

KNOWLEDGE REPRESENTATION MODEL FOR RESOLVING CONFLICT SITUATIONS IN TECHNOLOGICAL OBJECT

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The paper represents the knowledge model of expert system, intended for resolving conflict situations in technological object (TO) of discreet-continuous type. The knowledge representation model must be able to reflect the structural and functional properties of problem area and to support the process of knowledge base formation.

In structural aspect the technological object possesses the hierarchical structure with the fixed degree of detalization in each level, such as department, line, operation, etc.

In functional aspect TO is characterized with two sets of technological parameters: input and qualitative. Input parameters describe properties of raw materials, half-finished products and conditions of technological processes. Qualitative parameters describe properties of finished or half-finished products in the fixed points of structural hierarchy of TO.

The technological object may be represented by the structural-functional model M (SF-model) [1], defined as follows:

$$M = \langle M_s, M_f \rangle ,$$

where M_s - structural component of SF-model;

M_f - functional component of SF-model.

Hierarchical structure of TO is described by structural components of SF-model:

$$M_s = \langle M^0, M^1, \dots, M^n \rangle$$

where M_i^j , ($j=0,1,\dots, n$) - SF-model structural component of j level of TO.

The intercorrelation exists between components of model M_S , since component reflecting structure of TO in j level is decomposition of components of ($j-1$) level in structural hierarchy.

Model of i structural component of j level may be described as follows:

$$M_i^j = \langle E_i^j, R^{ST} \rangle, \quad (j=0,\dots, n; i=1,\dots,m_j),$$

where E_i^j - the main set of model with structure:

$$E_i^j = \langle M_*^{j+1}, G_j^j, H_i^j, T_i^j, Q_i^j \rangle,$$

where M_*^{j+1} - set of models of structural components received by the decomposition of M_i^j , $M_*^{j+1} \subset M_*^{j+1}$;

G_j^j - set of material and energetic flows entering structural components in i level;

H_i^j - set of finished and half-finished products - outputs of structural component of i level;

T_i^j - set of input parameters characterizing elements of set G_j^j and technological processes of structural component of i level;

Q_i^j - set of qualitative technological parameters characterizing elements of set G_j^j ;

R^{ST} - set of relationships describing structural and topological relations of TO. The following types of relationships may be selected: generalization-specialization, aggregation-detalization and space-temporal.

Now structure of technological parameters which are interesting both in structural and functional aspects must be uncovered.

The set of input parameters T is conjunction of sets T_i^j , ($i = 1,\dots, m_j; j=0,\dots, n$). It may be divided into two subsets: parameters of continuous and discrete type correspondingly.

Continuous input parameter is described by vector:

$$w_n = (t, t^-, t^*, t_-, t^0, t', t''),$$

where t - identifier of technological parameter;

t^- - maximal available value;

- t^* - nominal value of;
- t_* - minimal available value;
- t^0 - factual value;
- t' - indicator of measurability;
- t'' - indicator of controllability.

Input technological parameter of discrete type is described by vector:

$$w_d = (t, T^*, t^0, t', t''),$$

where T^* - set of possible values of technological parameter. It is not numeric in the most cases and may be defined by enumerating all its elements.

Qualitative technological parameter $q_k \in Q$ (Q - set of qualitative technological parameters obtained by conjunction of sets Q_i^j , ($i = 1, \dots, m; j = 0, \dots, n$)) is described by vector:

$$w_q = (q, q_a, q^0, q^-),$$

where q - identifier of qualitative technological parameter;

q_a - identifier which generalizes the sets of technological parameters of corresponding type. It is predetermined because of specific character of TO: qualitative technological parameters may be generalized in the most cases. This property permits to accelerate TO state analysis and increase the purposefulness of this process;

q^0 - factual value;

q^- - limiting value permitting to detect the state conflict of qualitative technological parameter.

Functional component of SF-model describes the functioning and control of TO. Its structure:

$$M_F = \langle T, Q, R^{PR}, PRC_V \rangle$$

where T - set of input technological parameters;

Q - set of the qualitative technological parameters;

R^{PR} - set of relationships describing causal relations between elements of sets T and Q ;

PRC_V - set of procedures developing corrections for input technological parameters from set T .

In functional aspect TO may be viewed as a system located in space S of situations. In every moment of time the state of TO $s_1 \in S$ may be characterized by two sets:

$$T_1^0 = \{t_{11}^0, t_{12}^0, \dots, t_{1r}^0\},$$

$$Q_1^0 = \{q_{11}^0, q_{12}^0, \dots, q_{1r}^0\},$$

where T_1^0 - set of values of input technological parameters T_{1i}^0 ($i = 1, \dots, n$) in fixed moments of time;

Q_1^0 - set of values q_{1j}^0 ($j=1, \dots, p$), describing factual state of qualitative technological parameters.

