Ontological Approach to Modeling the Domain of Inductive Modeling

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Abstract. *This paper considers the application of ontological approach to the structuring of knowledge and to the construction of a model of inductive modeling of subject area as a knowledge-based system.*

Keywords

GMDH, ontology, subject area (domain) model,
knowledge based computing system.

1 Introduction

One of the most urgent problems of modern society is the proliferating amount of information. Methods to receive, process, analyze, and store this extraordinary volume of information must be created.

The main direction to solve this problem is to switch from data storage and processing to knowledge storage and processing 1].

This direction is chosen due to the rapid progress in research of artificial intelligence, particularly in the development of "intelligent" knowledge-based computer systems.

2 The Problem of Structural and Parametric Identification

The process of development of intelligent computer systems is extremely complex and expensive.

The majority of applications are in the borderland among different subject areas (domains). This requires participation of experts in the design of knowledge based computer systems in these domain. Most of the complexity of designing and developing such software comes from the fact that the developer has to know the set of all possible stages and processes options in the problem solution(extension problem), subject to various permissible input data. The knowledge is required to be extracted, structured, formalized for computer processing.

Rapid changes in external conditions lead to changes in the requirements for the computer system. There is a need to constantly change the already existing systems to adapt them to new versions and capabilities of new information technologies. Usually, algorithms and data processing rules are "sewn" rigidly/permanently into the code when creating the system. Any changes in the algorithm lead to the need for changes in the code, and then - testing and so on. All these complications make the construction and maintenance (updating) of such system a long expensive process.

That is, the basic requirement in modern software design problems to simplify the design and modification, and therefore, to reduce execution time and the cost of such work remains important.

Usage of declarative descriptions of subject area can simplify the formulation of task of design of knowledge based complex systems, development of independent task models with repeated use, division of each architectural components, automatic generation (complete or partial) of the code, and so on.

In declarative coding code should describe the problem itself, not one of the solutions. The basic idea of this approach is that the internal structure of the program is a reflection of certain knowledge that needs to be expressed clearly.

3 The Notion of Ontologies and Benefits of Ontologies Usage

The notion of ontologies in information technology was first invented by Tom Gruber in 1993 and defined as "explicit specification of conceptualization."

Ontology is a hierarchically structured set of terms and rules for their usage, which together describe the domain. It can be seen as a system of set of concepts (terms) and the set of statements about these concepts by which you can describe classes, relations and functions.

Benefits of using ontologies:

• Ontologies allow common usage to understand data and its structure.

• Ontologies enable reuse of knowledge of the subject area and expansion of existing ontologies for application in specific area.

• Ontologies enable people to make assumptions explicit in the domain, to specify knowledge. This facilitates the work and can be useful for new users, researching the subject area.

• Ontologies enable separation of subject area knowledge from operational knowledge.

• Ontologies enable formal analysis of knowledge of the subject area. Such analysis is possible when declarative specification of terms is present. It is extremely important when reusing existing ontologies and particularly their extensions.

Typically a formal ontology model O is defined by three ordered sets

$$O = <C, R, F>,$$

where C - is finite (non-empty) set of concepts domain, which defines ontology;

R - finite set of relations between concepts of the subject area,

F - finite set of functions interpretations (axiomatization) defined on concepts and / or relations of ontology O [7].

Sets R and F can be empty. This occurs in the following specific types of ontologies: dictionary, taxonomy concepts, thesaurus. Thus, ontology must provide dictionary of subject area concepts and set of relations between these concepts.

4 The Ontological Approach to Modeling of Domain

There are three basic principles of ontology classification:

- by the level of formality: the top-level ontology - metaontology- uses general concepts and relations that are independent from subject area;
- by the content: subject area ontology or domain ontology - consists of concepts that describe specific subject areas, significant relations and set of these concepts and relations;
- by the purpose of construction: tasks ontology or applied ontology - concepts are the types of problems solved and relations are the decomposition of these tasks into subtasks, algorithms of solution.

Subject area ontology is used as a common conceptual basis for compact and efficient representation of system of knowledge in a particular subject area. It generalizes the concepts in some domain problems, but not the problems themselves.

Tasks ontology specifies the objects, statuses and tasks necessary for connections among objects. Formulas for calculating the values of objects can be the part of this ontology. Tasks ontology is necessary for the functionality of processing applications that solve specific types of problems. It is used in the development of software to perform a specific task.

