline{\Pi^2}$), which characterize respectively IFPST and the potential technical capabilities of the means of training at the adaptive generation of a sequence of information fragments (the optimal combination of the values of parameters of the displaying of information is realized by means of the adaptive representation of information fragments processor [3, 6, 8, 9]).

The features of the parametrical cognitive models block

The parametrical CM block contains in its basis of CM of two types and acts as the information basis for the realization of the system analysis of the information environment of the educational establishment, it provides the direct support and estimation of the efficiency of functioning of the technological process of the individually-oriented formation of knowledge of the contingent of trainees in ATS with the properties of adaptation based on the parametrical CM.

For each randomly selected object, process or phenomenon in a certain environment of its functioning, a set of developed methods and algorithms is selected, which are included in the basis of CMT, and then form the parametrical CM, including a fixed set of portraits, having the scientific justification in the context of specified subject areas.

At the developing of the complex of techniques and algorithms for the realization of the system analysis of a certain subject area and the object of research a key role has the iterative cycle and the modified generalized technique of using of CMT for the given subject area.

The model presents a structurally and functionally depleted entity (structure), which reflects the dynamics of functioning of the object of research in a given locality.

The parametrical CM reflects the key features of an object, process or phenomenon at its observed and recorded (computable) isomorphism in a certain environment of functioning for the subsequent analysis, acts as the extensible in width and depth repertoire of parameters, which is echeloned on the several portraits with a certain scientific justification and stratified on a row of sets, located on the two levels of allocated hierarchy.

In the course of realization of the system analysis it is recommended to approach differentially to the research of a given object, process or phenomenon, allocated in the environment of its functioning, therefore each from them is directly entered into the compliance the parametrical CM.

The portrait of CM corresponds to the key aspect of the analysis and its scientific justification.

The development of the structure of CM is realized by means of using of the algorithm of formation of the structure of CM in the structure of (the created by the author) the apparatus of the cognitive modeling technology (CMT) [2, 4, 6, 7, 10] based on one from the classical (the formal logical and frame models, the semantic network, the corteges on domains and ontology) or the proposed new ways of representation of CM (the oriented graph, combining the theory of sets and the multilevel structural scheme).

The creation of a new and the (re)constructing of the existing structure of parametrical CM is carried out based on one from the classical or innovative models of representation of the structured data by means of a sequential filling of the two available levels of the presented hierarchy with the elements, obtained at the analysis of the specified object.

The ways of representation of the structure of the cognitive model

The structure of the parametrical CM is presented by means of using of a row of ways:

- the formal ways of representation – the analytical (formula) and procedural (algorithm);
  - the logical model – based on the use of elements of the calculus of propositions and predicates of the first and second order (including quantifiers and difficult operations);
    - the simple logical expression – the logically indivisible and cannot be simplified by means of using of the laws of Boolean algebra of logic, acting as the rules of equivalent transformation of the difficult logical expressions to the simple;
    - the difficult logical expression – the structurally decomposes to a set of simple;
  - the production model – the hierarchical structure with a set of production kernels, each from which is equivalent to the elementary rule, including the antecedent (the condition based on logics) and the consequent (the direct and alternative actions, which are performed respectively in the case of truth or falsity of the source condition);
    - the simple production kernel (rule): if (condition), then (action);
    - the extended production kernel (rule) has a more difficult structure: if (condition), then (direct action), else (alternative action);
  - the graph, combining the theory of sets (proposed by the author) [4, 6] – a set of vertices, which are located on two levels of the allocated hierarchy, are connected by the arcs and form the several various independent sets (pic. 2, 3, 4);
- the nonformal ways of representation – the graphical and declarative;
  - the frame model – a set of proto-frames and frames-instances in the view of tables (corteges), containing the certain identifiers and values of information fields;
  - the semantic network – includes a set of vertices, corresponding the objects, processes or phenomena and the connections between them based on the principles of belonging, subordination and inclusion of one element (set) in relation to the another;
  - the ontology – the representation of weakly-structured and poorly-formalized subject areas by means of the structural scheme, combining the elements of the frame model and the semantic network using the methods of the object-oriented approach;
  - the multilevel structural scheme (proposed by the author) – excludes the connections between the elements and represents a set of information elements, which are located at the different levels of the allocated hierarchy by the principle of inclusion.

The (re)constructing of the new or obtained structure of CM is carried out by means of using of the algorithm of formation of the structure of CM based on the created CMT by the author [2, 4, 6].

Using the apparatus of the calculus using the corteges on domains, the developed structure of the parametrical CM can be presented in the following formal-analytical view:

- the system of designations allows to create the hierarchical multilevel pyramidal structure (CM_u – CM; $PR_{u,i}$ – the portrait of CM; $SJ_{u,i}$ – the scientific justification of the portrait; $KP_{u,i,j}$ – the kind of properties; $Pr_{u,i,j,k}$ – the property; $VP_{u,i,j,k,l}$ – the vector of parameters; $P_{u,i,j,k,l,m}$ – parameter; u – the index of the parametrical CM; i – the index of portrait of CM; j – the index of the kind of properties; k – the index of property; l – the index of the vector of parameters; m – the index of parameter);
- to each object, process or phenomenon is brought into compliance CM (CM_u), which includes the counting finite-dimensional set of portraits ($PR_{u,i}$), which have the exact scientific justification in the context of a certain subject area and branch of sciences:

$$\begin{cases} CM_1 = \{< PR_{1.1}, SJ_{1.1} >, < PR_{1.2}, SJ_{1.2} >, ..., < PR_{1.i}, SJ_{1.i} >\}; \\ CM_2 = \{< PR_{2.1}, SJ_{2.1} >, < PR_{2.2}, SJ_{2.2} >, ..., < PR_{2.i}, SJ_{2.i} >\}; \\ CM_u = \{< PR_{u.1}, SJ_{u.1} >, < PR_{u.2}, SJ_{u.2} >, ..., < PR_{u.i}, SJ_{u.i} >\}; \end{cases}$$

- each portrait of CM ($PR_{u,i}$) includes a set of the kinds of properties ($KP_{u,i,j}$):

$$\begin{cases} PR_{1.1} = \{KP_{1.1.1}, KP_{1.1.2}, ..., KP_{1.1.j}\}; \\ PR_{2.2} = \{KP_{2.2.1}, KP_{2.2.2}, ..., KP_{2.2.j}\}; \\ PR_{u.i} = \{KP_{u.i.1}, KP_{u.i.2}, ..., KP_{u.i.j}\}; \end{cases}$$

- each kind of properties ($KP_{u,i,j}$) includes a set of elementary properties ($Pr_{u,i,j,k}$);

$$\begin{cases} KP_{1.1.1.} = \{\mathrm{Pr}_{1.1.1.1}, \mathrm{Pr}_{1.1.1.2}, ..., \mathrm{Pr}_{1.1.1.k}\}; \\ KP_{2.2.2} = \{\mathrm{Pr}_{2.2.2.1}, \mathrm{Pr}_{2.2.2.2}, ..., \mathrm{Pr}_{2.2.2.k}\}; \\ KP_{u.i.j} = \{\mathrm{Pr}_{u.i.j.1}, \mathrm{Pr}_{u.i.j.2}, ..., \mathrm{Pr}_{u.i.j.k}\}; \end{cases}$$

- each property ($Pr_{u,i,j,k}$) includes the vectors of parameters ($VP_{u,i,j,k,l}$);

