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STRUCTURAL-FUNCTIONAL ORGANIZATION AND CORRECTNESS OF KNOWLEDGE MODELS OF PRODUCT SYSTEMS

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Abstract: Modern trends of society development are characterized by the complexity of monitoring and management issues in the conditions of globalization and changing requirements of the environment. A large amount of data requires the use of modern information and communication technologies (ICT) and corporate information systems (CIS) (Enterprise Information Systems, EIS) to solve problems with the complexity of their processing, analysis, forecasting (prediction) and assessment of the studied situations. Reaches such decision support systems combine business strategies and information technologies, which ensures the improvement of information management efficiency of corporations
Keywords: Tabular model, data mining, web mining, soft computing, enterprise information system.

INTRODUCTION

Modern trends of society development are characterized by the complexity of monitoring and management issues in the conditions of globalization and changing requirements of the environment. A large amount of data requires the use of modern information and communication technologies (ICT) and corporate information systems (CIS) (Enterprise Information Systems, EIS) to solve problems with the complexity of their processing, analysis, forecasting (prediction) and assessment of the studied situations. reaches [1]. Such decision support systems combine business strategies and information technologies, which ensures the improvement of information management efficiency of corporations.

Solving issues at the high strategic levels of corporations is usually carried out in conditions of imperfect, incomplete information (Imperfect, Incomplete Information). Analysis and support of unstructured decision-making (Soft Computing, Data and Web Mining, Business Intelligence and Analytics, etc.) in this KAT requires the use of intellectual technologies and databases (MB) and knowledge bases (BB) [1 -3]. These technologies are based on the theory of artificial

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intelligence, fuzzy logic and inference, neural network computing, logical inference, evolution, training, adaptation and optimization, heuristic natural-biological mechanisms. The main functional components of such KATs are: electronic information resource (EIR), information-analytical system (IAS), decision-making system (DMS) [1]. The EAR stores the data received, processed, systematized and structured from external and internal sources. At the same time, unstructured knowledge reflecting hidden interrelationships in the data of the researched processes is formed and stored in EIR [4-6]. The structural-functional structure of such EIRs is based on the concept of Data Warehouse (DW, Data Warehouse) [7]. This stored EIR ensures that information and knowledge are shared with the following characteristics: problem-oriented, integrated, immutable, multidimensional, and structured. This allows EIR to be implemented as a single integrated source of information and knowledge in the form of Data Marts for the entire corporation and its divisions. These Data Showcases are simplified fragments of the DW that contain the information and extracted knowledge required for the tasks of the relevant units CIS.

TABULAR MODEL OF PRODUCTION RULES

In the conditions of uncertainty, loosely formed empirical knowledge extracted from primary data and formed by experts in the form of linguistic interpretations is of particular importance for information management. The degree of accuracy and adequacy of such knowledge, shown in the form of certain models in KB, largely determines the quality of assessments and decisions made in conditions of uncertainty. Productive, network, and frame models are used to describe decomposable knowledge in KB. Modularity, modifiability, readability, demonstration, interpretation, universality, production models are widespread in order to achieve efficiency of memory organization to build BB. Such models are logical models close to logical models, which allow to organize effective inference procedures.

Production models are based on the representation of knowledge in the form of a set of rules of the "IF - condition, THEN - conclusion (action)" type. At the same time, they reflect knowledge more clearly than classical logic models. They do not have the strict constraints inherent in logical computations, and production rules allow changing the interpretation of elements. At the same time, production models have some disadvantages: a) it is difficult to formulate production rules for specific objects that are not well studied; b) the complexity of writing complex rules in a single format "IF - THEN" in the presence of similar conditions for different situations; c) when the number of rules in the database increases (about several hundred), the process of logical inference slows down, which leads to the appearance of conflicting rules in the database. This determines the urgency of improving methods and algorithms for rule verification and correctness checking in production systems KB.

To process the knowledge represented by production models, production systems and a logic inference mechanism module are used. An important task of the structural-functional organization of production systems is to give them opportunities to modify, update, supplement, as well as check the correctness and verification of

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production rules, that is, to assess the level of adequacy of knowledge models of the researched problem area (PA). Verification involves checking the syntactic and semantic correctness of the rules defined in KB by unambiguity, completeness and sufficiency.

One of the effective approaches to the solution of the above-mentioned problems is based on the representation of knowledge models of production systems in the form of tables of production rules (TPR), which are more general solutions [8]. Such tables are used as a specification language for defining researched problems of logical control nature. A problem statement is expressed as a sum of conditions (input variable logical functions) and their corresponding function values (output variables). This definition of the matter is distinguished by its conciseness and declarativeness. Below is a description of the rules and formations of the proposed method of checking the correctness and verification of knowledge models based on the representation in the TPR form.

