Ontological Model of Technological Process for the Production of Complex Shape Details

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Abstract: The paper presents the research devoted to the description of technological process using ontological modelling. For the correct management of the modern technological process it is very important to take into account the components of knowledge management and representation that are used and generated during the execution of such production processes. Ontological models are proposed to be used for this purpose. Such type of models is one of the most frequently used for presenting knowledge nowadays. It allows not only to structure and systematize knowledge, but also to describe certain processes of interaction between data and information for the extraction of new knowledge. The paper gives the research on how to systematize, structure and link information on technological process objects by means of ontology aiming to support knowledge management and representation of such process Specific ontological system is proposed in the paper, that allows to set description of complex technological process.

1 INTRODUCTION

Nowadays the term "knowledge" is considered from different points of view [1]. One of them positions knowledge as a condition for access to information. It is argued that the representation of knowledge should be organized in such a way that it is easy to access and retrieve it.

Authors [2] argue that knowledge representation requires different strategies and different types of knowledge management tools and technologies. For example, if knowledge is viewed as an object, then knowledge management initiatives should emphasize the importance of creating knowledge stocks in organizations. In this case, a knowledge management system such as knowledge repositories should have the ability to capture knowledge stocks. Similarly, if knowledge is viewed as a process, then knowledge management initiatives must operate with knowledge flows in the processes of knowledge creation, knowledge sharing, and knowledge dissemination.

Today, there are various models of knowledge representation [3, 4], each of which has its own advantages and disadvantages. Ontological modelling is one of the most frequently used methods of presenting knowledge at the moment [5, 6, 7], as it allows not only to structure and systematize knowledge, but also to describe certain processes of interaction between data for the extraction of new knowledge.

Various SAP systems and technologies for describing business processes and workflow are currently used to automate production and technological processes. However, for the correct management of modern work processes, it is also very important to take into account the components of knowledge management and representation, that are used and generated during the execution of such production processes.

The aim of the paper is to propose specific ontological system for the description of the technological process. The paper is structured as following: Section 1 sets the introduction; Section 2 presents the review of approaches and models used for knowledge representation, Section 3 describes ontological model of technological process, that is proposed by authors, Section 5 depicts the research conclusion.

2 APPROACHES TO KNOWLEDGE REPRESENTATION REVIEW

Knowledge representation includes various schemes, namely logical schemes, procedural schemes, network schemes, and structured schemes. The network diagram is constantly growing over time. On the other hand, a logical and procedural scheme works with a fixed set of symbols and instructions that are limited as the information to be encoded increases. Structured schemes use a complex structure for a node in a graph, that limits its widespread use. Network diagrams have simple nodes in a graph that stores data and allows a huge amount of data to be built into the system in the form of nodes.

Tolman introduced the concept of cognitive maps [8]. Cognitive maps provide a mental representation of spatial information as knowledge [9]. However, the cognitive map does not have its own cognitive processing. Kosko presented the combination of fuzzy logic and cognitive map as fuzzy cognitive maps (FCM). FCM uses fuzzy logic to calculate relations strength. In 1976, John F. Sowa developed concept graphs (CG) to represent semantic network-based logic using a graph [10, 11]. A CG is a finite connected bipartite graph, where a node either represents a concept or a conceptual relation. Arcs are allowed only between a concept and a conceptual relation, but not between two concepts or two conceptual relations. Sowa later proposed a semantic network as another area of knowledge representation. It is a graphical structure of interconnected nodes, where nodes are connected by an arc to represent knowledge [12].

Artificial intelligence applications for knowledge representation and manipulations use computer architectures that support semantic network processing [13]. The semantic web is based on the understanding that relations between concepts define knowledge.

The classic classification of knowledge representation models includes the following types of models :

- production models,
- logical models,
  frame models,
- network models.

The choice of the type of knowledge representation model depends on the requirements for the designed system. Thus, from the considered models, it is advisable to use production models in the case of developing a system aimed at the implementation of expert conclusions with a rigid "cause-effect" structure; frame models are used to implement a scenario approach in order to create systems oriented to forecasting and modeling future events; logical models are used to present information in the form of formal mathematical structures, which are expedient to use when it is necessary to optimize or automate certain processes during the design of information systems.

Another type of knowledge representation models are ontologies. An ontology is a conceptual model of subject domain that uses one or more taxonomies and includes descriptions of concepts, relations, properties of concepts, and constraints on property values. Ontologies are one of the modern means of describing the semantics of subject domain (for the description of information resources including), that use the main results of previously known knowledge models. At the same time, the ontological approach is quite transparent regarding its implementation within simple logical formalisms that have the property of permissibility. This approach is adopted as one of the basic methodologies in the implementation of ontological systems.

Ontologies are used to describe knowledge about some subject domain. Ontology describes the concepts of a subject domain, as well as the relations that exist between these concepts.

In the era of Big Data, the management and integration of large data sets provide enormous opportunities for the formation of new knowledge. Ontologies, which represent knowledge about the subject domain in the form of concepts, their classes and relationships between them, are a universal tool for overcoming barriers in the integration of data and knowledge from disparate sources of information, thereby facilitating the search for new knowledge.

