International Journal of Advanced Biotechnology and Research (IJBR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-7, Issue-2, 2016, pp710-716
http://www.bipublication.com

Research Article

Expert Diagnostic System Maintenance of Complexe Quipment in the Life Cycle

V. Kizim, A. V. Matokhina, V. A. Kamaev B.A.,
Y.F.Voronin and Le Thanh Tung Nguyen
Volgograd State Technical University
Russia, 400005, Volgograd, Lenin Avenue, 28

[Received-09/06/2016, Accepted-22/06/2016, Published-30/06/2016]

ABSTRACT
In this article, we propose a diagnostic methodology for complex systems based on the technical condition of the life cycle. We also present an approach to solve problems of the technical system condition diagnostic. The description of multi-agent system used for diagnosing the technical condition of complex system. An integrating approach to the diagnosis of technical system throughout life cycle described. The structure of production-frame model for represent knowledge using fuzzy rules and a fragment of production-frame knowledge base for printer condition diagnosis-shown in this paper.

Keywords: lifecycle, condition diagnosis, technical system, knowledge base, intelligent system, expert diagnostic system, multi-agent system, production-frame model, modernization, maintenance, repair, monitoring, exploitation.

1.INTRODUCTION
In recent years due to the global economic crisis, the issue is especially acute in reducing manufacturing cost and increasing the productivity of enterprises and organizations. Thus, creation of new methods to improve performance is a pressing challenge. A significant effect can be obtained by adopting not only the existing methods to improve productivity, but also experience analysis results of their application in various industries and service. The performance of any enterprise depends on the efficiency of its equipment provided by the rational exploitation, high quality, timely and safe technical maintenance and repair, equipment modernization making rational use of resources. The challenge of effective equipment exploitation, maintenance, repair and modernization throughout its life cycle is essential for enterprises and organizations in different industries (common industrial, material handling, electrical, mechanoprocessing, petrochemical, pipelines, boilers, pump equipment, ventilation systems and other types of engineering equipment).

From contemporary Russian researches on the methodological support for the tasks of the organization exploitation of technical systems, exploitation of technical systems deserve more attention on works by Yashchura A. I. [1], but they have quite common methodological orientation and do not provide a complete solution identified above actual problems.In international publications, there are methodologies for enhancing the efficiency of the equipment as Failure modes effects analysis (FMEA) and Failure modes effects and criticality analysis (FMECA) [2,3], Root Cause Analysis (RCA) [4,5], System Reliability Analysis, Fault Tree Analysis, Reliability Life Data

Analysis, Condition Monitoring and Condition Based Maintenance, Preventive Maintenance, Predictive Maintenance, Maintenance Task Analysis, “Reliability, Availability, Maintainability and Safety” (RAMS), Proactive Maintenance [6]. The most common of these are Reliability Centered Maintenance (RCM) [7], Total Maintenance Management and Total Productive Maintenance [8, 9]. These methods also have a general organizational direction and do not include the ways to assign to knowledge representation models of technical and organizational systems, and algorithm formalization of these methodologies for automation purposes (software and information support). Diagnostic problems of technical systems are solved mainly using intelligent and expert systems [11]. In the application of artificial intelligence to support the technical system exploitation, we can specify the work so authors such as RabchevskiyE. A. andArkhipov E. S. (An ontology-based expert systems, Vorozhtsova T. N.(The construction of software complexes for researching of heat and power systems using ontologies), PushchinM. N. (Development of Concept Tree modelfor knowledge representation and control providing a predetermined functioning level of man-machine control systems),Gorbunova V. V. (Development of modular ontological system technology determines mechanism design, functioning and development of the network distributed simulation of management systems using declarative ontological modules) and ArtemyevaI. L. (Development of methodological principles for building multi-level and modularontology of hard-structured area). [14]

However, the specified models and methods have limited application in separate industry or stage of life cycle. There are also contradiction in the area of project and information models about the exploitation of technical systems, and information gap between CAD and EAM/ERP systems.

2.Research methodology

Nowadays, technical systems have been developed and improved their functionality. Increasing functionality leads to emergence of large number of heterogeneous data needed for the analysis of technical system condition. For each of the technical system, it is very important and reasonable to determine opportunely the time of performing technical maintenance and repair (M&R), appropriate procedures and time schedule are developing based on M&R. However, functioning parameters throughout life cycle of technical system deteriorate, which can lead to technical failure.