The analysis of situation in TO is carried out by reviewing set Q_1^0 and separating subset $Q_1^{0k} \in Q_1^0$, which consists of values describing conflict states of qualitative technological parameters.

Now the causes of conflicts may be defined by some set of values of input technological parameters. It may be expressed by:

$$\xi_1: Q_1^{0k} \rightarrow T_1^{0k}$$

The second step is formation of control decisions, which may be defined:

$$\xi_2: T_1^{0k} \rightarrow V_1$$

where V_1 - set of control decisions to eliminate the conflict situation s_1 . It is subset of set of all control decisions V ($V_1 \in V$). The set V is not expressed explicitly in process of SF-model formation. It is only for definition the results of the work of set of procedures PRC_V developing control actions by estimating the states of input technological parameters from the set T_1^{0k} .

For representation of SF-model the semantic-production network (SPN) is created. It consists of specialized semantic network and production rules extension [2]. The specialized semantic network plays the role of framework, representing structure of TO and structural-topological relationships between it's components. The production rules extension fills up this framework and represents functional dependencies between fixed states of sets of input technological parameters and conflict states of qualitative technological parameters.

The intentional structure of specialized semantic network may be expressed:

$$ST_{int} = \langle P^{ST}, R^{ST} \rangle,$$

where P^{ST} - set of concepts;

R^{ST} - signature of relationships characterizing relations between components of P^{ST} .

Set P^{ST} includes concepts representing hierarchical structure of TO:

$$P_{STR} = \bigcup_{j=1}^n P_{STR}^j,$$

where P_{STR}^j is concept defining structure of j level of TO, n is a number of levels of structural hierarchy in TO.

In addition, P^{ST} includes class of concepts describing technological parameters:

$$P_{TP} = \{P_{tpart}, P_{tpard}, P_{tpk}\},$$

where P_{tpart} , P_{tpard} - concepts defining technological parameters of continuous and discrete type correspondingly;

P_{tpk} - concept defining qualitative technological parameters.

Each of concepts defined have some set of properties characterizing structure and features of TO components.

Elements of concept class P_{STR} have set of properties:

$$P_{STR}^j : (ID, AGR, PROC, FOL, TPAR, TPKS)$$

where ID - identifier of TO structural component represented by an instance of concept analyzed;

AGR - defines the correspondence between instances of concept P_{STR}^{j-1} and instances of concept P_{STR}^j . Instances of concepts are aggregated from concept instances;

PART - defines the correspondence between instances of concept P_{STR}^{j-1} and instances of concept P_{STR}^j . It expresses the aggregation of lower level components to higher level components;

FOL - defines relationships between instances of some concept and instances of another concept defining the following structural component of TO;

PROC - defines relationships between instances of some concept with the instances of another concept defining the preceding structural component of TO;

TPAR - defines relationships between instances of some concept and instances of concepts P_{tpart} and P_{tpard} . This property repre-

sents relationship between input technological parameters and corresponding structural component of TO;

TPKS - defines relationships between instances of concept P_{STR}^j and instances of concept P_{tpk} . This property represents dependence of qualitative technological parameters to corresponding structural component of TO.

The properties of concept P_{tpart} may be defined:

$P_{tpart} : (ID, LOC, MAX, NOM, MIN, FAKT, Z1, Z2)$

where ID - identifier of input technological parameters represented by instances of concept;

LOC - defines the relationships between instances of concept P_{tpart} and instances of concept P_{STR}^j ;

MAX, NOM, MIN, FAKT - define the existence of available maximal, nominal, available minimal and factual values of input technological parameters, represented by instance of concept P_{tpart} ;

Z1, Z2 - define the existence of measurability and controllability indicators of input parameters represented by instance of concept P_{tpart} ;

The content of concept P_{tpard} may be defined as follows:

$P_{tpard} : (ID, LOC, SVAL, FAKT, Z1, Z2)$

where SVAL - defines the existence of set of possible values of discrete input parameters represented by instance of concept P_{tpard} .

Remaining properties of concept P_{tpard} conform the properties of concept P_{tpart} .

Concept P_{tpk} has the following properties:

$P_{tpk} : (ID, LOC, IS, LIM, FAKT)$

where IS - defines the existence of concept generalizing instances of concept analyzed. This property represents the aggregation relationships existing between qualitative technological parameters of different levels;

LIM - refers to limiting value of qualitative technological parameter represented by instance of concept P_{tpk} . This property permits to detect conflict states of qualitative technological parameters.

