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Application of a Production a Network for Obtaining Information on the Reasons of Appearance of Defects and Ways of its Elimination

A.V. Matokhina and A.V. Kizim
Volgograd State Technical University, Volgograd, Russia

Abstract: In study application of two methods of representation of knowledge for obtaining information on the reasons of appearance of defects and ways of their elimination is considered. The first to diagnostics of defects applied a method of representation of knowledge on the basis of production model. In study process of creation of the knowledge base is considered, its contents are described and the fragment of a tree of production model is given. The example of research of expert system is given. Shortcomings of the created production model and possible ways of their elimination are considered. Development of a semantic-framed network became the following step on identification. In study options of automatic formation of a semantic network for defect diagnostics are considered. The module of creation of a network from documentary sources is described. The maintenance of a semantic-framed network and its set-theoretic description is described. The example of representation of frames is given. The fragment of a network is offered and process of extraction of knowledge and Semantic-Framed Model for search of the reasons of emergence of defect is described.

Key words: Artificial intelligence, production model, Semantic-Framed Model, slots of frame model, expert system, automatic processing of documents in a natural language, extraction of knowledge from model, modernization, elimination of defects

INTRODUCTION

Now in different branches of production the problem of detection and elimination of constructive and technological defects that is well reflected in works is particularly acute enough (Bailey *et al*., 2000; Leszak *et al*., 2000; Xie, 2008; Voronin *et al*., 2013). Difficult and sometimes it is also impossible to determine precisely and in due time a number of technological parameters. This study is also devoted to the solution of similar questions. Practical approbation of the received theoretical results was carried out on manufacturing techniques of castings.

Until now there is open a question of improvement of quality of molding and modernization of manufacturing techniques of castings. First of all castings should not have foundry defects to which sinks, cracks, veining, porosity, insomnia and others. A number of obvious defects identified in foundries, others in machining or during operation, significantly more dangerous. Analysis foundries shows that the production of castings suffer significant losses from casting defects.

The main reason for defective products consists in lack of system when developing technical processes of production of castings and the more, so at elimination of defective products casting (Voronin *et al*., 2013). This or that approach, effective in one situation can lead to emergence of defective products in another. Information on design of manufacturing techniques of castings described in literature does not contain full instructions for the modern equipment. In too time, when using in the course of production of the new equipment work the same principles of improvement of quality of castings. An important stage of improvement of quality of castings is definition of communications of the reason of emergence of defect with stages of manufacturing techniques of casting at which there was an emergence of defect (Voronin *et al*., 2004; Pandit *et al*., 2012). Thus, it is possible to allocate key stages of modernization of manufacturing techniques of the casting allowing to receive high-quality castings with use of the available equipment only due to correction of technology (Ramu *et al*., 2012; Saikaew and Wiengwiset, 2012; Creese *et al*., 1986). The technique of search of the reasons of appearance of defects and the corresponding ways of their elimination with use production and semantic-framed representations of knowledge is developed for these purposes. Are provided the description of the knowledge presented in models and also conclusions by results of application of models for modernization of manufacturing techniques of castings in study.

Corresponding Author: A.V. Matokhina, Volgograd State Technical University, Volgograd, Russia

The description of production model of methods of modernization of technology for elimination of defects: On the basis of production model of representation of knowledge the knowledge base on processing methods of modernization of manufacturing techniques was developed. Target object is the single technological decision eliminating the defect reason. The three "Object, Attribute, Value" estimates extent of emergence of defect in case of the validity of a condition.

On each of values of attribute of the chosen object in a tree of production model the probability specifying extent of its influence on possibility of defect is set. Probability indicates the possibility of obtaining a priori values for the true non-defective castings approval given by the triple "Object, Attribute, Value". In the process of inference ES recalculates, the values of probability on the posterior using Bayes' theorem. The truth of the fact the user is estimated on a scale from 5 to 5, step 1 wherein the a posteriori probability is determined by the fact of from 0-1 in increments of 0.1, respectively. If the value of facts unknown to the user, the system considers it a posteriori probability is a priori. In this case, the probability of the truth of the conditions specified in the case of withdrawal of the truth and if it is false. On the tree indicates a priori probability of the truth of certain facts troika "Object, Attribute, Value". For convenience in tops of the tree identifies the issues requested by the system user. The structure of the knowledge base contains a table of facts, rules and values and the file text description of production rules model search techniques elimination of defects.