The appearance of TPR in production systems is described [9-11]

$$P_L = <(A, B, M_A, M_B, P, F, G_A, G_B) > \quad (1)$$

Thus, $\mathsf{A} = \{A, B, M_A, M_B)$ - final alphabet describing the subject area under study and the set of possible cases of decisions being made;

$A = \{A_i\}, i = \overline{1, m}$ - multiplicity of conditions – coordinates of state vectors;

$B = \{B_r\}, r = \overline{1, k}$ - number of conclusions - coordinates of action vectors;

$M_A = \|a_{\text{grated}}\|, i = \overline{1, m}, j = \overline{1, n}$ - compliance of the matrix of elements of state vectors with production rules;

$M_B = \|b_{\text{rj}}\|, r = \overline{1, k}, j = \overline{1, n}$ or $j = \overline{1, n+1}$ if additional conditions E=< ¬, OTHERWISE B_{n+1}> if there are types of rules, then $B_{n+1} = \{b_{r,n+1}\}$vector with the conclusion determined actions $A_i, i = \overline{1, m}$,when $P_j, \overline{j = 1, n}$, does not mean that any rule can be applied;

$P = \{P_j\}, j = \overline{1, n}$ - the abundance of rules for certain types of (correct, inverse) productions;

$Q = \{F, G_A, G_B\}$ - - a number of additional parameters P_j rules describe some features, for example: $F = \{f_j\}, j = \overline{1, n}$ (e rule is available or when $j = \overline{1, n+1}$) – P_j productions are a vector of application coefficients, in a certain sense they reflect their reliability and power coefficients; $G_A = \{g_{\text{Ai}}\}, i = \overline{1, m}, G_B = \{g_{\text{br}}\}, r = \overline{1, k}$ - A_i and B_r a and b are the vectors of the complexity coefficients for calculating the terms of the conclusions, respectively. Information about Q parameters is used for the purpose of choosing and forming decision-making strategies that ensure the reliability of forming decisions and high speed of calculations. The set Q can be filled with values of production priorities Pj defined by logical relations between conditions A_I and types of situations (state, anomalous, emergency).

The review of the new TPR (1) model $A = \{A_i\}, i = \overline{1, m\, in}$ conditions of $P_j, j = \overline{1, n}$ rules as problematic in the survey area (PA) $S = \{\overline{S}_{\text{at}}, \overline{S}_{\text{an}}, \overline{S}_{\text{AV}}\}$I gather the

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vague possibility of the circumstances of the situation makes sense etalon-semiotika provides a description of the model [3], $B = \{B_r\}, r = \overline{1,k}$ conclusions – the current situation is required to change the required target $D = \{D_{rj}\}, r = \overline{1,k}, j = \overline{1,n}$ model provides a description of the uncertain decisions [4]. Packages a and b and accepted the terms and conclusion of the term established for the new ms survey of the value are formed from a recent collection.

Fuzzy model of FIS (fuzzy inference system) based on TPR models is a matching PA under investigation, $\overline{S}_0$ can pass from allowed goal states $\overline{s} \in \overline{S_0}$ to any goal states $\dot{A} \subset A$ conditions values are characterized by subsets $B = \{B_r\}, r = \overline{1,k}$ any last set can pass any $\overline{s} \in \overline{S}$ is semantic is considered correct [4].

The correctness of the TPR model is determined by the completeness of the production rules included in it and the absence of contradictions.

We will consider the rules for checking the correctness of the PQJ model for its simplified form, precisely for the situation where the set of condition values $\dot{A}_i = \{\dot{a}_j\}, i = \overline{1,m}$ has two values, that is, $\dot{A} = \{0,1\}$. In the general case, PA models with ambiguous $\dot{A}_i = \{\dot{a}_j\}$ conditions can be divided into models with two-digit values using normalization operations [5,6].

We introduce a series of definitions for the TPR model.

<u>Definition 1.</u> A fixed set of states $\overline{S}$ is a set characterized by a condition vector $A_i^q = \{0,1\}, q \in (1,2,...,2^m), i = \overline{1,m}$..

<u>Definition 2.</u> *A rule Pj is considered applicable (activated) in state* $\overline{S} = \{A_i^q\}$ *if the data vector Pj matches the rule, that is, if it meets the condition* $(\exists\, j \forall i)(a_{ij} \in A_i^q)$.

This is are written in form $A_i^q \rightarrow P_j$.

<u>Definition 3.</u> A PQJ model is said to be consistent with respect to its admissible set, if it is:

$$(\exists\, A_i^q, P_j, P_p)((A_i^q \rightarrow P_j) \wedge (A_i^q \rightarrow P_p) \rightarrow (\dot{B}_{,j} = \dot{B}_p)), j \neq P.$$

Conversely, a TPR model is said to be inverse to a set if there is a proportion $\dot{B}_j \neq \dot{B}_p$ in this expression.

<u>Definition 4.</u> TPR model $\overline{S}$ is called relatively complete if it contains rule E:

$$(\exists\, A_i^q \forall P_{,j})(A_i^q \rightarrow P_j), j = \overline{1, n+1}.$$

Otherwise, the TPR model is said to be relatively incomplete.