The concepts in the ontology should be close to objects (physical or logical) in the subject area. Since ontology is a model of the real world, the concept in the ontology must reflect this reality. Often this takes the form of nouns (concepts, objects, classes) and verbs (relations, properties) that describe specific domain.

Tasks ontology is part of domain ontology and contains objects needed to solve a specific problem.

5 Modeling of Inductive Modeling Domain by the Ontological Approach

In the inductive modeling field, a range of problems for which tasks ontologies can be developed are:

• building a mathematical model of the object /process;
• forecast of process specified by time series;
• classification - classification rules for construction of an object to a class on the set criteria;
• pattern recognition with training (identifying effective signs and rules of distinction between given classes);
• clustering (self-education or identification of effective features, forms and rules of distinction) in GMDH this problem is called "Objective Computer Clustering" (OCC);
• objective systems analysis (OSA) when you need to find out which among the measured variables are independent (input), which are dependent (output), which are unnecessary (uninformative) and then build the appropriate model.

Although there is no single correct methodology of developing ontologies, there are general points that must be considered:

1. Each task is analyzed and the key components ratio, limits and operations are defined.
2. A conceptual model of a problem is built using the identified component of an existing ontology domain.
3. New components are added in the domain ontology in case they weren't stated before.
4. The updated ontology is checked for completeness, contradictions and issues are resolved.

Inductive modeling by statistics data is consistent decision-making process, consisting of a specific set of steps performed sequentially. Analysis of methods to solve these problems revealed that each of the methods of historical data modeling can be described using basic components:

- Class models (basic functions), for which it is intended,

- Generator structure in the selected class of basic functions,

- Method of parameter estimation generated models

- Criterion of selection or choice of models.

Each of these components has its own parameters, characteristics and domains that allow the use of ontologies to describe them. Structuring results in defined principles of forming algorithmic modules to solve a particular problem. The choice of a particular element of each of these components depends on formation algorithm for a particular task. (fig. 1))

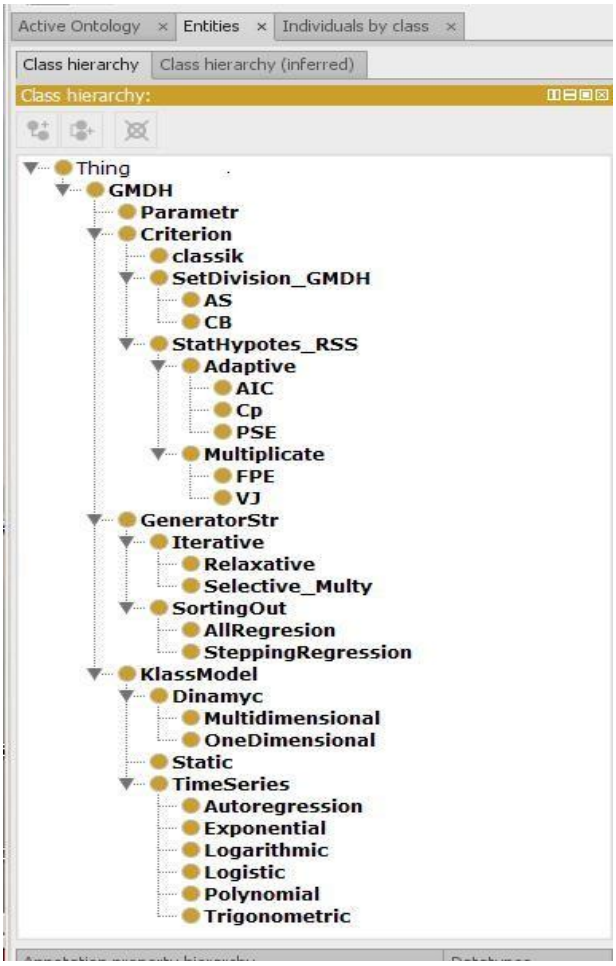

Fig.1 The hierarchy of classes and subclasses of base components in solving problems simulation statistics in GMDH

Conclusions.

Application of ontological approach to modeling of the domain in the design of computer systems based on knowledge is a forefront area of research.

Building of ontology of inductive modeling field is aimed at simplifying the process of developing specifications and software products for solving specific problems of building models of complex processes by statistic data, also to empower augmentations of existing computer tools.

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