The fact table contains the object and its attribute value. For the organization of the production model, the table includes: the question asked by users, supporting files that accompany the question, a text file with the information, photos. The model may contain different types of questions: alternative, numeric with a call auxiliary procedure Boolean (Table 1 and 2).

Another table production model the "rules". The Table 2 contains the rules of logical formulas, the conclusion by the rule in the case of a positive outcome and the conditional probabilities of acknowledgment and denial of the hypothesis.

In general terms, the rules of logical formula is as follows: The rules: (Hypothesis 1) and (Hypothesis 2) AND ... AND (Hypothesis N) TO (Fact); P+: Chance events when the facts P: probability of an event at refuting facts. The example of a logical formula of the rule allows to define sequence of hypotheses which demand confirmation for achievement of the fact.

Example rule: The 02401, 02501, 02601, 02701, 02901, 03001 and 03101, TO 12206; P+: 0.8; P: 0.4. Presented in example rules described in the fact table.

Table 1: Facts production model

Fields	Length	Type	Description
ID_fact	5	Num	Number fact
Object_fact	100	Char	Object
Atribut_fact	100	Char	Attribute
Importance_fact	40	Char	Meaning
Transcription_fact	100	Char	Question asked by the user
Inf_txt	10	Char	Text file with information on
Inf_pic	10	Char	Picture file accompanying question
Answer_txt	10	Char	Text file with information on the response
Answer_pic	10	Char	Picture file accompanying response
Id_ question	1	Num	Type of question
Answer_exe	10	Char	File library of design parameters
P_par	3	Float	Priori probability

Table 2: Table rules

Fields	Length	Type	Description
ID_rul	3	Num	Number rule
Formula_rul	500	Char	Logical formula rule
Conclusion_rul	100	Char	Conclusion
P_plus	3	Float	The conditional probability of a hypothesis is confirmed
P_minus	3	Float	The conditional probability of negation of the hypothesis

Testing methods of production model of modernization technologies to eliminate defects in castings: Originally based on the production system was developed knowledge base for technological modernization of technology techniques for making castings. The knowledge base contains information about the methods the elimination of defects of castings gas origin. If no apparent cause of defect associated with errors in the implementation of the technology calculates the gas pressure. If the pressure is normal, the system recommends to recheck the process parameters such as the storage conditions of the forming material and the basic parameters of the fill. If the pressure is greater than normal, the system organizes a variety of technological methods of elimination of the defect. If the complexity class allows you to perform the vents, the system recommends that you design them, otherwise, you choose another way to eliminate defects. When choosing a method to resolve the problem of ES can provide advice, comments and descriptions to ask questions which allows the user to increase the level of trust. Detail of a table of values "Object, Attribute, Value" is shown in Table 3.

At the beginning of the existence the production model totaled about 70 rules constructed on 150 facts. Subsequently, the model started expanding. Finally, there was a situation at which the rules contradicting each other began to appear. After that the decision to find other ways of submission of information and more visual teaching methods of its representation was made. As an alternative way of representation of knowledge the Semantic-Framed Model is chosen.

Table 3: Detail of a table of values

Objects	Attributes	Values
Rods form	Pressure	Calculated value formula
Rods	Class complexity	Appendix 3
Rods	Gas permeability	100 and 150 pcs
Rods	Weighing	>30 and <30 kg
Rods	Reduced length	Calculated value formula
Production rods	Curing of	in a snap in a dryers
Sand	Fraction	Large, small and medium
Repair of the rods	Gluing of a break	Across the surface, the edges
Gas outlet channels	Quantity on weight	Calculated value formula
Gas outlet channels	Paint availability	Yes, no
Gas outlet channels	Communication with the atmosphere	Yes, no
Mixture	Moisture content	<4 and >4%
Mixture	Amount of clay	Pcs.
Mixture	Quantity of a binder	Pcs.
Mixture	Amount of ground coal	Pcs.