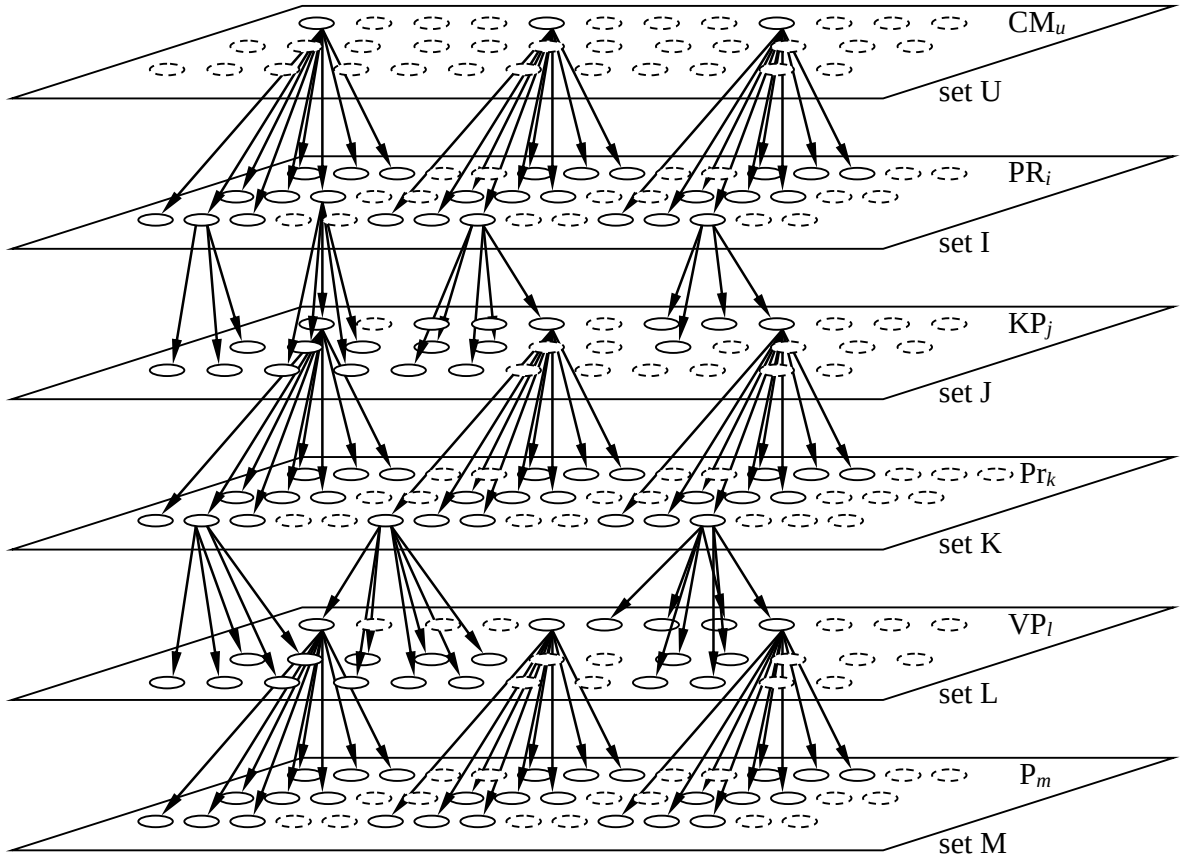
$$\begin{cases} \mathrm{Pr}_{1.1.1.1} = \{VP_{1.1.1.1.1}, VP_{1.1.1.1.2}, ..., VP_{1.1.1.1.l}\}; \\ \mathrm{Pr}_{2.2.2.2} = \{VP_{2.2.2.2.1}, VP_{2.2.2.2.2}, ..., VP_{2.2.2.2.l}\}; \\ \mathrm{Pr}_{u.i.j.k} = \{VP_{u.i.j.k.1}, VP_{u.i.j.k.2}, ..., VP_{u.i.j.k.l}\}; \end{cases}$$

- each vector of parameters ($VP_{u,i,j,k,l}$) includes the several elementary of parameters ($\Pi_{u,i,j,k,l,m}$) at the lower level of hierarchy of the represented CM:

$$\begin{cases} VP_{1.1.1.1} = \{P_{1.1.1.1.1.1}, P_{1.1.1.1.1.2}, ..., P_{1.1.1.1.1.m}\}; \\ VP_{2.2.2.2} = \{P_{2.2.2.2.2.1}, P_{2.2.2.2.2.2}, ..., P_{2.2.2.2.2.m}\}; \\ VP_{u.i.j.k.l} = \{P_{u.i.j.k.l.1}, P_{u.i.j.k.l.2}, ..., P_{u.i.j.k.l.m}\}. \end{cases}$$

The parametrical CM can be represented not only analytically (the logical and production models), but also in the view of the structural-graphical representation (the graph and multilevel scheme).

In the process of (re)construction of the structure of the parametrical CM based on the presented system of analytical equations the hierarchical structure can be obtained (pic. 2).



Pic. 2. The hierarchical structure of the cognitive model by means of the corteges on domains

CM is obtained in the view of the hierarchical structure, which represents a set of mutually nested pyramids with the homogeneous parameters and includes the several sets of different powers located at the diverse levels of the allocated hierarchy: a set of CM U – u', a set of portraits of CM I – i', a set of the vectors of properties J – j', a set of properties K – k', a set of the vectors of parameters L – l', a set of elementary parameters M – m'.

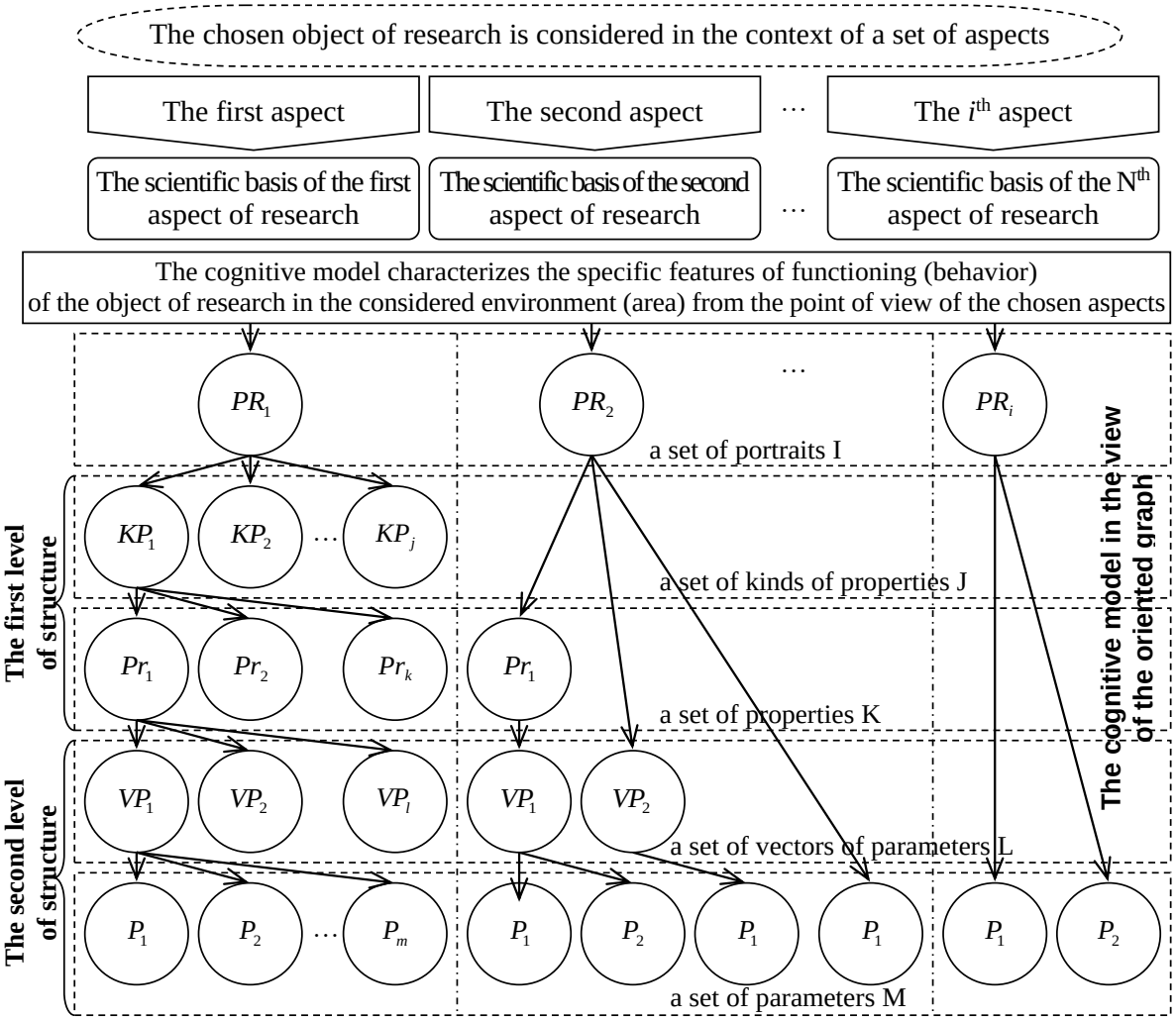
The integral power of the obtained pyramidal structure: $p=u'\cdot i'\cdot j'\cdot k'\cdot l'\cdot m'$.

After the determining of the optimal quantity of portraits of CM providing the formation of sets: the kinds of properties, the elementary properties, the vectors of parameters and elementary parameters.

Each element of the structure of the parametrical CM, located at the arbitrary level of hierarchy allows the possibility of including of the several derivative (subordinate) elements, which are created directly in the extension at the lower level.

