KNOWLEDGE MANAGEMENT SYSTEM FOR MARINE DIESEL ENGINE DIAGNOSIS

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Abstract

The paper presents the conception of knowledge management system for a diagnostic expert system. Development of knowledge management system is necessary during the construction of the expert system. The most important reason is that knowledge in this system is not a static whole, but is subject to dynamic growth, is modified and updated. Advantages afforded by the creation of diagnostic systems based on knowledge, such as expert systems, compared to traditional diagnostic systems based on closed algorithms were characterized.

The conception of knowledge management system established in the diagnostic work associated with the development of expert system for marine diesel engine diagnosis. The main elements of the developed management system are: dictionary editor, rule editor, knowledge assessment module and import and export module. Knowledge management system is also equipped with an electronic form that is used to obtain knowledge from experts, specialists in diesel engines operation. The article presents the tasks and the performance of individual components of the system. The knowledge management system enables integration within a single frame of both information collected from experts and automatically collected one. A doubtless advantage of expert system is the opportunity of updating and developing the content recorded in the database. Due to this feature, the effectiveness of the system may grow during engine operation and facilitate gaining new experience.

Keywords: *knowledge management system, diagnostic expert system, marine diesel engine diagnosis*

1. Introduction

The diagnostic expert systems are based on knowledge (Knowledge Based Engineering KBE). The knowledge is stored in the knowledge database to support the diagnosis of technical objects. Expert systems are usually sophisticated computer programs capable of obtaining and recording the diagnostic knowledge of a specific area of operation of objects. Knowledge can then be used repeatedly to perform tasks related to the area of operation.

The diagnostic knowledge for the expert system can be obtained from human experts or from diagnostic databases, which gathers information about the process of the objects exploitation. Collection and the formal record of knowledge is called knowledge acquisition process. The process of knowledge acquisition is implemented using dedicated methods and computer tools. Collected knowledge is stored in a computer in a particular form of representation [5].

During the work associated with the creation of the expert system, it is possible to use ready-made tools. There are now a number of packaged applications, called skeletal systems, which can greatly accelerate the construction stage of the expert system. Free environment for creating expert systems are not directly contain tools supporting the process of collecting and managing knowledge (Knowledge Base Management, KBM).

There is a possibility to use commercial tools, but primarily because of high costs, particularly for research purposes, it seems more reasonable to develop a dedicated knowledge management system for diagnosis. The advantage of that is flexibility and the ability to take into account the characteristics of the expert system application domain.

The conception of knowledge management system established in the diagnostic work associated with the development of expert system for marine diesel engine diagnosis. The system was developed in CLIPS environment. Knowledge for the system was represented in the form of rules.

The article presents the conception of the knowledge management system for diagnosis, describes the basic functions of the system and outlines the structure of developed knowledge database.

2. The conception of knowledge management system

During the construction works of the expert system for marine diesel engine diagnosis, there was a need to develop a dedicated system, which aimed to knowledge management. Knowledge in this system is not a static whole, but is subject to dynamic growth, is modified and updated. Additionally, the system allows the integration of knowledge obtained from two sources, and it is so king of an interface between different software environments.

The proposed knowledge management system allows the integration of knowledge obtained from experts and in an automatic way with inductions methods. Knowledge of specialists can be introduced into the system using the electronic form. Knowledge obtained in automatic way from ROSE 2 software [6][7], can be directly imports to knowledge management system.

Knowledge management system enables to update, add new portion of knowledge and their evaluation. The final effect of the system work is a complete knowledge database, including knowledge from the experts, and obtained automatically, in accordance with the format of the CLIP language. Thanks to this process inference can be conducted in the CLIPS environment.

Considering the conditions, assumed that the knowledge management system will perform the following tasks:
- enter and edit the dictionary attribute names, objects and faults,
- add new rules, view and edit the rules already saved knowledge database,
- assessment of the rules stored in the knowledge database,
- import rules to the knowledge database from the ROSE2 environment,
- export rules to the format of the knowledge database CLIPS environment.

Knowledge management system is also equipped with an electronic form that is used to obtain knowledge from experts, specialists in diesel engines operation.

The software was created in Delphi and, as an independent module, is a part of the diagnostic expert system for marine diesel engines diagnosis.

2.1. Dictionary editor

Dictionary Editor allows to view, edit and add names (synonyms and names of principal) of components necessary to record knowledge in the field of diagnosis of the marine diesel engine. The system can distinguish the following basic dictionaries:
- dictionary of names of object attributes used to create the conditions of the rules,
- dictionary of names of diagnosed engine components,
- dictionary of names of faults,
- dictionary of names of faults symptoms.