<u>Definition 5.</u> A TPR model is said to be correct with respect to S if it is consistent and complete with respect to $\overline{S}$. Otherwise, the TPR model is considered to be incorrect with respect to $\overline{S}$. This definition reflects the semantic correctness with respect to the accepted interpretation of the PA under study. The correctness of the PA model is $\overline{S}$onsidered to be semantic with respect to the set of all possible situations $\overline{S}$ (not only with respect to the reference situations $\overline{S}$) in which situations PA are any interpretations.

Formed definitions are the basis for proving the following points.

View 1: If a model TPR is syntactically correct with respect to all possible states of S, then it is also semantically correct with respect to any set of reference states $\bar{S} \subseteq S$.
It follows from this idea that syntactic correctness is a sufficient but not a necessary condition for semantic correctness. This causes a syntax error because the condition vector A_i^q belongs only to the set $S / \bar{S}$ and may not belong to the set $\bar{S}$. Then the TPR model is semantically correct.

View 2. A model TPR is complete with respect to $\bar{S}$ if and only if it contains a rule E or a set $A = \{\dot{A}_j\}, \; j = \overline{1,n}$ describes the set $\bar{S} = \{\dot{A}_i^q\}$ and generates $\bar{S} \subseteq S$.

Then for all elements of the sets A, B and P we have a certain proportion $\bar{S} \to P.$ in the complete model TPR.
The algorithm for checking the correctness of TPR consists of two stages: 1) checking for syntactic correctness; 2) generation of vector-conditions causing syntactic errors (if it is detected in the first step) and semantic correctness checking. The TPR model is semantically false if such non-definable, i.e., in the TP model, the generated $\bar{A}_i^q$ belong to a set $\bar{S}$ that does not correspond to some rule $P_i \in P$. If $\bar{A}_i^q \in S / \bar{S}$, then TP is semantically true by view 1.

In order to simplify and strengthen the formalization of the consistency check procedure of the TP model, we introduce additional Boolean matrices $M'_A = \|a'_{ij}\| \; u \; M''_A = \|a''_{ij}\|$ for conditions A arising from the matrix M_A [2]. The elements of these matrices are determined by the following conditions.

This allows reducing the set power of the matrix conditions to separate the conditions that can be satisfied from the conditions that cannot be fulfilled due to non-existence. It should be noted that the matrix M''_A is assumed to be Boolean for the case $a''_{ij} = [0,1]$.
Using these matrices, we form the following points.

View 3. (will come out from view 2). The conditions vector A_i^q satisfies the rule P_j is recognized by the TP model, and the rule P_j can be applied if and only if $(\forall j)(A_i^q \bullet M'_{Aj} = M''_{Aj}),$

In it, matrices M'_{Aj} and M''_{Aj}, columns of M'_A and M''_A .are vectors. $A_i^q * M'_{Aj}$ multiplication is done by coordinates.

View 4: (will come out from view 3). The PJ model was consistent with respect to S when only and only $(\exists j, p)((M'_{Aj} \bullet M'_{Ap}) \to (\dot{B}_j = \dot{B}_p)), \; j \neq P.$
$M''_A = \|a''_{\text{grated}} = [0,1]\|$ For case Q, the multiplication operation (x)is replaced by the conjunction $(\wedge)$ operation.

The consistency check algorithm is based on view 3 and view 4, and the consistency check $(M'_{Aj} \bullet M'_{Ap} = M'_{Ap} \bullet M'_{Aj}) \wedge (\dot{B}_j = \dot{B}_p)$. consists of performing cyclic procedures. It changes from j to n-1, p – j+1 to n. If this proportionality holds for all j and p, then the TP model is syntactically consistent. Otherwise, M'_{Aj} and M'_{Ap} columns - vectors are found that define the sum of the condition vectors that satisfy the rules P_j *ва* P_p, which are $B^{\&}_j \neq B^{\&}_p$ for j and p.

The completeness check of the TPR model with respect to the set S consists in the generation of all possible vectors of conditions defining the set of states and their recognition and completeness check according to view 2 and view 3.

In the process of implementation of the second stage of the considered algorithms, in most cases, the participation of a decision-maker or an expert involved in the creation of the TPR model is provided. In order to completely automate the procedures of these algorithms, as stated in [2], it is necessary to specify the logical conditions among the conditions by an expert, for example, the calculation of the first series of predicates should be specified using properly structured functions.

CONCLUSION

One of the important tasks of intellectual systems is knowledge work and management, which is determined by the sum of the processes of collecting, updating, storing, developing and distributing knowledge. They are mechanisms of logical inference, reasoning and evolution; knowledge is based on the use of low-form (verbal expert) knowledge (production, frame, semantic networks) representation models. Production models have become widespread due to their demonstrability, interpretability and universality. Knowledge models of production systems expressed in the form of PQJ differ from corresponding models implemented in programming languages (LISP, OSP, PROLOG type) by the use of logical operations (matrix, vector). Due to this, the speed of processing is increased and the possibility of automation of execution of rule verification operations in production systems is provided.

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