Expert Systems and their Use in Oil and Gas Complex

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Abstract: In article questions of structural creation of static and dynamic expert systems are considered. Also in article examples of expert systems successfully applied in oil and gas branch are given. Prospects of use of expert systems in dispatching services are noted. Besides, results of successful practical application of technology of expert systems are in summary given.
[Kurmangaziyeva L.T., Balbupe Esenzhanovna Utenova B.E., Mailybayeva A.J. **Expert Systems and their Use in Oil and Gas Complex.** *Life Sci J* 2014;11(3):392-395] (ISSN:1097-8135). http://www.lifesciencesite.com. 55

Keywords: Expert system, structure, static expert system, dynamic expert system, oil and gas branch, difficult systems.

1. Introduction

Keystones of building expert system [1, 2] are the following:

1). Knowledge base power and possibility of its refill is conditioned by the power of expert system;

2). Knowledge, on the basis of which an expert (and subsequently the expert system itself) gets effective solutions, has to the great extended a heuristical character;

3). Direct interaction with an expert system should be performed in man-machine mode - this requirement is conditioned by unformalization of solving tasks and the heuristical character of the knowledge used in the process of making solution (see above - principle 2).

On the basis of these principles we can define the structure of the expert system.

The first two principles condition the existence of the following components in the structure of the expert system:

- inference machine (usually called solver);
- knowledge base that has a dynamic character of changes.

On the basis of the third principle the requirements which are imposed to the expert system are formed:

- the system shall be able to dialogue with the user with the help of understandable and convenient for the user language;
- the system shall be able to acquire new knowledge during the dialogue;
- the system shall be able (in the process of solving tasks) to make its arguments understandable for the user and shall be able to explain the lie of its argument.

Thus, the structure of the expert system is represented as follows (Fig. 1).

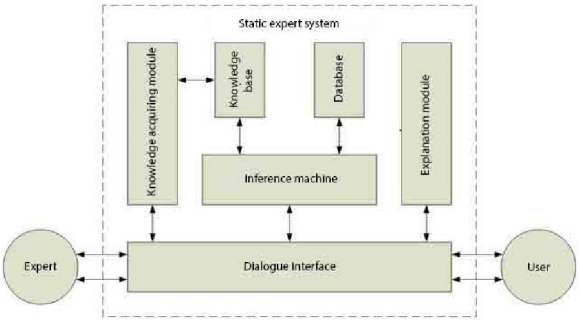

Figure 1. Generalized structure of the expert system

With the help of ***dialogue interface (dialogue subsystem)*** that provides the communication environment, an expert (or an ultimate user of the system) interacts with the expert system itself. Dialogue subsystem is oriented to the organisation of an user-friendly interface with all the categories of users in the process of both solving tasks and acquiring knowledge and explaining the results of the work.

Acquiring knowledge module serves to develop the expert system - adding new knowledge to the system.

Inference machine is used for acquiring new facts and knowledge. The process of acquiring is based on the comparison of the initial conditions (master data) from temporary storage with knowledge that is already kept in the knowledge base.

It should be noted that in the inference machine is the most important element in whole structure of the expert system, as with its help the algorithm of direct or/and backward changing is realized.

Formally the inference machine can be

represented by the four elements ***V, S, K, W***, where:

- ***V*** is the procedure of selecting rules and facts from the knowledge base and temporary storage;
- ***S*** is the procedure of comparison of facts an rules. In the result of performance of this procedure a lot of facts to which one can use rules for acquiring knowledge, are being formed and determined;
- ***K*** is the procedure of conflict resolution; it defines the order of usage of rules if in conclusion of rule similar names of facts with different meanings are mentioned;
- ***W*** is the procedure of execution of actions which correspond the acquired meaning of the fact (conclusion of rule).

Thus, the inference engine attains the evaluation of a goal statement by means of interaction with the information of system's knowledge base and use of data which are either already kept in knowledge base or requested of the user.

The structural element ***knowledge base*** is used for keeping long-term facts which describe the investigated area, for keeping rules which describe the relationships between these facts and other types of declarative knowledge about application environment. Also besides rules and facts which make up the declarative part of knowledge base, it can contain the procedure part - a lot of stored functions and procedures which realise optimization, calculating and other algorithms needed for acquiring.

Explanation module (subsystem) serves for explanation of getting of problem solution by the system (or reasons of its absence). Besides, the subsystem says which knowledge has been used in the process of making solution.

The possibility of explaining its actions is one of the most important requirements to the expert system, since:

- ultimate users' credibility to the acquired results increases
- the process of test of system is easier for the expert;
- the conditions for experts and ultimate users concerning opening of new rules in application environment are created;
- the explanation of the attained conclusion can serve as the method of finding ideal point in pareto-optimal set of decisions.

The latter of the above listed qualities makes the expert system more friendly to the ultimate user and provides him/her an opportunity to show the whole string of logic which has led the expert sysytem to the attained decision. Moreover, this quality allows to use the expert system not only for consultation but also as the educational system.

The real expert systems can have more extended set of modules.

After the consideration of the characteristics of the visual environment it becomes clear that there exists a vast class of applications in which it is necessary to take into account the dynamics of the state of the system, i.e. changes which take place in the visual environment during the application run-time. That's why dynamic expert systems or the real-time expert system were recently developed and got actual use.

The classification of expert systems by agility [3, 4, 5] divides the expert systems into static and dynamic.

The statics of the application environment means the permanence of initial data describing it. The derived data (deduced from the initial ones) can come again and be changed (not changing, however, the initial data). If the initial data that describe the application environment are changed during the problem solving, the application environment is called dynamic [6].