During the recording of knowledge by an expert it is possible to use the terms stored in dictionaries or create new one. In case of import of knowledge from the ROSE2 environment system automatically uses the default dictionaries.

2.2. Rule editor

A key element of knowledge management system is the rule editor. This editor allows to browse, edit the rules stored in the knowledge base and adding new ones. Sample rule editor window is shown on Fig. 1.

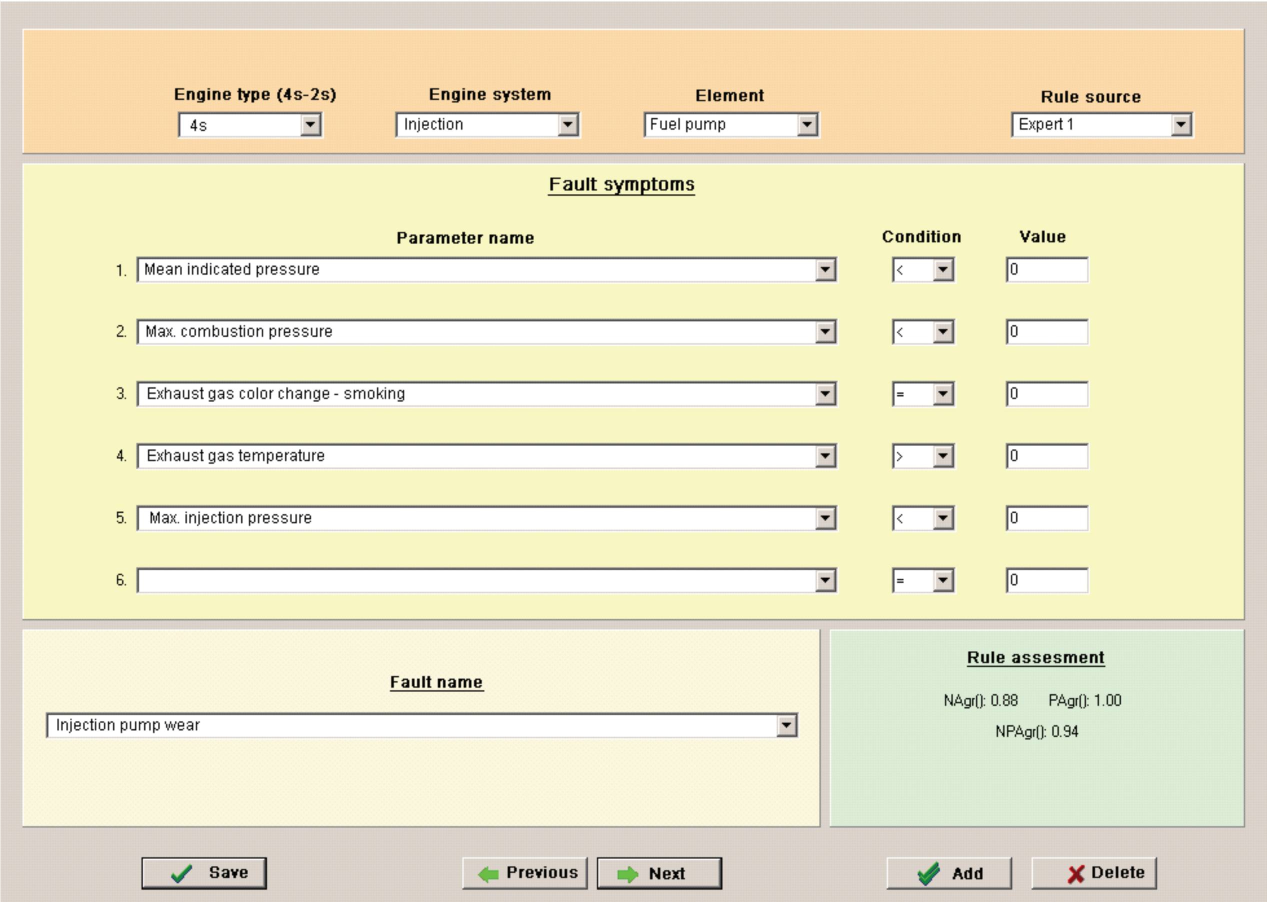

Fig. 1. Rule editor window

Creating a new rule is followed by the choice of the name attribute from the dictionary attribute names and determines the conditions and conclusions of rule. The condition of each rule may consist of up to 6 elementary conditions. In addition to the conditions of rule it's necessary to specify the class of engines, systems and component (example - class of engine: 4-stroke / system: injection / element: the injector).

