Frame model of knowledge representation in the expert system of technological route selection

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Annotation. In the process of technological preparation of production, a large amount of industrial data is used, such as the availability of production materials and components, the availability of production resources, the use of various tools and information systems for production management based on ERP and MES. In order to ensure operational management and help a technologist in making a decision while choosing a technological route for manufacturing a product, there is a need to use an expert system. Taking into account the above-mentioned requirements, a frame representation of knowledge becomes the most appropriate method of presenting knowledge in an expert system. The paper proposes a frame model for representing knowledge about the technological route of manufacturing an expert system product.

1. Introduction

The process of technological preparation of production involves the use of a large amount of information, working with large amounts of data, such as the availability of production materials and components, the availability of production resources, the use of various tools and information systems for production management based on ERP and MES.

An important task in the process of technological preparation of production (TPP) is one of selecting equipment and forming product manufacturing routes. The task of selecting equipment in the machine-building industry to fulfill an order only by the capabilities of a specialist is characterized by the use of a subjective solution that depends on the experience of this specialist and requires a lot of time. For such tasks, it is advisable to use multi-agent technologies used for dynamic management of network resources, which have advantages when used in a distributed environment. The use of multi-agent technology in relation to the problem of automatic selection of equipment and formation of the product manufacturing route is due to the developed model of the external world due to the presence of a multi-agent system knowledge base, mechanisms for solving and analyzing actions. Since the production process involves a lot of people from different departments working in different directions, an important task of automating this process is to resolve contradictions in the construction of the optimal technological route for manufacturing the product at the stage of the TPP. With a multi-agent approach, this problem is solved by using methods for organizing interaction and coordinating the actions of intelligent agents. To achieve the maximum effect, the production management system must be fully automated [1].

2. Methodology for presenting knowledge in an expert system
The methodology of presenting knowledge in an information system should help to extract elements of knowledge in the right situation using a relatively simple and natural mechanism. Also provide translation of input data into a form suitable for storing in machine-readable form and have a knowledge base with advanced indexing and contextual addressing tools. Then the information system will be able to manage the sequence of application of certain knowledge, even without having accurate information about how they are stored.

The use of multi-agent technology requires a systematic method of describing at the machine level what the technologist who specializes in the field of TPP knows, and a certain organization of knowledge.

The main issue in the representation of knowledge is to determine the composition of knowledge and an adequate representation of the simulated system.

The information system consists of a database that stores data about the manufacturing process of the product; a knowledge base that accumulates the rules of the expert system; and a precedent base that generates new knowledge for the knowledge base.

The knowledge base includes the subject area of the TPP: a set of entities that describe the area of expertise, i.e. a set of objects that affect the choice of the optimal route for manufacturing the product, the values of their characteristics and the relationships that link them. The knowledge base includes entities-data structures and tasks solved on them, represented as executable statements in the form of rules, procedures, and formulas [2].

From the point of view of the architecture of knowledge in the knowledge base, it is advisable to divide it into interpreted and non-interpreted. The first type is the knowledge that the technologist is able to interpret. All other knowledge is of the second type.

One of the indicators of system intelligence in terms of knowledge representation is the ability of the system to use relevant knowledge at the right time. Knowledge connectivity is the main way to speed up the search for relevant knowledge. Knowledge should be organized around the most important objects (entities) of the subject area. All knowledge that characterizes an entity is linked and represented as a separate object. The most appropriate method of presenting knowledge in an information system, taking into account the above mentioned requirements, is the frame-representation of knowledge.

Firstly, a frame is a data structure designed to represent some standard situation. Unlike formal models, heuristic models have a diverse set of tools that convey the specific features of the manufacturing process. This is why heuristic models are superior to logical models both in terms of the ability to adequately represent the problem environment and in terms of the effectiveness of the inference rules used.

Secondly, frame representations of knowledge in expert systems differ from formal production systems in that they use more complex rule structures, often expressed as semantic structures, since this occurs when describing a technological process. The difference between frames and procedure descriptions is that frames can be called not by name, but by matching the current situation to the situation that this frame describes. Associated with each frame slot are descriptions of conditions that must be met. In the simplest cases, these conditions can be reduced to specifying semantic categories that the slot value must satisfy. In more complex cases, the conditions may relate to the relationship between values selected for multiple slots [3].

Thirdly, the most important property of frame theory is the property inheritance borrowed from the theory of semantic networks. Inheritance of properties can be partial or full borrowing of properties, which is convenient when forming typical technological processes for structurally similar products [2].

Fourthly, the main advantage of frames as a model of knowledge representation is that it reflects the conceptual basis of the organization of human memory, as well as its flexibility and visibility.
Figure 1 shows a general diagram of the frame representation of the subject knowledge base of the information system for selecting a technological route for manufacturing a production order using the relationships between the individual blocks of the process of technological preparation of production.

In the diagram the main identifier that determines the uniqueness of the route is the order frame to which the unit part frames are linked. Each unit part frame has a link to the process frame. A process frame contains a description of the dependencies between the material, equipment, operation, personnel, transportation, tooling, and tool frames that are included in it. The frame operation is further decomposed into the frames of the setting, position, transition, and working stroke.
Each of these frames has its own set of slots that allow you to describe the essence of the frame and ensure the relationship of frames to each other, forming a unified system. By using this representation of dependencies explicitly, it allows to predict the transition from one state A (expressed by frame Ar) to another state B (expressed by frame Br) that depends on it, and to perform this transition effectively, i.e., without re-calculating the values of all parameters that characterize state B, but listing only the changed or new parameters [2].

The choice of alternative variants of the technological route is made by comparing the corresponding source data of the sample frame with restrictions on the processed part of the frame instance.

Reference

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