All sets are finite-dimensional, and the quantity of elements in the basic and subordinated sets is arbitrary, so the potentially possible the to and reduce the elements of the formed structure of CM based on the proposed way of representation (cortege and scheme).

The oriented graph, combining the theory of sets allows to directly display a set of vertices corresponding to the different elements, which are located on the two levels of the presented hierarchy of the parametrical CM, and also the connections between them in the view of a set of arcs displaying the different relations: subordination, inclusion and encapsulation (pic. 3).



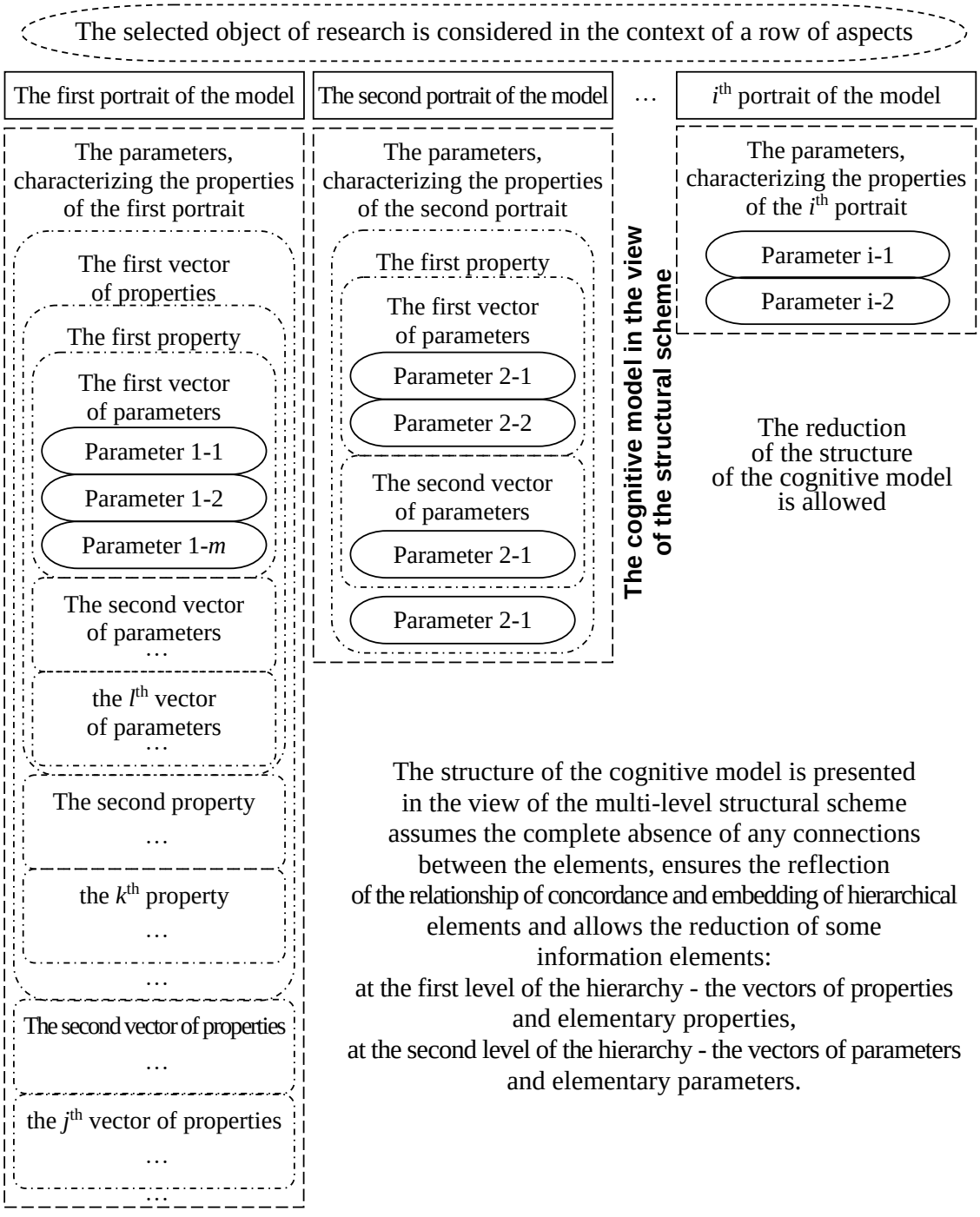
Pic. 3. The recommended way of representation of the cognitive model in the view of the oriented graph, combining the theory of sets

CM is presented by means of using of the oriented graph, combining the theory of sets presents the hierarchical structure, which includes a row of portraits with SJ (I) and a various sets, located on the two independent levels of the allocated hierarchy:

- at the first level – there are located the several independent vertices, which directly form a set of the kinds of properties (J) and a set of elementary properties (K);
- on the second level – there are located the several vertices directly forming a set of the vectors of parameters (L) and a set of elementary parameters (M) in the basis of CM.

The deterministic and random reduction and absence of some elements of CM is allowed.

The multilevel structural scheme includes a set of independent information elements, reflecting the features and localities of a certain object of research, which are located directly at the different levels of the allocated hierarchy and form the several mutually independent sets in the basis of the structure of the parametrical CM (pic. 4).



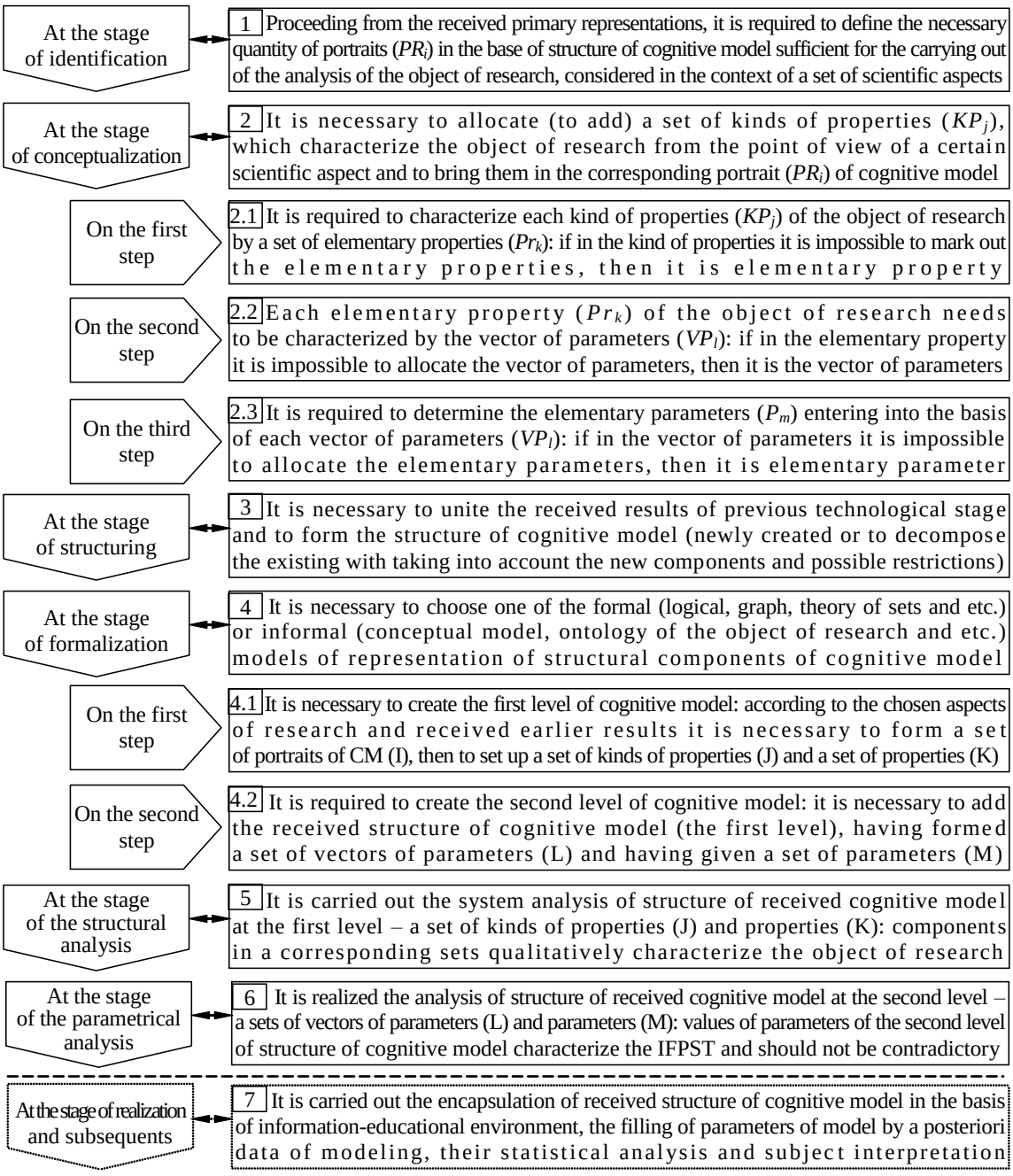
Pic. 4. The recommended way of representation of the cognitive model in the view of the multi-level structural scheme

The multilevel structural scheme allows the relative reduction (exclusion and absence) of some elements in the basis of the developed structure of the parametrical CM.