Ontologies can help organize and analyze large volumes of data that are too large for a single system to manage. Ontological models can be applied to represent different knowledge. It is ontologies that will allow not only to structure or classify knowledge, but also to integrate information through the formalization of standard terminology. Ontological models are well integrated into intelligent decision-making support systems that is why information, as a result of its presentation with the help of ontology, can be further presented and processed by different SAP.

3 ONTOLOGICAL MODEL OF TECHNOLOGICAL PROCESS

The given study is devoted to the development of an ontology that characterizes the production technological process.

In the study, the technological process is defined as a set of technological operations that are performed systematically and consistently in time and space on homogeneous or similar objects, as a result of which the aggregate state, location, or properties of the object of research change. Its peculiarity is that it has a finished character for the production purpose, as well as a set of its elements and sub-processes is known a priori.

Such ontology is a system of interrelated components, each of which is a complete ontology in itself. In total, a set of such components allows not only to describe all the elements and stages of the technical process, but also the corresponding equipment, software and technical support used in the technical process, as well as to introduce and describe some performance indicators of the described technological process. The system of ontologies for the description of the technological process is presented in Figure 1.

The ontology of technological processes is the main ontology of the system. It describes the characteristics and elements of the technological process, as well as the connections between them. Three lower-level ontologies are included in the system:

- ontology of production environment,
- ontology of software,
- ontology of subject domain.

The ontology of the production environment describes a variety of technological means, such as equipment, facilities, tools and materials, that are used in the technological process; the ontology of the software environment describes the software and technical means used in the technical process; the ontology of the subject domain is based on the direct description of the concepts of the subject domain and sets the structures for their "connection" with other ontologies of the system, it contains all the information related to the processes and objects that take part in the technical process, depending on the subject domain for which this technological process is applied.

In the process of each introduced ontologies development, it is necessary to describe its elements. The ontology includes the following elements [14]:

- classes,
- attributes,
- relations,
- types of attribute values,
- restrictions on attribute values,
- instances of classes.

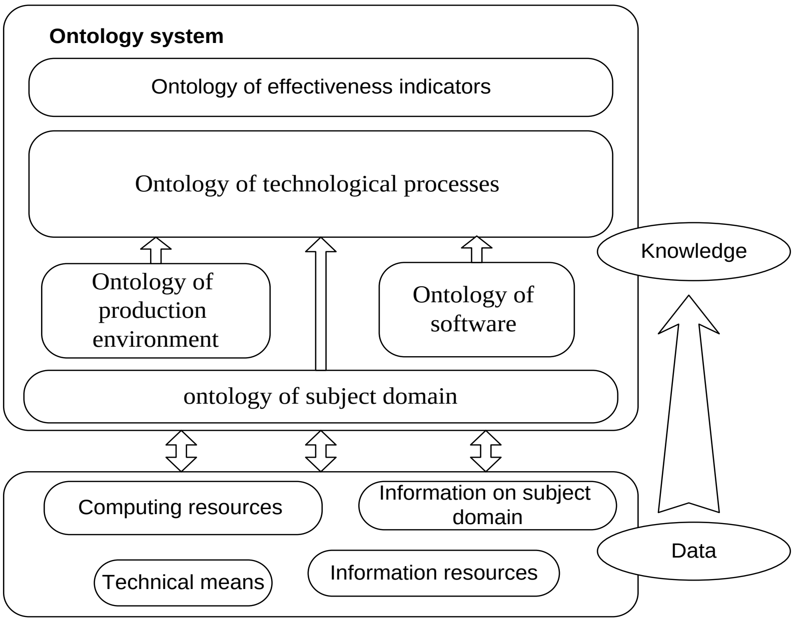

Figure 2: System of ontologies for the description of the technological process.

It is this set of elements that allows us to define ontology as a complex model. Thus, ontology is a hierarchy of concepts (or classes) connected by relations. The use of associative type relations allows defining the ontological model not only as a hierarchical structure, but also as a structure that takes into account the substantial meaning of the connection between real objects. The various properties of each concept are described based on the attributes of the concepts and the constraints imposed on the domain of their values.

The technological process ontology contains a set of classes that are described by the corresponding attributes. Classes are an element of an ontological model that describes the concepts of some subject or problem domain. Attributes are elements of the ontological model that describe the properties of classes and relations. Attribute value types define standard types for class attribute values. The restriction on the values of attributes of classes and relations is not used for all attributes, but only for those whose values must lie in some area. They cannot be less than/greater than a given value, or are determined by a certain rule.

For example, let's describe the classes and their attributes for the technological process ontology (Figure 2):

- Class "Technical process": name, environment, structure, function, internal properties, external properties, technological route.
- Class "Transitions": type (complex/simple), number, operations that combine.
- Class "Operations": name, type, type of surface for which it is applied.
- Class "Technical object (detail)": name, identification data (item number, drawing number), classification data (batch number, classification number), technological data (material, quality), design data (shape, dimensions, tolerances) , data for processing.
- Class "Construction drawing": name, number, set of structural constituent elements (surfaces) of the technological object, drawing (drawing) characteristics.