Remaining properties of concept P_{tpk} conform the properties of concept P_{tpart} .

The definition of concept structure by enumerating its properties discloses the structure of set of relationships R^{ST} . It is caused by semantics of relationships playing the role of references to the corresponding properties.

The structure of specialized semantic network is presented in figure 1:

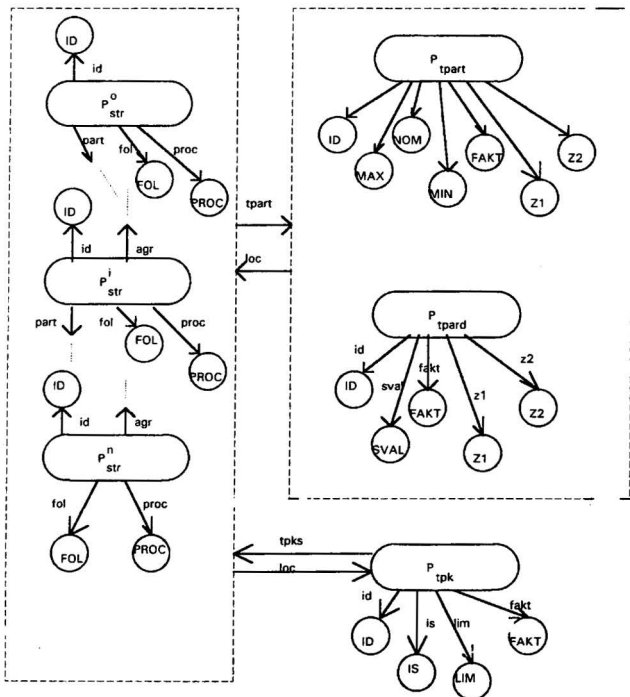


Fig. 1. The intentional structure of specialized semantic network

To represent the process of detection of TO conflict states the specialized semantic network is extended by the production rules. It is based on two specialized concepts:

P_{KONT} - defines the conflict context composed of set of input parameters in fixed states caused the conflict states of corresponding qualitative parameters;

P_{PR} - defines the predicates composing the antecedent part of production rules.

Concept P_{KONT} has the properties:

$$P_{KONT} : (ID, PRS, KE)$$

where ID - identifier of conflict context represented by instance of concept analyzed;

PRS - denotes the existence of set of instances of concept P_{PR} corresponding instances of concept P_{KONT} . It represents the inclusion of predicate sets to instances of concept P_{KONT} ;

KE - defines the existence of presence factor corresponding to each conflict context and each instance of concept correspondingly. The presence factor represents heuristic expert estimation of TO conflict state presence caused by specific conflict context.

The properties of concept P_{PR} may be defined:

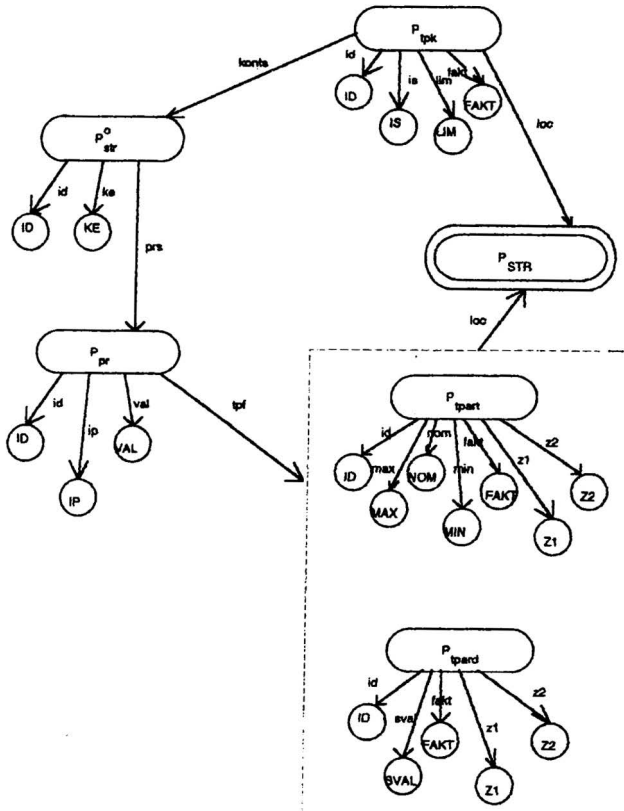
$$P_{PR} : (ID, TPF, IP, VAL, KI)$$

where ID - identifier of predicate represented by instance of concept P_{PR} ;

TPF, IP, VAL - define structure of predicate represented by instances of concept P_{PR} . There TPF defines identifier of input technological parameter which factual value expresses the causal side of production rule, IP defines the comparison operator, VAL defines the constant, the set of constants, reference of technological parameter normative limitations or reference to procedure making some calculations on factual and normative values of technological parameters;

KI - defines the existence of influence factor corresponding to each predicate represented by instance of concept. This influence factor represents the heuristic expert estimation of degree of participation of conflict context component (predicate) in the appearance of conflict state.

