Knowledge Representation Using Multilevel Flow Model in Expert System

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1. Introduction

Knowledge representation is a key element of expert system, and it plays a vital role in constructing the Knowledge Bases (KBs). As for the knowledge representation, of course, there are a great many methods available for knowledge representation. These include frames, causal models, and many others [1]. This paper presents a novel method called Multilevel Flow Model (MFM), which is used for knowledge representation in G2 expert system.

2. Expert System

Artificial Intelligence (AI) is that branch of computer science that seeks, in some measure, to emulate human behavior, and expert systems are a special type of computer software for which the objective is to reproduce the capabilities of an exceptionally talented human or groups of humans. This is achieved by encoding human experience in various knowledge representation schemes. Expert systems differ from conventional algorithmic programming in two aspects. First, as new information is obtained, it can be added to the knowledge base without revising the inference engine. That is, no reprogramming is needed. Second, an expert system can at any time provide the rationale for its conclusion. It does this by keeping track of the chain of deductions that support each particular conclusion. Expert systems are, as noted, very simple entities consisting of a knowledge base, reasoning machine, expositor, global database and human machine interface (HMI) [2]. The structure of expert system is as shown in Fig.1.

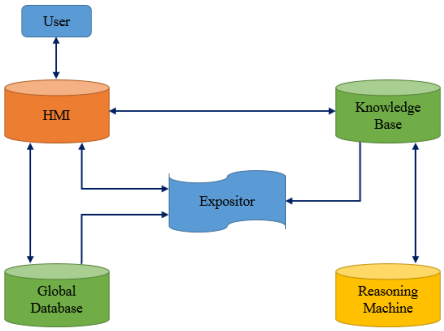

Fig.1 Structure of Expert System

G2 expert system is a complete development environment for creating and deploying intelligent real-time, knowledge-based applications [3]. G2 development is based on object-oriented design. Knowledge representation is maintained and extended through classes in the G2 class hierarchy.

3. Basic Theory of MFM

Multilevel Flow Model (MFM) is a methodology for modeling of industrial processes on several interconnected levels of means and part-whole abstractions. The basic idea of MFM is to represent an industrial plant as a system which provides the means required to serve purposes in its environment [4]. MFM represent goals and functions of process plants involving interactions between flows of mass, energy and information. It describes the system goals, functions and components to model the process of the plant by using some specific graphical symbols. In MFM, the goals are the basis of modeling thought to realize functions of each part of system, such as "supply electricity" and the functions nodes consisting of functions relate to goals to represent the capabilities of a system, for example, "transport coolant", and components represent the physical structures of a system, such as a piece of pipeline. Symbols of MFM are as shown in Fig.2.

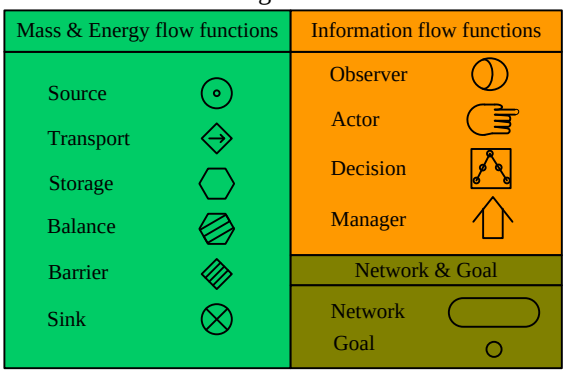

Fig.2 Symbols of Multilevel Flow Model

On the basis of classes of G2 and the functional symbols of MFM, the classes can be described using symbols of MFM, which provides a concise way to represent system knowledge. Therefore, MFM can be combined with G2 expert system.

4. The Combination of MFM and G2 Expert System

This section presents how to represent knowledge using MFM in G2 expert system. G2 is a development and deployment environment for building and implementing fault management applications. The diagnostic process of G2 expert system is as shown in Fig.3.

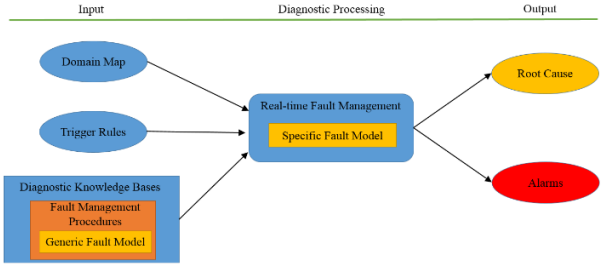

Fig.3 Diagnostic Process

As can be seen in Fig.3, diagnostic knowledge consists of generic fault model that allows G2 to perform fault diagnosis. Incoming specific events trigger diagnostic reasoning. Domain map is an object-oriented model of a managed system, which can represent physical equipment and abstract entities, such as pump, valve, etc. It plays a vital role in designing fault diagnosis knowledge base, which includes domain object classes and their instances representing the managed entities, their connectivity, containment, and other relationships.

The relation between MFM and domain map is as illustrated in Fig.4.

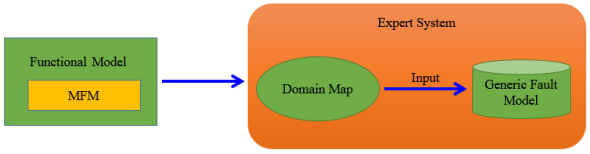

Fig.4 Relation between MFM and Domain Map

As can be seen in Fig.4, The functional model is built using MFM, and the functional model is served as domain map in expert system. Domain map is an input to generic fault model. The premise of building generic fault model is to make the domain map of a system.

For example, the mass flow and energy flow of reactor coolant system (RCS) that designed using MFM are as shown in Fig.5 and Fig.6 respectively. They are also served as domain map of RCS in G2 expert system. The building of generic fault model depends on domain map. Thereby, the domain map designed using MFM determines how to build knowledge bases.

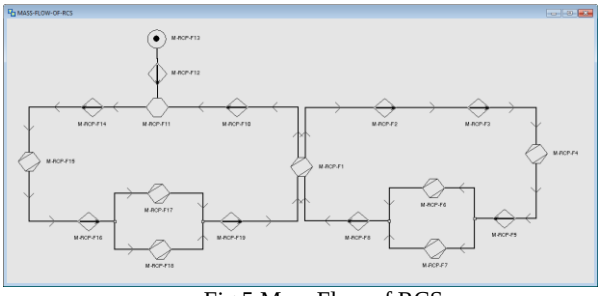

Fig.5 Mass Flow of RCS

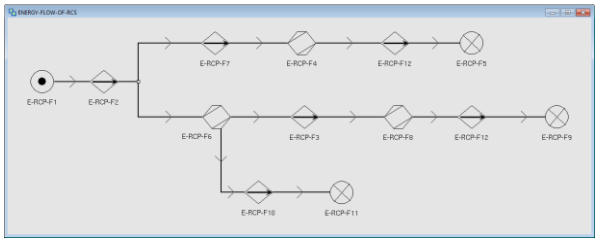

Fig.6 Energy Flow of RCS

5. Conclusions

Knowledge representation plays a vital role in constructing knowledge bases. Moreover, it also has impact on building of generic fault model as well as knowledge bases.

The MFM is particularly useful to describe system knowledge concisely as domain map in expert system when domain experts are not available.

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