2.3. Knowledge evaluation module

Evaluation of the rules has been implemented in accordance with the concept proposed by W. Moczulski [3]. Evaluation is based on assignment by a professional to each rule, the degree of subjective conviction of the rightness of the rule (Fig. 2). The system automatically generates the aggregation of assessment with assessments recorded in the knowledge database. Based on the aggregated assessment the degree of certainty is determined for each rule.

2.4. Knowledge import and export module

Knowledge management system is equipped with an automatic export / import module for rules stored in various formats. This module is a specific interface, which integrates a suite of programs of developed system and allows the transfer of knowledge between its elements.

The rules for the knowledge management system are imported from the ROSE2 environment, where their automatic induction is implemented. The rules are interpreted by a knowledge management system using the default dictionary of terms, and stored in the knowledge database.

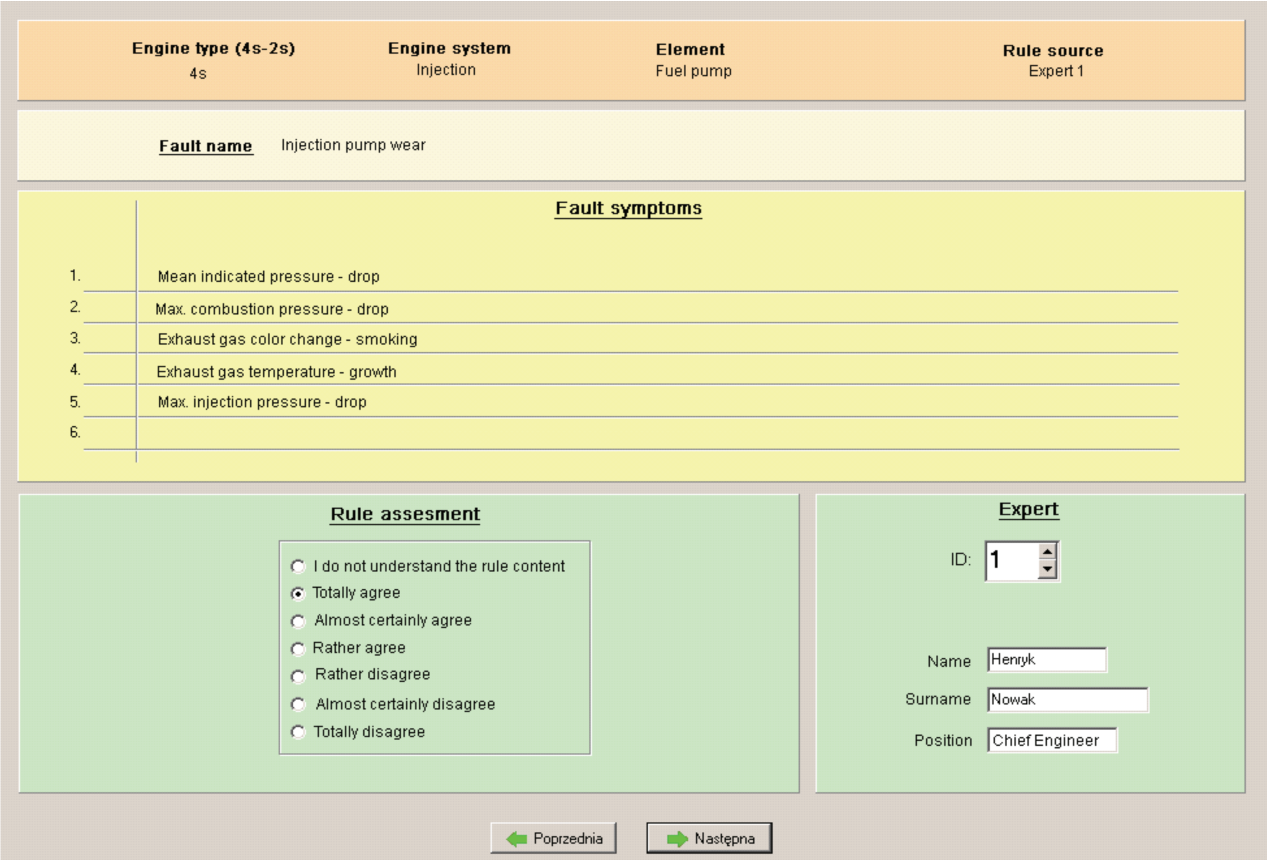

Fig. 2. Knowledge evaluation module window

The main task of the export module is to translate the knowledge database content (introduced by experts, and automatically extracted from the ROSE2 environment) to the CLIPS format. This operation is very important from the standpoint of the whole system. Its task is not only to record of the rules in a form acceptable by the CLIPS language, but also to generate the code needed to carry out the process of inference using these rules. In view of the fact that the detailed description of CLIPS syntax is not the subject of this paper, and is thoroughly described in the literature [1], [4], will be presented only the general concept of export knowledge.