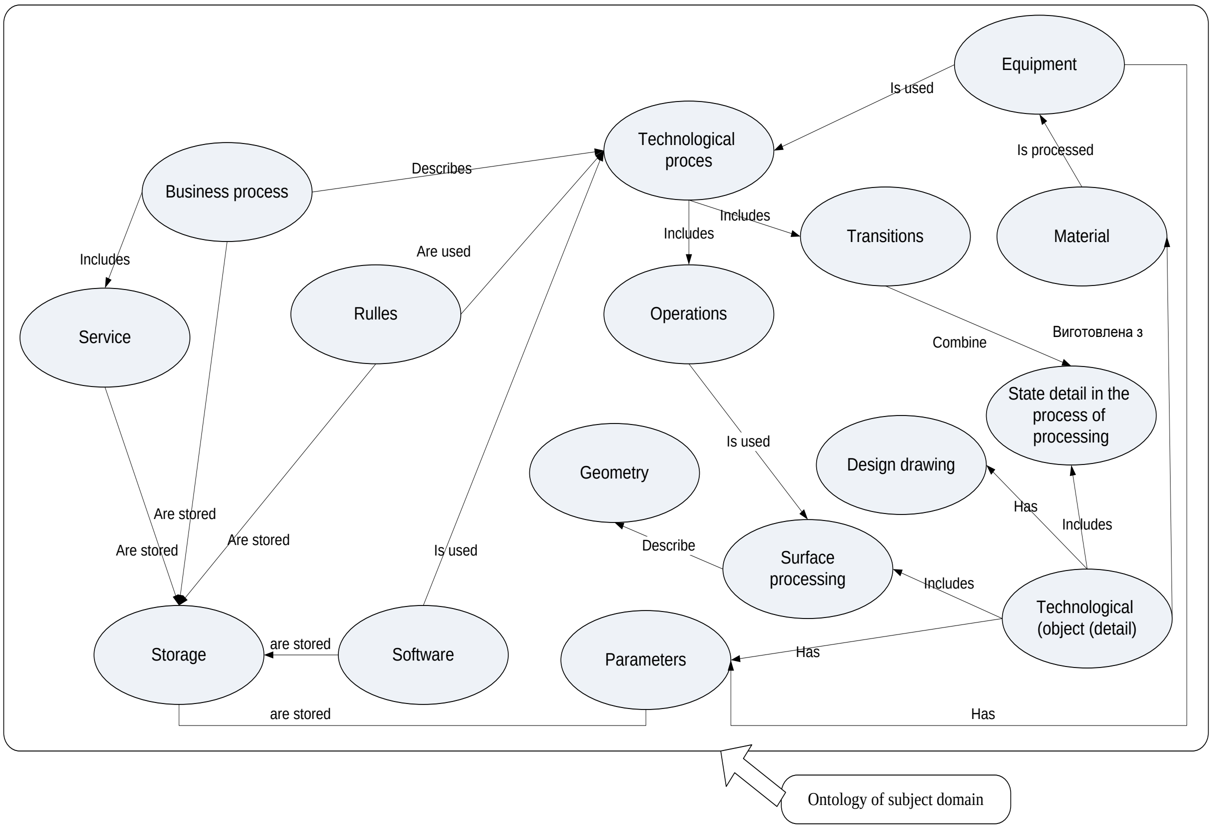

Figure 2: Fragment of technological process ontology.

- Class "Surface treatment": name (type), type (characteristics), dimensions, design parameters of the surface (roughness, size tolerance), operations.
- Class "Geometry": type of surface, dimensions, drawing (drawing) characteristics. Class "State of detail in the process of processing": general information (code and name of the detail, general information about the product, volume of the optimal batch of details, data about the workpiece), processing surface, operations, surface code, description of the workpiece on the surface, parameters that determine the presence of identical surfaces, surface roughness and parameters that impose, restrictions on the cutting process, parameters that describe the accuracy of detail manufacturing, a data set that defines the profile, surfaces and its own geometric constraints, a data set that represents the location of the surface in the coordinate system of detail.

An ontology contains a set of relations that are defined on classes and reflect either the relationship of classes to each other or the relationship of classes to data or attributes. The following types of relations exist: associative relations, part-whole relations, inheritance relations, and class-data relations [16].

Thus, such a description of ontology elements allows managing all elements of technological process, as well as setting the semantic connectivity through them.

4 CONCLUSIONS

In this study, an original approach to the design and storage of data regarding objects of design and technological preparation of production (parts, equipment, materials, design procedures, etc.) is proposed in the form of an ontological model of the technology of manufacturing complex details.

The proposed approach makes it possible to obtain a functionally complete list of elementary, algorithmically correct functional tasks intended to develop regulatory documentation for design and technological preparation of production; methods of making technical decisions using artificial intelligence; principles of flexible adaptation to a specific production environment and requirements of the modern market.

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