The algorithm of formation of the structure of the cognitive model

At the formalization of the structure of the parametrical CM for the providing of the system analysis of a certain object, process or phenomenon a row of innovative ways of representation its structure is applied: the calculus using corteges on domains (analytical), the graph, combining the theory of sets (graphical) and the multi-level structural scheme (schematical).

The proposed algorithm enters in the basis of (the developed by the author) the apparatus of CMT and directly provides the formalization of the iterative sequence of ordered stages, which realizes directly the formation of the structure of the parametrical CM (pic. 5).



Pic. 5. The algorithm of formation of the structure of the cognitive model

The cognitive model of the subject of training

CM of the subject of training accumulates the individual features of sensory perception (the physiological portrait), processing (the psychological portrait) and understanding (the linguistic portrait) of the content of a sequence of information fragments, presented by a given way in a certain national or foreign language by the subject of training.

Let applicate the calculus using corteges on domains, at the same time the structure of the parametrical CM includes a row of designations and it is presented directly as follows: $CM_1 = \{PR_1^1, PR_2^1, PR_3^1\}$ – the parametrical CM has three independent portraits and a row of elements:

- the first portrait of CM of the subject of training is presented in the view $PR_1^1=\{KP_1^1\}$, where:
  $KP_1^1 = \{Pr_1^1, Pr_2^1\}$;
  $Pr_1^1 = \{VP_1^1, VP_2^1, VP_3^1\}$, $Pr_2^1=\{VP_4^1\}$;
  $VP_1^1 = \{P_1^1, P_2^1, P_3^1\}$, $VP_2^1 = \{P_4^1, P_5^1, P_6^1\}$, $VP_3^1 = \{P_7^1, P_8^1, P_9^1, P_{10}^1\}$, $VP_4^1 = \{P_{11}^1, P_{12}^1, P_{13}^1\}$;
- the second portrait of CM of the subject of training is reflected in the view $PR_2^1 = \{KP_2^1\}$, where:
  $VP_2^1 = \{Pr_3^1, Pr_4^1, Pr_5^1, Pr_6^1\}$;
  $Pr_3^1 = \{VP_5^1\}$, $Pr_4^1 = \{VP_6^1, VP_7^1\}$, $Pr_5^1 = \{VP_8^1, VP_9^1, VP_{10}^1, VP_{11}^1, VP_{12}^1, VP_{13}^1\}$, $Pr_6^1 = \{VP_{14}^1\}$;
  $VP_5^1 = \{P_{14}^1, P_{15}^1, P_{16}^1, P_{17}^1, P_{18}^1, P_{19}^1, P_{20}^1, P_{21}^1, P_{22}^1\}$; $VP_6^1 = \{P_{23}^1, P_{24}^1, P_{25}^1, P_{26}^1\}$;
  $VP_7^1 = \{P_{27}^1, P_{28}^1, P_{29}^1, P_{30}^1\}$; $VP_8^1 = \{P_{31}^1, P_{32}^1\}$; $VP_9^1 = \{P_{33}^1, P_{34}^1\}$; $VP_{10}^1 = \{P_{35}^1, P_{36}^1\}$;
  $VP_{11}^1 = \{P_{37}^1, P_{38}^1\}$; $VP_{12}^1 = \{P_{39}^1, P_{40}^1\}$; $VP_{13}^1 = \{P_{41}^1, P_{42}^1\}$; $VP_{14}^1 = \{P_{43}^1, P_{44}^1\}$;
- the third portrait of CM of the subject of training is formalized in the view $PR_3^1=\{KP_3^1\}$, where:
  $KP_3^1 = \{Pr_7^1\}$; $Pr_7^1 = \{VP_{15}^1\}$; $VP_{15}^1 = \{P_{45}^1, P_{46}^1, P_{47}^1\}$.

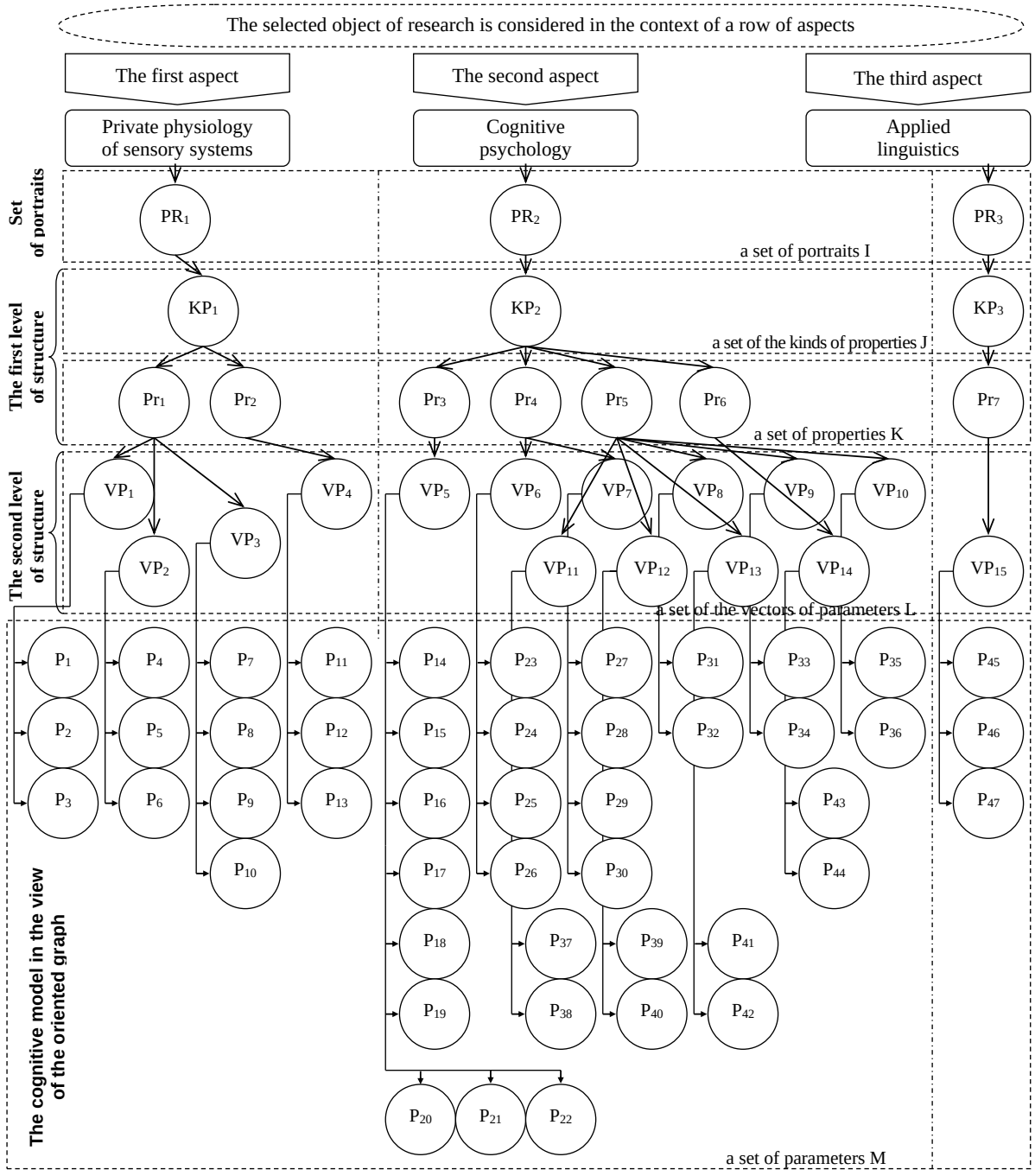
In the basis of the obtained structure of CM of the subject of training are absent some elements, at the same time it is significantly branched, that allows directly to talk about the significant breadth of coverage of the considered in the course of the system analysis of the object of research.

The theoretical CM contains an exhaustive set of parameters, and the experimental CM can contain an actual set of parameters for the organization of the process of research.