In the first stage of the export of knowledge process, rules in CLIPS language format are created. As a result of the analysis of rules, facts list necessary to the process of inference is created. Then, the dialog functions are created, whose purpose is to determine the values of all the necessary facts in dialogue with the user. Additionally, during the exports, all the functions needed to implement the process of inference are created, such as initiating rules and terminating sessions with the user.

Schematic flow of knowledge within the system is shown in Fig. 3.

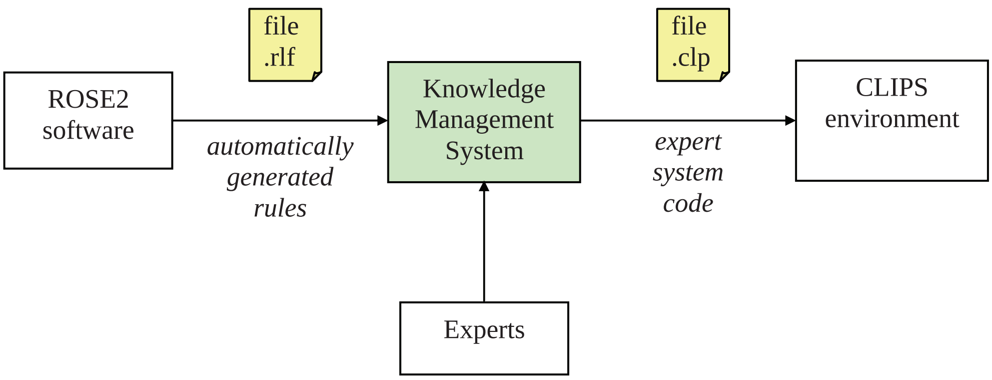

Fig. 3. Flow of knowledge within the expert system

2.5. The electronic form of knowledge collection

Knowledge collection from experts is difficult and time consuming task. The problem is the availability of experts and persuades them to cooperate. In the classical approach the knowledge acquisition is implemented using the questionnaires survey in paper form. In this case, it is necessary to perform the interpretation of the knowledge stored in the questionnaires by a knowledge engineer. Experts often use different concepts and terms to determine the diagnostic relations. Interpretation of knowledge through a common vocabulary of terms is labour intensive.

In order to facilitate the process of collection knowledge from experts, which seems to be extremely valuable and should be an important element in diagnosis of marine diesel engines, electronic form was developed. The electronic form allows writing of knowledge in management system directly by the expert. In this case, it is not necessary to its interpretation by a knowledge engineer, experts use the previously proposed based on the survey, a common vocabulary of concepts, which simplify and greatly accelerates the process of knowledge collection.

Electronic form allows gaining knowledge in the form of diagnostic relations such as: fault – symptoms of faults. The list of faults was developed based on the literature research [2], [8]. The survey questions were open-ended, is also foreseen the possibility of expanding the list of new faults proposed by the expert.

Knowledge introduced with the electronic form should be also evaluated.

3. Knowledge database

In knowledge database, saved is the basic information on application sector and operational instructions enabling engine diagnosis. Basic information includes object description and object classes, object attribute description, as well as, term dictionaries (of objects, attributes, faults and symptoms).

Operational knowledge is included in rules, enabling assessments of engine conditions. Operational knowledge comprises two sub-basses. This is due to the different methods of recording expert information and automatically generated information. Expert information is of quality type. While collecting data from experts, it was fund that they tend to use expressions like "high temperature of combustion gases" or "low pressure of charged air". However, they have problems when it comes to expressing quantitative values of such attributes. In case of data obtained with inductive methods, existent rules relate to quantitative values of attributes. The decision to divide the database in order to convert it to uniform representations, was made for the following reasons:

- quality information from experts, converted to quantity relations, would demand determining nominal engine and quantitative definition of terms like "high temperature" and "low pressure". The second part seems to be particularly difficult. The definition of "high temperature" may assume different meanings for different experts, and it may strongly depend on the kind of diagnosed engine,
- quality relations seem to be the most suitable for recording general diagnostic relations and useful for diagnosing various kinds of engines. What is more, this kind of representation enables easy information update, because it intuitively corresponds with the reasoning shown by experts,
- it is generally possible to obtain quality information in an inductive way with the use of initial digitalization, however, it substantially complicates the process of the automatic information collecting. Discretization also diminishes readability of thus obtained rules and makes the dialogue with user difficult.