The established planning system M&R becomes inadequate. Therefore, decision-making approval for diagnostic problems becomes a necessary stage in the control process of heterogeneous information growth in contemporary society and the complexity of the control object.

The approaches combine to achieve artificial intelligence, fuzzy logic, data mining and others must be used to improve the efficiency of diagnostic procedures. One of the main objectives in creating diagnostic expert system is in the forming and structuring of knowledge system of research object domain.

3.Diagnostic method for technical system throughout the life cycle

Diagnostic of technical system is associated with the analysis of its condition. Monitoring of the technical system allows getting complete information about its condition. Specialists make subjectivity into the process and permit appearance of the unnecessary mistakes, which can lead to additional expenses performs condition diagnosis.

Diagnostic process of technical system begins with monitoring and scheduling its components and systems. At present, self-controlling and monitoring systems are actively developing and implementing. For examples, temperature, pressure, liquid level, engine speed monitoring systems pressure, etc.

However, their use increases the cost of maintenance and personal qualification. The automation system on the scheduling stage significantly improves efficiency and reduces the cost of eliminating denials of technical system.

For scheduling, we propose to use multi-agent systems implemented as hardware and software complex. The basic idea of multi-agent scheduling system is the organization of condition system self-control using specialized agents. Architecture presented to implement the condition diagnosis of technical system and appropriate software support system as shown in Fig. 1.

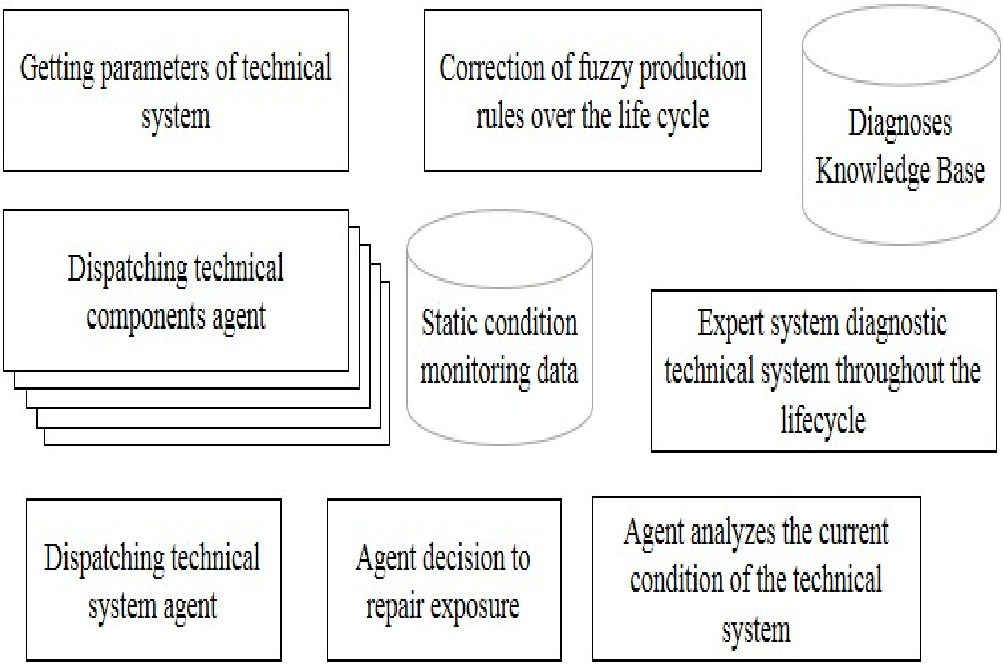

Figure 1 –The structure of diagnosis system for technical system throughout life cycle

4. Description of the TS expert diagnosis system

The methods of mathematical statistics for diagnosis based on the use of experimental data. Problem of diagnosis is formulated as an expert classification of objects and their condition is described by a set of diagnostic symptoms [13, 14]. In general, the logical structure of the problem can be represented by a graph. At each node of the graph is set one condition (solution of problem) of diagnosis, which is defined as a set of diagnostic solutions with probable estimate of the establishing diagnosis.

The process of expert classification is represented as a movement from one node of graph to other in depending on the answers to questions according to identified criteria. While appearance of new symptoms occurs, the process of diagnosis is repeated. Thus, diagnostic expert system (ES) defines the graph's status, condition of diagnosis is located on nodes of graph and arcs specify the way to manage the change of conditions.