The parametrical identification of the experimental CM is carried out by means of the technique of research of the parameters of CM of the subject of training [6, 7] in the basis of the cognitive modeling technology [2, 6, 10] and directly at the aid of the applied diagnostic module in the structure of the complex of programs for the automation of the applied tasks of the system analysis [3, 6, 8].

The normative-methodical basis for the diagnostics of the parameters of CM of the subject of training are the methodical manuals and descriptions of the methods of research, which have a scientific justification in the different subject areas: psychophysiology of perception (the physiological portrait), cognitive psychology (the psychological portrait) and applied linguistics (the linguistic portrait).

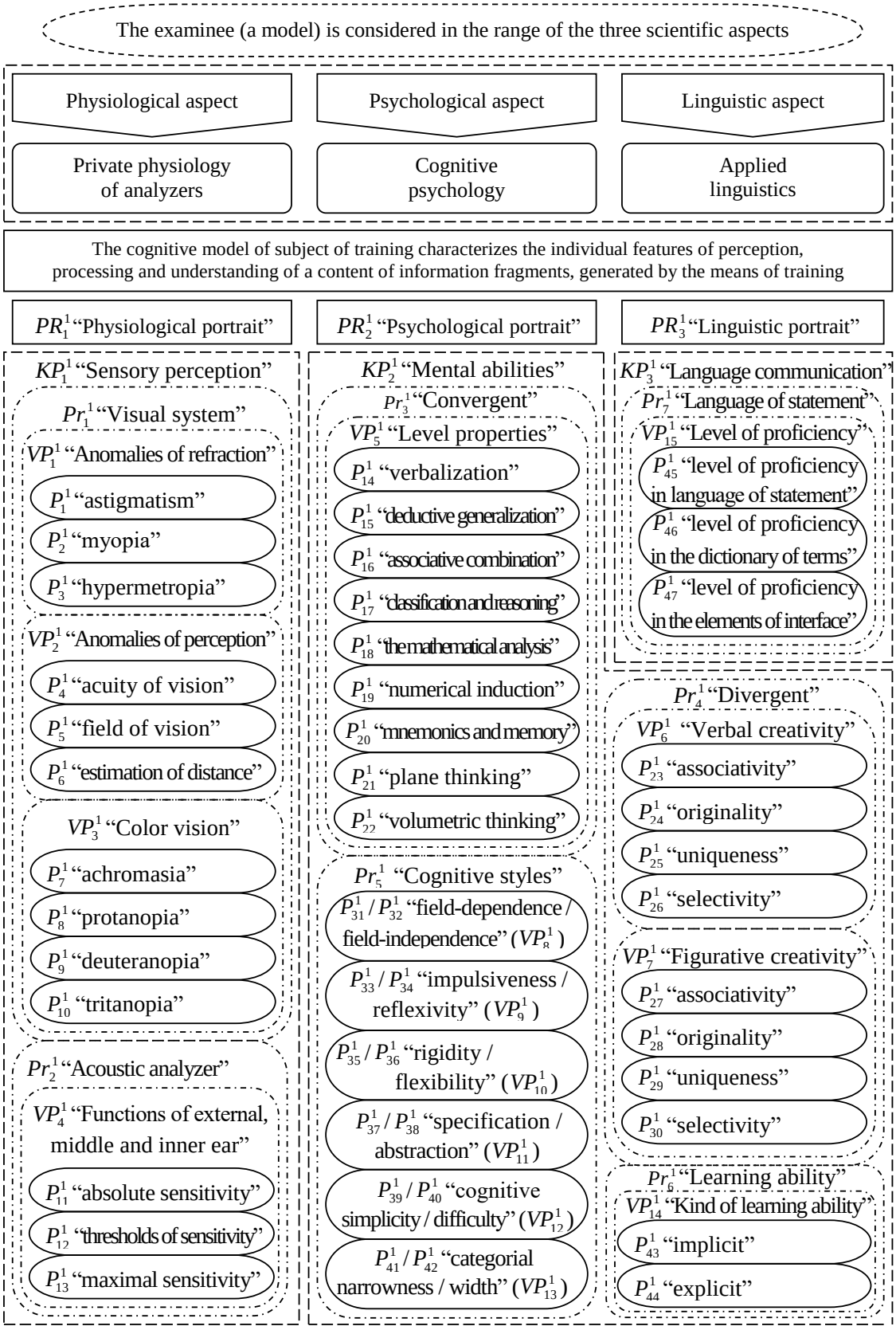
Next follows the structure of CM of the subject of training, which is represented by means of using the innovative oriented graph, combining the theory of sets (pic. 6).



Pic. 6. The structure of the cognitive model of the subject of training in the view of the oriented graph

The structure of CM of the subject of training [2-4, 6] contains the physiological, psychological and linguistic portraits, having a exact scientific justification in the context of a selected set of the subject areas for the realization of possibility of a subsequent interpretation of the revealed dependencies and regularities by means of use of the statistical methods.

CM of the subject of training is presented in the view of the multi-level structural scheme (pic. 7).



Pic. 7. The structure of the cognitive model of the subject of training in the view of the multi-level structural scheme

The cognitive model of the means of training

CM of the means of training aggregates a set of parameters, characterizing the potential technical capabilities of the means of training at the generation of a sequence of the diverse of information fragments by the different ways (text, table, flat scheme, volumetric scheme, the static or dynamic audio- and video-stream, sound scheme as the main or accompanying).

The practical use of the calculus with the corteges on domains directly allows to present CM of the subject of training as follows: $CM_2^2 = \{PR_1^2, PR_2^2, PR_3^2\}$, where the available in its basis portraits of the parametrical CM are presented in the analytical view:

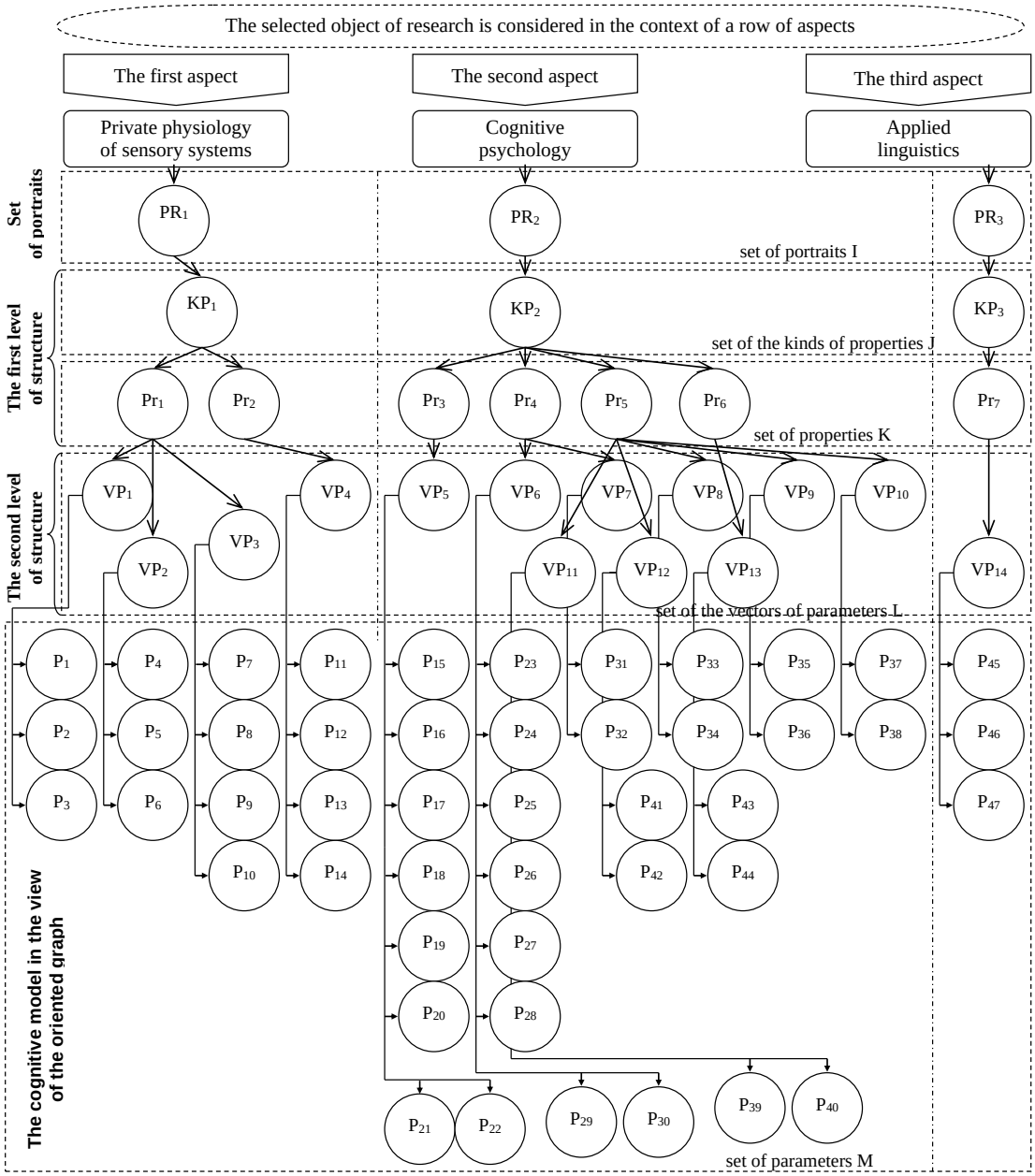
- the first portrait of the parametrical CM of the means of training $PR_1^2=\{KP_1^2\}$, where:
  $KP_1^2 = \{Pr_1^2, Pr_2^2\}$, in its turn:
  $Pr_1^2 = \{VP_1^2, VP_2^2, VP_3^2\}$, $Pr_2^2 = \{VP_4^2\}$, and also
  $VP_1^2 = \{P_1^2, P_2^2, P_3^2\}$, $VP_2^2 = \{P_4^2, P_5^2, P_6^2\}$, $VP_3^2 = \{P_7^2, P_8^2, P_9^2, P_{10}^2\}$, $VP_4^2 = \{P_{11}^2, P_{12}^2, P_{13}^2, P_{14}^2\}$;
- the second portrait of the parametrical CM of the means of training $PR_2^2=\{KP_2^2\}$, where:
  $BC_2^2 = \{C_3^2, C_4^2, C_5^2, C_6^2\}$, в свою очередь:
  $C_3^2 = \{B\Pi_5^2\}$, $C_4^2 = \{B\Pi_6^2, B\Pi_7^2\}$, $C_5^2 = \{B\Pi_8^2, B\Pi_9^2, B\Pi_{10}^2, B\Pi_{11}^2, B\Pi_{12}^2\}$, $C_6^2 = \{B\Pi_{13}^2\}$,
  а также $B\Pi_5^2 = \{\Pi_{15}^2, \Pi_{16}^2, \Pi_{17}^2, \Pi_{18}^2, \Pi_{19}^2, \Pi_{20}^2, \Pi_{21}^2, \Pi_{22}^2\}$; $B\Pi_6^2 = \{\Pi_{23}^2, \Pi_{24}^2, \Pi_{25}^2, \Pi_{26}^2, \Pi_{27}^2, \Pi_{28}^2, \Pi_{29}^2, \Pi_{30}^2\}$;
  $B\Pi_7^2 = \{\Pi_{31}^2, \Pi_{32}^2\}$; $B\Pi_8^2 = \{\Pi_{33}^2, \Pi_{34}^2\}$; $B\Pi_9^2 = \{\Pi_{35}^2, \Pi_{36}^2\}$; $B\Pi_{10}^2 = \{\Pi_{37}^2, \Pi_{38}^2\}$; $B\Pi_{11}^2 = \{\Pi_{39}^2, \Pi_{40}^2\}$;
  $B\Pi_{12}^2 = \{\Pi_{41}^2, \Pi_{42}^2\}$; $B\Pi_{13}^2 = \{\Pi_{43}^2, \Pi_{44}^2\}$;
- the third portrait of CM of the means of training is presented in the view $PR_3^2=\{KP_3^2\}$, where:
  $KP_3^2 = \{Pr_7^2\}$, в свою очередь:
  $Pr_7^2 = \{VP_{14}^2\}$, а также
  $VP_{14}^2 = \{P_{45}^2, P_{46}^2, P_{47}^2\}$.

The available portraits of the parametrical CM of the means of training allow with sufficient accuracy for practice to characterize the object, process or phenomenon to be researched.

The parametrical identification of CM of the means of training is carried out on the basis of the technical description of the means of training in the course of its life cycle, at the same time using the technique of research of the parameters of CM of the means of training is located in the basis of the apparatus of the developed cognitive modeling technology for the system analysis of IEE [2, 4, 6, 7, 10].

The modifications of the program realization of the procedural and declarative basis of functioning of the means of training (ET), including the changes of the infological scheme of the database, are directly reflected in the technical description of the means of training and significantly effect on the values of the actual set of parameters of CM of the means of training, and also have a great influence on its structure, which is potentially presented by the different ways.

CM of the means of training is presented in the view of the hierarchical two-level structure by means of the proposed oriented graph, combining the theory of sets (pic. 8) [4, 6, 7, 10].

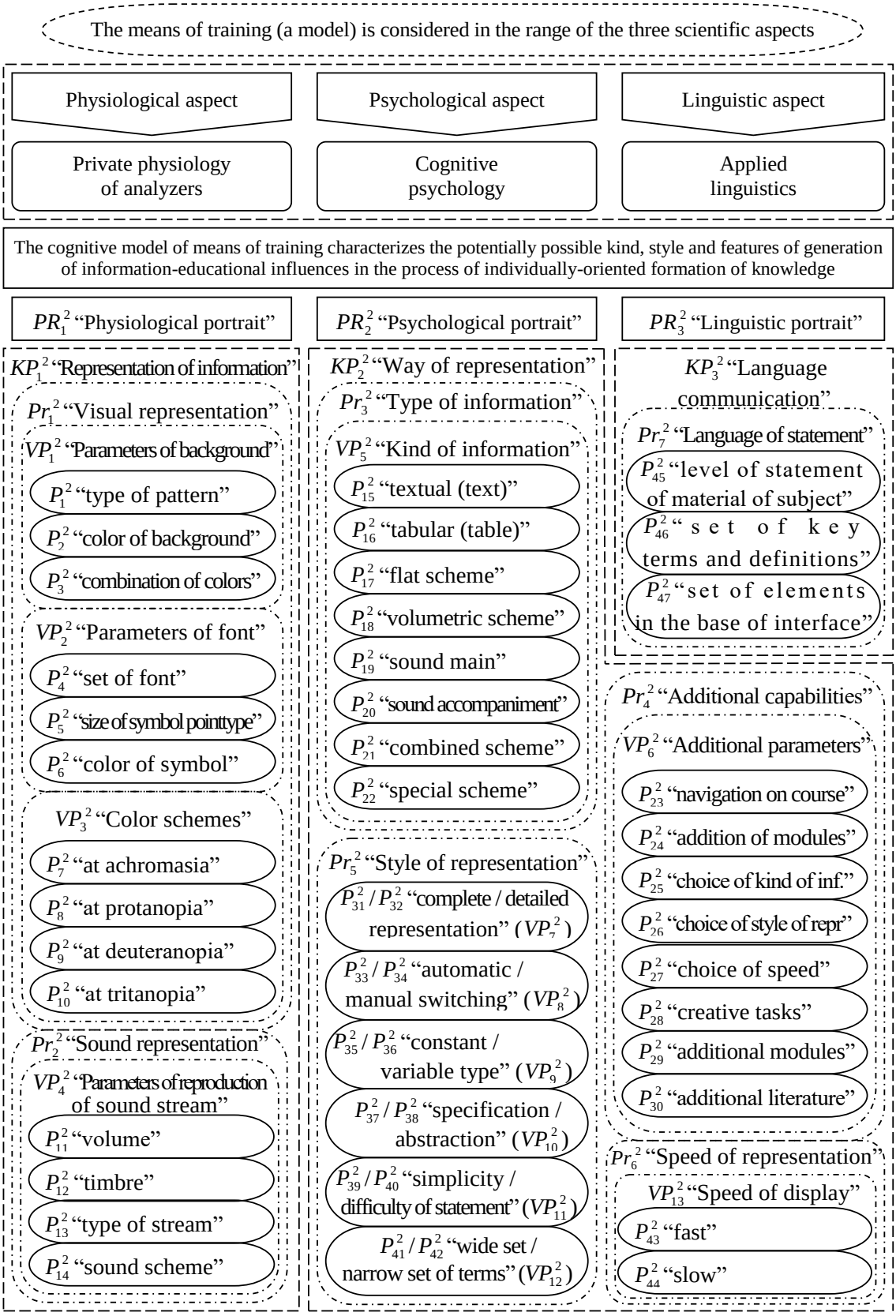


Pic. 8. The structure of the cognitive model of the means of training in the view of oriented graph

The oriented graph, combining the theory of sets allows to conveniently clearly to interpret the structure of CM of the means of training only from the analytical point of view, and also indicates about the potential possibility of algorithmization of all elements of the structure of CM.