SEMANTIC-FRAME MODEL DIAGNOSING DEFECTS

Description of Semantic-Frame Model of diagnosis of defects of castings: Classification of casting defects in researches by Voronin *et al.* (2013) and Voronin (2010, 2011). They describe the methodology which allows using a systematic approach to accurately determine the variety of defects, the stages of their formation and elimination methods. Identifies several major groups of defects cracks, shrinkage defects, blowholes, etc. For each of the groups of defects are allocated separate species occurrence describes the processes and methods of elimination discussed specific castings. All descriptions with photographs of defective castings and various schematic representations of processes (Voronin, 2011).

After the analysis of the presented methodology, it is revealed that various groups of defects have the general communications of the reasons of emergence and ways of elimination. In this regard, the task to unite in the general system of the reason of emergence of various groups and kinds of defects to establish connection with manufacturing techniques of castings and to define universal ways of elimination of defects is set. The semantic network was under construction on the example of casting "A frame lateral" carts of freight cars in which many kinds of defects can be formed.

Effective way of the solution of this task is development of semantic model of communication of the reasons of emergence and ways of elimination of defects of castings. A semantic network the information model of subject domain having an appearance of the focused count which tops correspond to objects of subject domain and arches (edges) set the relations between them. Objects can be concepts, events, properties and processes.

For representation of subject area in the form of Semantic-Framed Model of representation of knowledge as tops, we will describe the possible defects of castings, factors influencing their emergence (including elements of manufacturing techniques of castings) and as arches (directed) we will describe interrelations between them which or lead to defective products emergence or reduce probability of its emergence. Thus, the semantic network reflects semantics of subject domain in the form of concepts and the relations.

One of the most important advantages of use of semantic models consists in formalization of text recommendations about elimination of defect in an evident schematic look.

At creation of the count freely distributed software of GraphViz which allows in the text of the description of the count in the DOT language was used to construct graphical representation of a semantic network.

As an experimental analysis of the object has been selected casting "Rama side". According to the analysis of literature constructed semantic network comprising basic defects that may occur in the casting as well as elements of the technology of the casting as for example, capture nonmetallic inclusions (moldable mixture, slag erosion ceramic, etc.) getting into the casting together metal.

Final knots of this model are concrete elements of manufacturing techniques of casting. For representation their quantitative (the sizes, weight, etc.) and qualitative characteristics the decision to use frames was made. From the point of view of semantic model, the frame allows to present essence as the structured objects with the named cells and the related values. In a general view the frame can be described in the line: <IF, (IS, TD, ZS), ..., (IS, TD, ZS)> where IF: a Frame name; IS: a Slot name; TD: Type of Data of the slot; ZS: Value of the Slot.

As names of frames it is used concrete elements of technology for example: filling time, hardening type. The characteristic of an element of technology is specified as a name of the slot and its value for example for a frame of the slot describing the qualitative parameters "Hardening Type" a name "The hardening type" and the value of the slot its options "Directed"or "Volume" serves. As definition of the slot data of the following types can be applied:

- Text (text) or List (list) for determining the quality characteristics
- Lisp (attached procedure) or Expression (expression) in case of need calculations of parameters for example for definition of time of filling or the estimated size of the elements of gating system
- Integer (whole) or real (material) to determine the numerical value of the parameter

- Range (Range) interval quantitative values of the slot
- Bool (Boolean) for determination of value of type yes/no

For example, when determining an element profit, the slot "Existence" matters "Yes" that means its obligatory placements. Respectively at comparison of the values received from the user in the analysis of technology the indication of value of this slot "No" will mean possible existence of defect "The closed shrinkable sink" that it is possible to track on a set, other option of the semantic network considering emergence of nonmetallic inclusions. Specifically, the network is constructed by a fragment "Defect could be formed when using a gating system without elements for a hunt for nonmetallic inclusions and also from the insufficient durability of forming mixture and the feeder increased by the size causing washout of a form. Defect is corrected using the keystone in the gating system and centrifugal slag catcher".