An ES is developed for automation of diagnostic. A hybrid model of knowledge representation is used to build an expert system.

Hybrid knowledge base was built using frame models and fuzzy production rules. Frame model used to describe the area of diagnosis and provide statistical information about the condition of the TS (quantitative estimates of symptoms, quantitative integral estimates of the probabilities for the various diagnoses based on the identified symptoms).

Fuzzy production knowledge base contains descriptions of cause-and-effect relations linking diagnoses with symptoms complexes

Condition of the investigated object is described by a set of symptoms with the input estimates on the scale, and status of diagnosis of the condition is a set of possible classes of diagnoses with output estimates on the scale.

A single quantitative scale [0.0; 1.0]is used to assess the strength of manifestation of symptoms and establishing diagnosis.

Frame-based knowledge base describe the field of diagnostics (group of diagnoses, diagnoses, group of symptoms, individual symptoms), and also used to present statistical information about condition of TS (quantitative estimates of the strength of symptoms, quantitative integral estimates of the probabilitiesfor the various conditions based on the identified symptoms).

The knowledge base is specified as follows:

KB =

FC,FSD,FSM,FSS,FSC,$\{FID_i\}$,$\{FIM_j\}$,{FISk },{FIGh },{FICl},

where:

FC – Frame-class;

FSD – Frame-prototype of diagnoses;

FSM – Frame-prototype of diagnoses group;

FSS – Frame-prototype of separate symptoms;

FSG – Frame-prototype of symptoms group;

FSC – Frame-prototype of symptoms complex;

$\{FID_i\}$ –Frame-instance of diagnoses collection;

$\{FIM_j\}$ – Frame-instance of symptoms groups collection;

{FISk} – Frame-instance of separate symptoms collection;

{FIGh } – Frame-instance of symptoms group collection;

{FSCl} – Frame-complex of diagnoses collection.

Frame-class is defined by name and set of slots as follow:

FC = NFC,{NS,TS,VS,$\{PDS_i\}$,$\{PMS_j\}$},

where: NFC – frame-classname; NS – slotname; TS – slot data type; VS – slot value;

$\{PDS_i\}$ – collection of domains performed by accessing to the slot value; {PMS j}

– attached procedure collection.

Fuzzy production rule is defined as follows:

FR = NFR,{ LVS_i,LTS_i}$\rightarrow$ LVD,LTD,ω,

where: NFR – name of the fuzzy production rule; LVS_i, LTS_i – linguistic variable ofi-th symptom and its linguistic term from the premise of fuzzy production rule; LVD,LTD – linguistic variable of condition and its linguistic term from the decision of fuzzy production rule; ω – weighting coefficient of fuzzy production rules.

Diagnostic process is described as follows:

Step 1. Select group of diagnoses or symptoms as appropriate (according to history of investigated object diagnosis and others).

Step 2. «Condition of object learning»cycle:

Step 2.1. Execute the questions' generation byguiding symptoms.

Step 2.2. Enter input estimate so strength of theleading symptom.

Step 2.3. Calculate the integral estimates of the presence of possible diagnoses.

So far, if diagnostic decision is not established, go to step2.1.

Step 3. Diagnostic decision-making (list of showing symptoms and diagnostic hypothesis).

Step 4. Displaytheproposed diagnostic decision.

A diagnostic expert system for printer was built for approbation and implementation of obtained design solutions.

Figure 2 shows a fragment of knowledge representation for printer error diagnosis using hybrid knowledge base.

The main frame-prototypes are: PrototyeDiagnosis, PrototyeDiagnosisGroup, PrototyeSymptom, PrototyeSymptomComplex. Examples of diagnoses, symptoms and fuzzy rules (If-then) also are shown in Fig. 2.