At the construction and analysis of the elements of CM the reduction is permissible, it may not observe the symmetry at its (re)construction by means of the algorithm of formation of the structure of CM.

CM of the means of training in the view of the multi-level structural scheme is presented (pic. 9).



Pic. 9. The structure of the cognitive model of the means of training in the view of the multi-level structural scheme

The features of diagnostics of the parameters of the cognitive model of the subject of training

The theoretical CM of the subject of training and CM of the means of training act as the potentially extensible in width and depth repertoires of parameters, which are echeloned on the several independent portraits having a certain scientific justification and stratified on a row of sets, located at the different levels of the allocated hierarchy of model (CM).

The diagnostics of the values of parameters of CM is carried out in a certain sequence by means of using of the method of research of the parameters of CM regardless of the kind and structural features of the parametrical CM based on the methods of research in the form of tests.

The kind of parametrical CM depends significantly from the subject area and the object of research, and its structural features are determined by a set of classification signs, which characterize the selected object for the subsequent analysis.

For the creation, analysis and the improvement in the efficiency of functioning of IEE and ATS with the properties of adaptation based on the parametrical CM block the two CM are introduced into the consideration: CM of the subject of training and CM of the means of training, at the same time each CM includes three portraits, the three scientific aspects of the analysis of the selected object of research and the three areas for the scientific justification.

The typical sequence (algorithm) of carrying out of the research of parameters of CM includes:

- the preliminary stage – the search, selection, the initial analysis, the classification and systematization of the various scientifically-reasonable methods of diagnostics of the given parameters of CM;
- the preparatory stage to the research of parameters of CM – adjustment of the applied DM;
- the diagnostics of the values of parameters of CM – the automated testing of individual features of the contingent of trainees by means of a set of methods of research;
- the accumulation and primary mathematical processing of a posteriori data – it is carried out on the basis of a series of experiments, involves the analysis of compliance to the normal law of distribution of the nominal values in the samples with a posteriori data;
- the secondary mathematical processing of a posteriori data – represents the mathematical processing by means of using of a set of statistical methods;
- the interpretation – the scientific substantiation of revealed dependencies and regularities, their graphical interpretation with the presentation of conclusions and essential comments.

The analysis and interpretation of the obtained regularities and dependencies actualizes the use of the means of visualization in the basis of the packages of mathematical statistics, the systems of spreadsheets, the multimedia presentations, which allow to visually present and discuss the qualitative changes on the seminars based on the quantitative values of signs.

The diagnostics of the values of parameters of the cognitive model of the subject of training

The diagnostics of parameters of CM of the subject of training is carried out on the basis of the technique of research of the parameters of CM of the subject of training and the applied DM, that allows to provide:

1. The preparatory stage to the research of different parameters of CM of the subject of training:
   - the analysis and verification of the existing structure of the theoretical CM of the subject of training;
   - the formation of an actual set of parameters of CM for the subsequent research based on a priori given theoretical structure of CM of the subject of training;
   - the modernization and recombination of the existing methods of research of the existing parameters of CM of the subject of training, located in the basis of the database of the applied DM;
   - the searching and selecting of a set of various methods of research from the certain applied areas, related with the object of research and the problem environment for the diagnostics of new parameters in the basis of the being created experimental CM of the subject of training;
   - the modernization of the existing and creation of new procedures for the realization of automation of the process of diagnostics of the newly included parameters of CM of the subject of research;
   - the collection of a list of the names of groups and parameters of examinees for the realization of formation of the database with the accounts of users and a posteriori data of testing;
   - the filling of the database with the parameters of the methods of research in the basis of the applied DM by the available values of parameters of the used methods of research;
   - the filling of the database with the parameters of the accounts of users in the basis of the applied DM by the values of parameters of the new and existing accounts of users.
2. The automated testing of the individual features of the contingent of trainees:
   - the providing of clarifications and personal cards for the registration of a posteriori data of testing;
   - the carrying out of cycle of the automated diagnostics of parameters of CM of the subject of training based on the specified methods of research by means of using of the applied DM;
   - the registration of a posteriori data of research in the form of test on the personal cards of examinees and in the database of the complex of programs with a posteriori data of testing;
3. The systematization of a posteriori data of testing based on a series of experiments:
   - the classification and sorting of a posteriori data of testing in the database;
   - the formation of samples and complexes for the realization of primary and secondary processing of a posteriori data of a series of experiments by means of the packages of statistical analysis;
4. The processing of a posteriori data of research, obtained in the course of a series of experiments:
   - the systematization of a posteriori data of research of the parameters of CM of the subject of training;
   - the archiving of the temporarily unused methods of research and a posteriori data.

The diagnostics of the values of parameters of the cognitive model of the means of training

The diagnostics of the values of parameters of CM of the means of training is carried out on the basis of the technique of research of the parameters of CM of the means of training, which enters in the basis of the apparatus of the created CMT and the technical description of the means of training for the providing of the system analysis of IEE:

1. The preparatory stage to the research of various parameters of CM of the means of training:
   - the analysis of the existing formed theoretical structure of CM of the means of training;
   - the formation of an actual set of parameters of CM of the means of training for the subsequent use directly based on the theoretical structure of CM;
   - the analysis of the available technical description for the verification of a set of parameters of CM of the means of training with the purpose of subsequent support of the process of conducting of the experimental researches and adjusting of the parameters of the means of training (the adaptive ET) [3, 9];
   - the searching, selecting and systematizing of a set of various technical descriptions and manuals to the means of training for the support of the potential possibility of addition of the new parameters in the basis of the created experimental structure of CM of the means of training;
   - the modernization of existing and the creation of new procedures for the realization of the automation of diagnostics of the newly included actual parameters of CM of the means of training;
   - the formation of the database in the basis of the applied DM with the values of parameters of the accounts of users and the obtained experimental CM of the means of training.
2. The methodical support of the complete cycle of automated testing of the individual features of the contingent of trainees by means of the use of the applied DM:
   - the providing of various comments, explanations and recommendations on the questions of creation, introduction and practical use of the different means of training (the adaptive ET);
   - the control and instructing for the providing of registration of aposteriori data of research on the personal cards of examinees and into the database of the complex of programs.
3. The systematization of a posteriori data on the fact of conducting of a series of experiments:
   - the comparison of various parameters of the displaying of information of ET with IFPST;
   - the formation of samples and complexes with a posteriori data for the realization of primary and secondary mathematical processing of a posteriori data of a series of experiments;
   - the recommendations to the improving of the architecture of components of ATS based on the block of CM.
4. The processing of a posteriori data of testing of the obtained in the course of a series of experiments:
   - the saving of a posteriori data of research of the technical parameters of the means of training (ET);
   - the backup copying of the values of parameters of the components of IEE and ATS, which reflect the potential technical capabilities of displaying and processing of the information [6, 8, 9].

The conclusions in the result of practical use

of the parametrical cognitive model block

1. CM of the subject of training directly allows to characterize the features of primary sensory perception (psychophysiology), processing (cognitive psychology) and understanding (cognitive and applied linguistics) of the content of a sequence of information fragments in a certain language, which reflect the content of the subject of studying.

2. CM of the means of training reflects the potential technical parameters of displaying of a sequence of information fragments of the different kind in the different way.

3. The parametrical CM block allows to carry out the system analysis of the efficiency of functioning of IEE and ATS taking into account the parameters of CM of the subject of training and CM of the means of training.

4. The innovative ways of representation of the structure of the parametrical CM are offered.

5. The optimal combination of the values of parameters of the displaying of sequence of the information fragments is calculated taking into account IFPST stored in CM of the subject of training and the parameters of CM of the means of training reflecting the potential technical capabilities of the adaptive ET (the adaptive representation of information processor is offered, which is made according to the block-modular principle taking into account the features of parallel architecture [3, 6]).

6. The practical use of the obtained scientific results has been carried out since 2004 y. in the learning process of "The international banking institute" and since 2003 y. in the learning process of "The Saint-Petersburg state electrotechnical university "LETI"", and in the course of carrying out of a series of experimental researches the two acts about practical use and the four copyright certificates on the obtained scientific results have been received.

7. The technological process of controlled formation of knowledge of the contingent of trainees acts as the difficult for carrying out of the system analysis on the basis of cognitive modeling technology [6], includes a set of gaps and phases of information processing, it significantly depends from the different parameters, caused by the subject and technical means of training [11].