Insertion of production rules extension to specialized semantic network is presented in figure 2.



In summary, the intentional structure of the semantic-production network may be defined as follows:

$$\text{SPS}_{\text{INT}} = \langle P, R \rangle$$

where P is set of concepts, R is signature of relationships.

Components of SPS_{INT} have structure:

$$P = P^{\text{ST}} \cup \{P_{\text{KONT}}, P_{\text{PR}}\},$$

$$R = R^{\text{ST}} \cup \{\text{prs, lce, tpf, ip, val, ki, konts}\}$$

Without relationships defining properties of semantic network and concepts P_{KONT} and P_{PR} the signature of relationships R includes the relationship *konts*. It defines inversion of causal relationship between concepts P_{KONT} and P_{TPK} . This relationship specifies the multivalued reflection of instances of concept P_{KONT} to instances of concept P_{TPK} . In intentional structure of semantic-production network the inversion of this relationship must be used, because conflict situations in TO are detected by determining causes of conflict states of qualitative technological parameters. Therefore concept P_{TPK} acquires additional property *konts*, defining the existence of corresponding set of instances of concept P_{KONT} .

The semantic production network defined above permits structuring of knowledge about TO, supports developing of effective inference mechanism [3] and utilization of specialized method for knowledge acquisition and knowledge base construction.

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EKSPERTINĖS SISTEMOS, SKIRTOS KONFLIKTINĖMS SITUACIJOMS TECHNOLOGINIAME OBJEKTE SPREŠTI, ŽINIŲ MODELIS

Santrauka

Straipsnyje analizuojamas diskretus-tolydus technologinis objektas, jo pagrindinės struktūrinės ir funkcinės savybės. Formaliam technologinio objekto aprašymui panaudotas struktūrinis-funkcinis SF-modelis.

Struktūrinė modelio dedamoji atspindi technologinio objekto vidinę hierarchiją: objekto sudėtinės dalis, technologinius parametrus ir santykių tarp jų aibę kiekviename hierarchijos lygyje. Išskiriamos dvi technologinių parametrų klasės: įėjimo ir kokybiniai. Pateikiamos šių klasių charakteristikos.

Funkcinė SF-modelio dedamoji charakterizuoja technologinio objekto funkcinį valdymo procesus. Pateikiama situacijos technologiniame objekte charakteristika, jos analizės ir valdymo sprendimų gavimo principai.

Technologinio objekto SF-modeliui atvaizduoti ekspertinės sistemos žinių bazėje siūlomas semantinis-produkcinis tinklas, sudarytas iš specializuoto semantinio tinklo ir produkcinų taisyklių. Struktūrinė SF-modelio dedamoji vaizduojama specializuotu semantiniu tinklu, o funkcinės technologinių parametrų priklausomybės aprašomos produkcinėmis taisyklėmis.

Darbe pateikiama semantinio-produkcinio tinklo intensionalo struktūra, apibrėžiamos pagrindinės sąvokos ir jų savybės. Šis tinklas leidžia sukurti efektyvų sprendimų gavimo mechanizmą, palaiko žinių įgijimo ir žinių bazės formavimo procesus.

KNOWLEDGE STRUCTURIZATION PRINCIPLES TO RESOLVE THE CONFLICT SITUATIONS IN THE TECHNOLOGICAL OBJECT

Summary

In this paper the technological object of partial unremmiting type is analysed, its main structural and functional properties are detailed. The formal description of technological object is presented by using the structural-functional model (SF-model).

The structural component of model describes the structural hierarchy of technological object, its components, the technological parameters and the set of relationships of these structural components. The classes of entrance and qualitative

technological parameters are declared and the properties of these classes are presented.

The functional component of SF-model characterize the functional-control processes of technological object. The description of conflict situation in the technological object, the principles of it analysis and the control decisions inference is presented.

The semantic-productional network is proposed to represent the SF-model of technological object in the knowledge base of expert system. This network is composed of the specialized semantic network and semantic rules. The structural component of SF-model is represented by the specialized semantic network, while the functional dependencies of technological parameters are expressed by production rules.

The intensional structure of the semantic-productional network is disclosed, the set of concepts and they properties are described.