Taking into account the above difficulties of uniform representation of expert-obtained information and inductively obtained one, each source was stored independently. Expert-obtained information, of general nature, was presented in the form of qualitative rules. Inductively obtained information was saved in the form of quantitative rules (strict).

Quality information was obtained in expert interviews. The database includes 36 rules enabling diagnosing of chosen engine systems.

All rules, saved in qualitative database, were assessed by experts. The detection of malfunctions in the said engine systems with use of these rules is possible at expert-determined certainty level.

Another independent information database of Expert System makes the base with automatically obtained data. Here MODLEM algorithm was used. The rules saved in the base are quantitative in nature (strict). The database contains 35 rules enabling detection of chosen malfunctions of injection system, serviceable parts changing system and combustion chamber system.

The presented database is open. It can be developed and modified in any way.

4. System verificaiton

During the verification of the proposed expert system, the assessment concerned the information saved in system database, as well as, operative value of the system itself (procedures of reasoning and concluding, as well as, interface control).

Expert-obtained rules were verified for their subject-matter properties. Such arrangement resulted in feedback, which in turn enabled the verification of the adopted terminology and applying the method for interpretation by programmer on one hand, and on the other hand, the verification of essential correctness of the rules themselves.

Information assessment made by experts was conducted by means of choosing particular certainty level, ranking the rule correctness [3].

Automatically obtained diagnostic rules were verified with regard to efficiency in diagnosing specific engine conditions, as well as for their subject-matter qualities.

The assessment of system operation took into account the abilities of interface dialogue and the process of correct reasoning.

5. Conclusions

Complex diagnostic systems for marine diesel engine diagnosis face limited application in ships, particularly due to their high cost. Ship engines are fitted with assorted indicators and measurement tools enabling control of many operational parameters, as well as, storing such measurements in databases. Technical condition verdict is however still the responsibility of the engine operator and here comes the room for IT systems, which could facilitate such processes.

The expert system application may substantially enhance abilities of monitoring systems presently existent in power rooms, in respect of ship engine diagnosis. Such system enables saving valuable, operational knowledge for later use. Additional advantage represents the opportunity of automatic collection of diagnostic information with machine learning methods. The usefulness of such methods for creation of diagnostic rules was proved on the basis of examples stored in database.

To knowledge collection for expert system and its subsequent update and evaluation, it is necessary to apply a knowledge management system (KMS).

The paper proposes the original system of knowledge management for the marine diesel engine diagnosis. The system allows the collection of knowledge from different sources, the subsequent evaluation and update.

The proposed diagnostic knowledge management system has been verified in practice.

The expert system enables integration within a single frame of both information collected from experts and automatically collected one. A doubtless advantage of expert system is the opportunity of updating and developing the content recorded in the database. Due to this feature, the effectiveness of the system may grow during engine operation and facilitate gaining new experience.

References

[1] *Clips. User's Guide*, 2007.

[2] Grzywaczewski, Z., *Niezawodność statków*, Wydawnictwa Przemysłu maszynowego WEMA, Warszawa 1988.

[3] Moczulski, W., *Metody pozyskiwania wiedzy dla potrzeb diagnostyki maszyn*, ZN Pol. Śląskiej, Nr 1382, Seria: Mechanika, Z. 130, Gliwice 1997.

[4] Mulawka J., *Systemy ekspertowe*, WNT, Warszawa 1996.

[5] Pokojski, J., *Systemy doradcze w projektowaniu maszyn*, WNT, Warszawa 2005.

[6] Predki, B., Slowinski, R., Stefanowski, J., Susmaga, R., Wilk, Sz., ROSE - *Software Implementation of the Rough Set Theory*, In., L. Polkowski, A. Skowron, eds. Rough Sets and Current Trends in Computing, Lecture Notes in Artificial Intelligence, vol. 1424. Springer-Verlag, 605-608, Berlin 1998.

[7] Predki, B., Wilk, Sz., *Rough Set Based Data Exploration Using ROSE System*. In., Z.W.Ras, A. Skowron, eds. Foundations of Intelligent Systems, Lecture Notes in Artificial Intelligence, vol. 1609. Springer-Verlag, 172-180, Berlin 1999.

[8] Żółtowski, B., Cempel, Cz., *Inżyniera Diagnostyki Maszyn*, Polskie Towarzystwo Diagnostyki Technicznej, Instytut Technologii Eksploatacji PIB Radom, Warszawa, Bydgoszcz, Radom 2004.