8. The estimation of efficiency of ATS with the properties of adaptation based on the parametrical CM block was carried out by means of using of the generally-accepted indicators of efficiency (resultativity) of the process of automated formation of knowledge of the contingent of trainees: $\mathbf{K} = \{k_1; k_2; k_3\} = \left\{ Y_2 - Y_1; \frac{Y_2}{Y_1}; \frac{Y_2 - Y_1}{Y_1} 100\% \right\}$, where coefficients k_1, k_2, k_3 accordingly indicates absolute, comparative and relative indicators of resultativity of the formation of knowledge of the contingent of trainees [2, 4, 6, 8, 10], and the results of statistical processing of a posteriori data of a series of experiments are processed, summarized and consolidated in tabl. 1 [11].

Table 1

The results of primary statistical analysis of the resultativity of training

The indicator	The number of the group of trainee							
	1	2	3	4	5	6	7	8
The indicators of resultativity of training for 2004 y.								
Size of sample	20	21	25	18	18	15	0	0
Average point Y_1	4,05	4,286	4,24	4,611	4,056	4,4	-	-
AQD of av. point	0,686	0,845	0,779	0,502	0,802	0,507	-	-
The indicators of resultativity of training for 2005 y.								
Size of sample	24	22	24	25	24	22	23	21
Average point Y_2	4,333	4,046	4,375	4,16	4,042	4,091	4,696	4
AQD of av. point	0,817	0,785	0,824	0,8	0,859	0,811	0,559	0,894
The indicators of resultativity of training for 2006 y. (from the use of CMT in 3 groups)								
Size of sample	26	23	29	24	25	22	22	22
Average point Y_3	4,5	4,609	4,379	3,708	3,92	3,773	4,455	3,818
AQD of av. point	0,707	0,656	0,775	0,751	0,572	0,612	0,858	0,853
The results of the primary statistical analysis								
The indicators, reflecting the change of efficiency of training for 2004-2005 y.								
k_1	0,283	-0,240	0,135	-0,451	-0,014	-0,309	-	-
k_2	1,07	0,944	1,032	0,902	0,997	0,93	-	-
k_3, %	6,996	-5,606	3,184	-9,781	-0,345	-7,023	-	-
Change of AQD	0,131	-0,06	0,045	0,298	0,057	0,304	-	-
The indicators, reflecting the change of efficiency of training for 2005-2006 y.								
k_1	0,167	0,563	0,004	-0,452	-0,122	-0,318	-0,241	-0,182
k_2	1,039	1,139	1,001	0,891	0,97	0,922	0,949	0,955
k_3, %	3,854	13,915	0,091	-10,865	-3,018	-7,773	-5,132	-4,55
Change of AQD	-0,11	-0,129	-0,049	-0,049	-0,287	-0,199	0,299	-0,041

9. In the result of the regression analysis of a posteriori data the obtained values of the coefficient of multiple correlation (CMC = 0.558) and the coefficient of multiple determination (CMD = 0.312) indicate, that 31.2% of the dispersion of the dependent variable $\hat{Y}_i$ (the estimation of LRKT) is determined directly by the variation of values of the coefficients (predictors) K_i, located in the obtained linear model of multiple regression $\hat{Y}(K_i)$. The nominal values of initial (β) and standardized coefficients (β') of the linear model of multiple regression $\hat{Y}(K_i)$ are presented in the report on SRW [11]. The constant is 4.653.

The predictors (the independent variables) in the linear model of multiple regression are presented, at the same time the resultativity of training Y (the estimation of LRKT) as the dependent variable or factor, which determines the efficiency of process of the formation of knowledge of the trainee.

The predictors (factors) determine the degree of influence on the resultativity of the formation of knowledge.

Then the linear equation of multiple regression takes the following view:

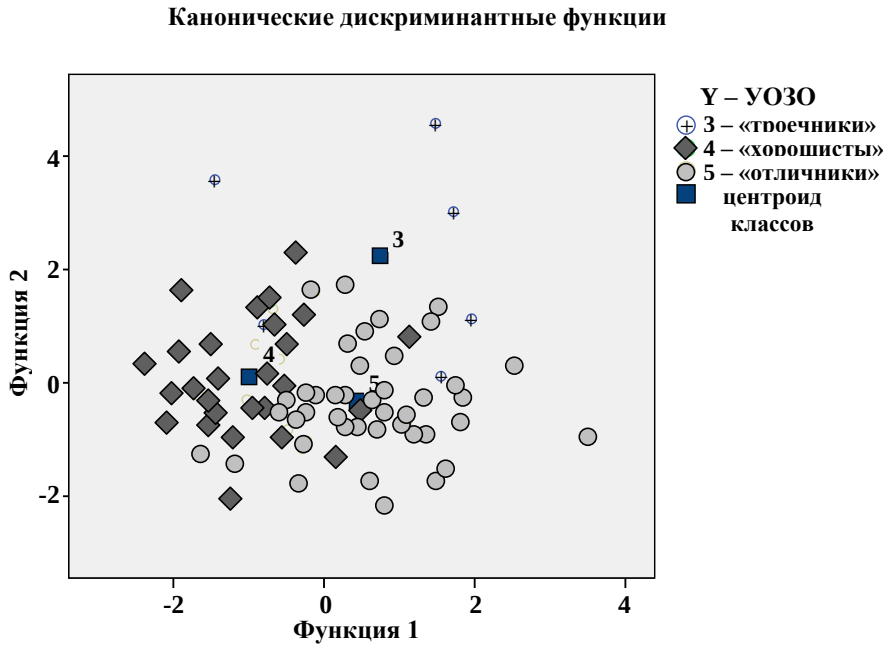
$$Y = 4{,}653 - 0{,}006VOZR - 0{,}002K_7 - 0{,}156K_8 + 0{,}121K_9 + 0{,}064K_{14} - 0{,}029K_{15} + 0{,}006K_{16} -$$
$$- 0{,}074K_{17} + 0{,}025K_{18} - 0{,}009K_{19} - 0{,}026K_{20} + 0{,}001K_{21} + 0{,}035K_{22} + 0{,}013K_{23} + 0{,}009K_{24} -$$
$$- 0{,}008K_{25} - 0{,}111K_{27} - 0{,}008K_{28} + 0{,}032K_{29} + 0{,}022K_{45}$$

The predictors are indicated as follows: VOZR – age, K_7 – achromasia, K_8 – protanopia, K_9 – deuteranopia, K_{14} – verbal intelligence, K_{15} – deduction, K_{16} – combinatorics, K_{17} – reasoning, K_{18} – analytics, K_{19} – induction, K_{20} – mnemonic and memory, K_{21} – planar imagination, K_{22} – volumetric thinking, K_{23} – verbal associativity, K_{24} – verbal originality, K_{25} – verbal uniqueness, K_{27} – figurative associativity, K_{28} – figurative originality, K_{29} – figurative uniqueness, K_{45} – the level of proficiency in the language of statement.

10. CMT allows to realize the additional contour of adaptation based on the parametrical CM block, and also to conduct the complex system analysis of IEE, directed on the increasing in the efficiency of functioning of ART system and the resultativity of the process of the formation of knowledge of the contingent of trainees with the minimal transactional and time costs.

11. In the course of carrying out of the discriminant analysis the several groups of trainees in dependence from the estimation of LRKT: "5" – excellent-students; "4" – good-students; "3" – mediocre-students [11].

Pic. 10 reflects the geometrical interpretation of position of the centroids of the classes corresponding to the allocated groups of trainees in the space of coordinates of the two canonical functions.



Pic. 10. The centroids of classes of trainees in the space of canonical functions

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БЛОК ПАРАМЕТРИЧЕСКИХ КОГНИТИВНЫХ МОДЕЛЕЙ ДЛЯ АНАЛИЗА ЭФФЕКТИВНОСТИ ОБМЕНА ИНФОРМАЦИЕЙ В АДАПТИВНОЙ СРЕДЕ АВТОМАТИЗИРОВАННОГО ОБУЧЕНИЯ

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Блок параметрических когнитивных моделей является информационной основой системного анализа, содержит когнитивные модели субъекта и средства обучения, каждая из которых выступает репертуаром параметров, эшелонированным на ряд портретов и стратифицированным на несколько независимых множеств расположенных на двух уровнях выделенной иерархии. Системный анализ информационно-образовательных сред инициирует необходимость учета широкого спектра разных научных фундаментальных и прикладных направлений современной науки, а также обуславливает необходимость использования инновационного аппарата исследования.

Ил. 10. Библиогр. 10 назв.

Ключевые слова: *информационно-образовательная среда; когнитивная модель; система автоматизированного обучения; технология когнитивного моделирования*.

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