As in this model, we have the final knots describing both qualitative and quantitative characteristics for determination of values of quantitative characteristics as the Attached Procedures (AP) we use mathematical models of calculation of elements of the technological project of production of casting (Leszak *et al*., 2000). As input parameters for the attached procedures, we use characteristics of the made casting. For example, the frame example "Feeder" with the parameters determined in the attached procedure of mathematical model of calculation of elements of gating system is presented in Table 4.

The semantic model contains links causes the defect and the elements of manufacturing techniques for casting all varieties of defects that can occur in this casting.

The program of machine translation of texts in a limited natural language in a semantic network: For automatic analysis of natural language documents and translations in the language format (dot) translator designed to help you analyze proposals on limited natural language which includes transfers, lists conditions. The program allows you to translate the text not only in the format (dot) but in the format (html). Translated into a format (html) performed for the selected concepts in the semantic network based on a user-specified number of levels of translation.

The algorithm of automation of the translation of naturally language text in the dot format contains the following steps: algorithm of automation of creation of semantic model the following:

- Get the input sequence in a natural language
- Split into lexical units

Table 4: Frame "Feeder"

IF (element technology)	Feeder	Parameters
EC (the characteristic of the element)	ZS (value features)	PP (model calculation)
Type casting	Swivel bucke	-
Number of feeders	8	-
Height	1.4 mm	Calculation PM
Feeder width	6.5 mm	Calculation PM

- In case the lexical unit is not defined to give to the user opportunity to define it (either it is a synonym available or it is a new lexical unit of a certain category)
- To define rules of grammar of a source language to which the offer submits
- If the rule isn't defined to pass the offer
- Proceeding from the rule to make a document transfer in a semantic network

The screen form of the program is shown in Fig. 1. The database is developed for convenience of work and the accounting of synonyms of concepts of a semantic network.

Use of the developed module allowed to organize automatic formation of a semantic network that allowed to increase the sizes of a semantic network. Semantic-Frame Model was applied to automatic formation of texts of the training systems having hierarchy of an enclosure of concepts and transitions.

Possibilities of application of Semantic-Frame Model of representation of knowledge: Having studied, the presented scheme can be defined at what development stage of the technological project there were mistakes which led to defect emergence. Having united all similar schemes for concrete kinds of defects having described quantitative and qualitative values of parameters of manufacturing techniques of casting in the form of frames, we will receive the general scheme of communication of the reasons of appearance of defects and elements of manufacturing techniques of a detail, taking into account their quantitative characteristics.

This scheme will help to define ways of elimination of defect and can become a basis of the expert training system in which knots of semantic model can become information articles, the manufacturing techniques describing an element and ways of the prevention of emergence of defect because of its wrong design. Frames of quantitative characteristics will be able to specify concrete values of parameters of manufacturing techniques of castings at which appearance of defects is possible.

For the purpose of modernization of technology the questionnaire to model knots allowing to define