Two additional components are entered into the architecture of the dynamic expert system in comparison to the static one:

- subsystem of external world modelling;
- subsystem of communication with external surrounding.

The subsystem of communication with external world communicates with external world by means of the set of sensors and controllers. Moreover, the traditional components of the static expert system (knowledge base and inference engine) also underwent a significant modification in order to depict the temporal logic of events which take part in the real world.

In recent years dynamic expert systems or real-time expert system became a frequent practice; their success was determined by the following reasons:

- transfer to the specialised (problem/subject) software tools, which results in reduction of time for application design and allows for multiple usage of infoware and software (objects, classes, rules, procedures);

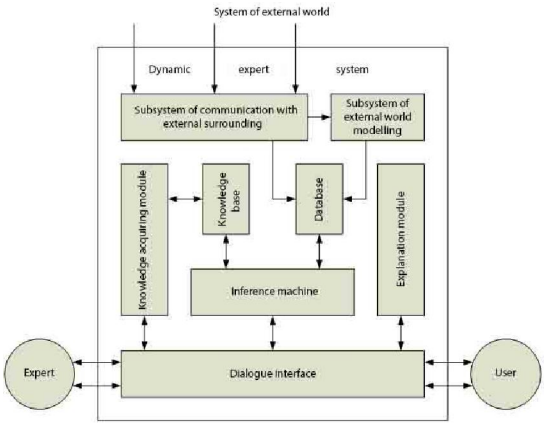

Figure 2. Generalized structure of the dynamic expert system

- use of widely used software programming languages and workstation languages; this provides the reduction of application requirements to such instrument responses of a computer as processing speed and span of frame memory, simplification of integration possibility increase of list of the used applications;

-open code;

- portability;

- scalability;

- use of client/server architecture.

Dynamic expert systems serve for solving tasks, in which [7]:

- data are being changed in time, come from outer sources and are to be kept and analysed;
- temporary inferences on several demand driven tasks are being performed simultaneously;
- the reasoner is provided when the resources are restricted;
- the "predictability" of system behaviour is provided, i.e. the run task is being performed in strict compliance with temporary restrictions;
- the surrounding world, in which different states are reflected, is being modelled;
- actions are being logged;
- the filling of knowledge base is effectively and conveniently provided (this possibility is represented by object-oriented approach);
- system tuning for task solving is provided;
- user interface for different categories is being realized.

Use of the expert systems for solving tasks of computer-assisted management in oil and gas sphere

Today a lot of experience of expert systems use has been accumulated in oil and gas sphere. We fix only on several examples of expert systems use in oil and gas sphere.

Expert system **TIGRESS (The Integrated Geoscience and Reservoir Engineering Software System)** is a set of applications for interpretation of geologic-geophysical data and geological modelling of deposits, integrated on the basis of common database - Tigress Project Data Store (PDS). This system combines all the possible means of a system analysis for the thorough investigation of deposits. The system includes three application environments - geology, geophysics, oil business. Tigress applications are installed in more than 45 countries in the world on 6 continents. The first version of the TIGRESS expert system was issued i 1992 [8].

DRILLING ADVISOR is an expert system which was developed for rendering of assistance to the drill man in the process of oil-well drilling, it realise advices in on-line mode, these advises are connected with the revealing of causes and possible solutions during the sticking of tools. For example, the causes for sticking of tools can be conical shape of the well, blockage of a drillstring by the drilled solids, and ways for overcoming these difficulties can be lift or drop of drillstring [9].

PROSPECTOR expert system served for geological exploration of mineral deposits and was an expert system f the interpretation type, which makes some conclusions on the basis of observation and helps geologists in finding deposits [10].

MUD system [11] serves for consultation of engineers during the drilling operations on the gassy and fluid seams; it helps engineers to provide optimal drilling mud properties. On the basis of description of the seams properties the system analyses the problems which appear in the process of such drilling and suggests the ways of overcoming the above said. The change of seams properties such as sudden viscosity growth in the process of drilling can occur as the result of different factors, for example, temperature or pressure increase or wrong formula of chemical additives mixture.

MUD system was realised with the help of production rule description language OPS5 [12].

Besides the given examples of expert system use, their use for support of making dispatcher decisions and as a real method of system integration in the process of management of complex systems is considered to be prospective.

Let us consider these applications in depth. It is known that the main objects of ACS

management of any economic object in any branch are technological processes and business systems, usually called the operations and production systems. These systems include accounting records, logistic support, planning, finances, marketing etc.

In the result of these qualitative changes in the system of technological process management, functions and conditions of service desks were also changed. Dispatch office personnel often find it difficult to make decisions in the case of emergencies as they are working in modern information environment - consolidated information area. Such situations as "what will be if..." need a prompt which is based on the rules, formed on the basis of life experience or in the result of model analysis. The real-time expert system or dynamic expert system is the "show-advice" system.

Conclusion

Thus, we defined the difference of the expert systems building structure depending on the tasks and explained the perspective of the dynamic expert systems.

Moreover, the article has the examples of the existing expert systems which are being used in the oil and gas sphere. Here are the results of the successful use of expert system technologies:

• Sira (USA) reduced the expenses for pipeline building in Australia for 40 million dollars thanks to the use of the expert system which managed the pipeline. The expert system is realised on the basis of IC G2 (Gensym) [13];

• Monsanto (USA) every year saves 250 - 500 thousand dollars thanks to the expert system of detection and blocking of faults in petrochemical industry. The expert system is realised on the basis of IC G2 (Gensym) [13].

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