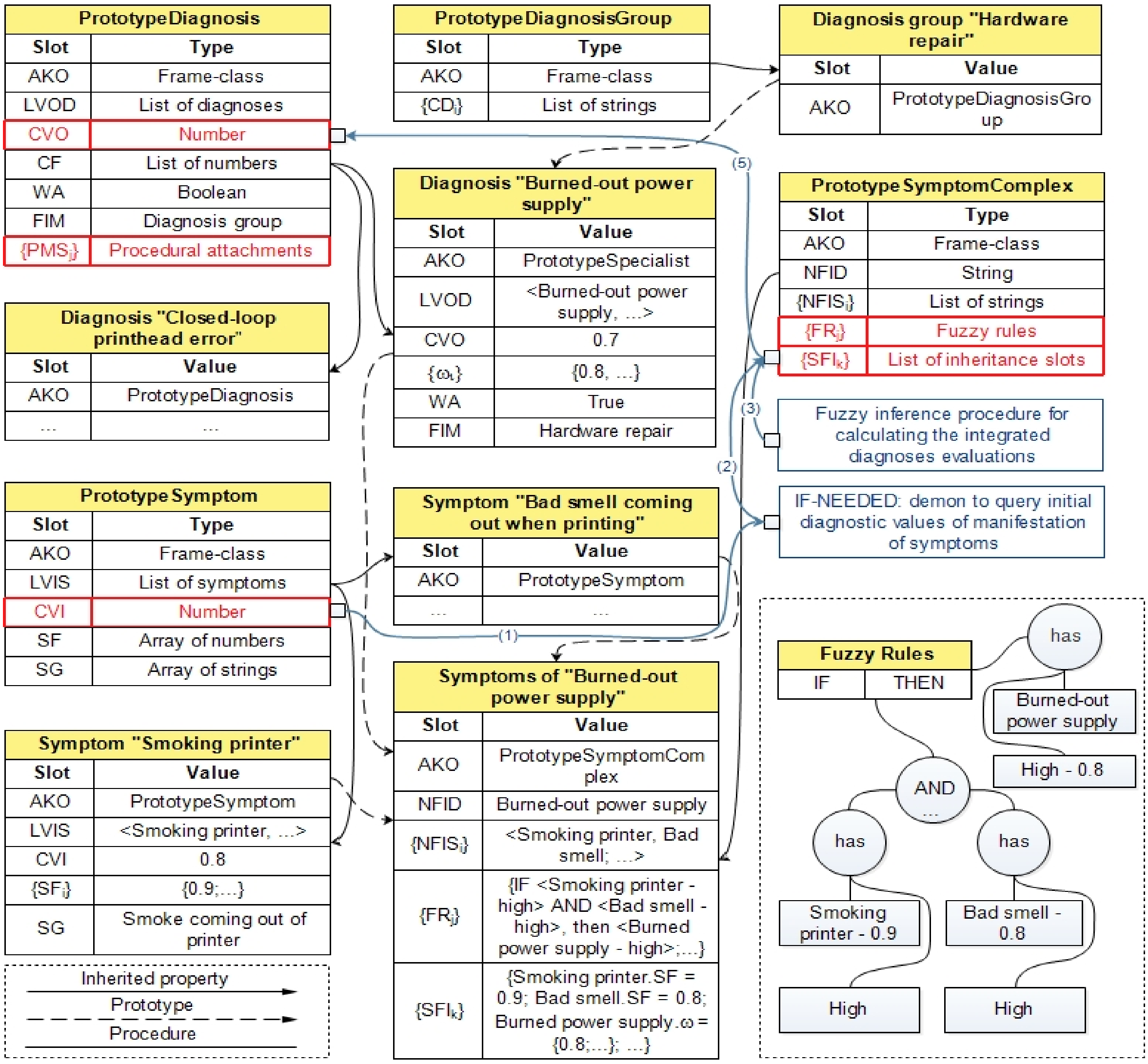

Figure 2 –Knowledge representation for printer diagnosis using the hybrid knowledge base

5. CONCLUSION

Problem statement in management of the equipment exploitation is formulated in carrying out project. Therefore, a knowledge representation and reasoning system in combining with knowledge representation models about the structure, parameters and system functioningis built. Hybrid models of knowledge representation combining the use of Frame and Fuzzy production models are implemented to solve complex tasks such as diagnosing a technical equipment condition in its life cycle. New methods for management equipment operation is presented based on obtained models and allow maximizing the performance efficiency of their usage and return of investments throughout life cycle of technical systems. It is also developed and adapted methods of monitoring and decision making support.

The developed models and methods are investigated and used in management of exploitation and modernization of distributed systems, industrial equipment, transport vehicles, and the others for use in commercial and municipal, regional enterprises.

Results obtained in the support of the Ministry of Education and Science of the Russian Federation (project number 2.1917.2014K_2014 as a project part of the state assignment) and RFBR (project number16-07-0063516 A).

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