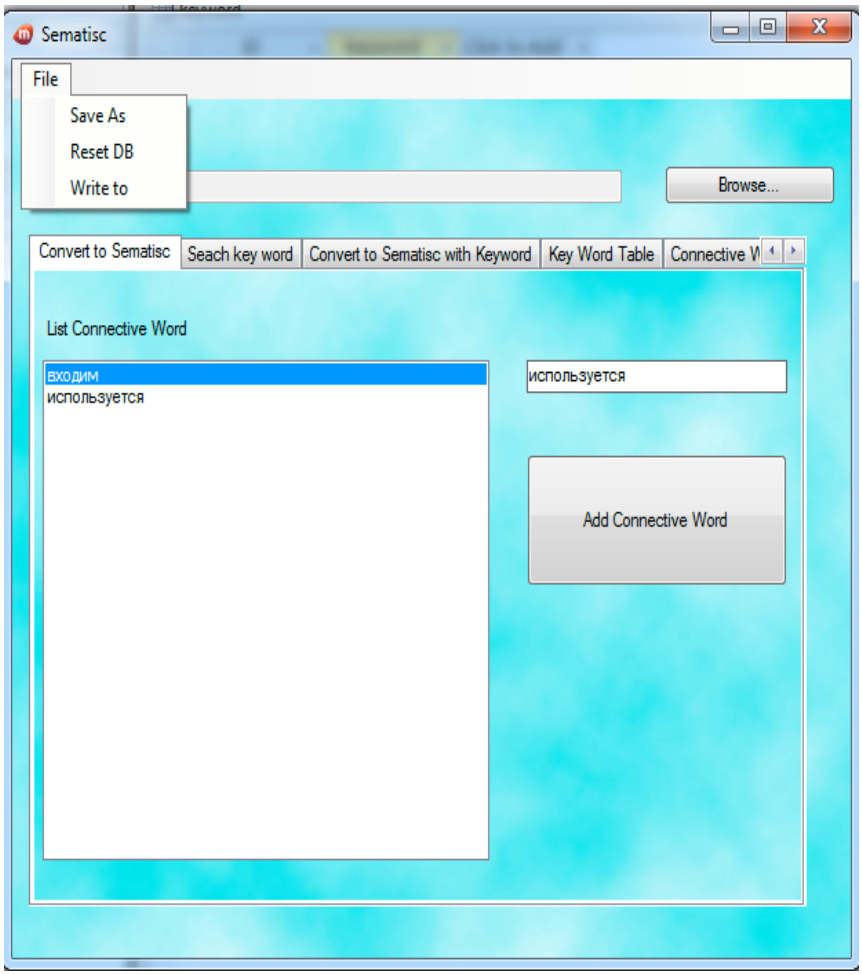

Fig. 1: Screen form of the program

Table 5: Fragment of the questionnaire of definition of characteristics of technical process

Questions	Data type	Communication with the node model
Whether the gating system has a slag catcher?	Bool	Absence slag catcher
What is the temperature of the cast metal (C)?	Integer	Increased temperature casting metal, low temperature casting metal
Is the carbon content in the metal (%)?	Real	Increased carbon ratio, low carbon ratio
What type of hardening used?	List	Lack of the directed hardening, lack of volume hardening
Profits are used?	Bool	Lack of profit
Refrigerators are used?	Bool	Lack of the refrigerator
It is used slag catcher devices of filling of metal?	Bool	Lack of the slag catcher of ladles

characteristics of technical process is created. The fragment of the questionnaire is presented in Table 5.

Pass through the nodes semantic framing network will determine not only the cause of the defect but the methods and technology upgrade. Modernization strategy is determined through convolution with the characteristics of the selected nodes technology with deviations. On the resulting network is easy to see the characteristics of the defect and its causes.

CONCLUSION

Application of the developed models is connected with complexity of the organization of the process of search of methods of modernization. So for example, application of Semantic-Frame Model is connected with need of search of knots of a deviation of technological parameters that with growth of model leads to increase in time. Finally, it is possible to judge that application of these models possibly on condition of their limited size. But, modern conditions of production and regular

updating of the equipment it is connected with need of introduction of new knowledge for model. Thus, it is possible to draw a conclusion on need to use the new methods of representation of knowledge not subject to problems of increase in volumes of information stored in them and existence of the unified language of inquiries to the knowledge base. Such option of representation of knowledge is the ontology (Denisov *et al*., 2013). As further development of the received results comparison of the received models to models on the basis of fuzzy logic and expansion of a scope of the received results on area of operational defects is conducted now (Denisov *et al*., 2014; Panteleev *et al*., 2014).

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