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The technique of creation of simulation systems with experiments design and analysis controlled by user's questions

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Abstract

The article describes a technique of creation of simulation systems with elements of intellectual handle of experiments initiation and analysis results of experiments. The technique proposed is based on user question analyzing, determination of necessary simulation experiments for the question answering, initiation of these experiments running and obtaining the answer on the basis of experiments results.

1 Introduction

The continuously varying conditions and competitiveness make necessary a tentative estimation for decision making in anyone area, especially in the economic domain. The computer simulation is the most flexible and well-observed complex systems analysis method for such evaluation [2, 8].

Naturally, the higher intellectual level of computer simulation systems results in the wider area of their application and the higher effect of such application. Therefore association of simulation and artificial intelligence technique is a modern and perspective direction of Computer Science. For today there is not general techniques for this. The problems are resolved for each special case separately. The article describes a technique of creation of systems analysis environments on the basis of simulation with elements of intellectual handle of experiments design, execution and analysis of results of experiments.

2 The problem background

The main goal of simulation is to answer user's questions about a researched system by execution of experiments with its simulation model. The process of complex systems researching by simulation method includes the following stages[12]:

- define a problem space;
- define the conceptual model;
- collect input data;
- design the simulation model;
- verify and validate the model;
- design experiments;
- execute simulation experiments;
- analyze simulation experiments results.

It is obviously that a simulation system (SS), which supports more steps of this process, is considered as more intellectual one. Let us to list steps of automation of this process in the chronological order:

- design of special languages for simulation models description and translation systems for these languages;
- design of simulation systems supporting simulation experiments running;
- design of integrated simulation systems supporting analysis of results of simulation experiments.

Today the majority of SSs includes more or less powerful tools for supporting these steps of simulation. In this article the conceptual scheme of integrated simulation environment is proposed, which automates the steps of experiments design and analysis of their results. The technique proposed is based on user question analysis, determination of necessary simulation experiments to answer the question, initiation of these experiments running and obtaining the answer on the basis of experiments results. The technique is approved by development of a system for credit-bank process simulation [11].

When the model has been designed it is repeatedly used to execute a lot of experiments. Let us consider this process of design and run of simulation experiments in detail:

1. the user realizes what does he want to know about the system (model) researched,

2. he formulates his question in any natural language;

3. the user finds any computational method (mathematical, statistical or any other) which helps him to receive the answer for his question, so he expresses the question in the corresponding formal (mathematical) language;

4. the user realizes what experiments it is necessary to execute for obtaining of all values he needs from simulation experiments results;

5. the user carries out the experiments needed, obtains the values and calculates the answer;

6. as result of obtained answer analysis a new question may appear.

So this process is cyclic and usually is multiple repeated. It is the reason why it is worth to be automated. The pay for automation (convenience) is formalisation of the questions language or restriction of their list. Because the answer is based on the simulation experiments results it is obvious that the questions language has to be based on main concepts of simulation, means of simulation experiment results representation and analysis.

3 The language for description of questions about the researched simulation model

3.1 Primary knowledge

Results of simulation experiments are the source of primary knowledge about the model. Thus primary knowledge represents primary functions, which are determined for the set of model parameters. They are defined to a great extent by main concepts of simulation and then by a language for simulation model description. So they may be common for the majority of simulation languages. The language for user's questions presented here is oriented to discrete simulation language SOL[7]. The following primary knowledge about a model is includeded in this language for user's questions:

- model time of simulation completion;

- total transactions number;

- the maximal number of active transactions which have been existed in a model simultaneously;

- statistics of all objects of a model (facilities, stores, tables, processes and labels).

1. The statistics of facilities are:

- the number of facility demands;
- the coefficient of facility utilisation;
- the average time of facility busyness;
- the maximal facility queue length.

2. The statistics of stores are:

- the maximum store units which have been used;
- the average store units which have been used;
- the coefficient of store utilisation.

3. The statistics of tables are:

- the number of table entries;
- the number of table non-entries;
- the table minimal value;
- the table maximal value;
- the mean of a table;
- the standard deviation.

4. The statistics of labels are represented by label's counts.

5. The number of transactions created by a process is statistical information about it.

3.2 Secondary knowledge

On the base of primary knowledge, functions are defined for secondary knowledge. The secondary knowledge is obtained by tools available in the integrated environment [10] for analysis of results of a separate experiment or a series of experiments. The majority of them are listed below:

- the maximal, the minimal and the average values of any statistic of any object (on the base of a series of experiments);

- the number of the best experiment of a series of experiments (the best from the point of view of negative and positive characteristics chosen by the user [3]);

- the values of negative and positive characteristics of the best experiment;

- the values of the model parameters for the best experiment.

3.3 Expressions

The expressions constructed from constants, primary knowledge, secondary knowledge, arithmetic and logical operations, operations of comparison and standard functions represent possible questions of the user (abstract knowledge about the model). Their syntax and semantics are similar to syntax and semantics of expressions in any programming language. These expressions values are concrete knowledge about the model.

So the formal questions language (QL) is defined.

4 General purpose SS with experiments design controlled by user's questions

To support experiments design controlled by user's question a general purpose SS has to include additional menu points "question description", "question compile" and "question answer". Correspondingly the system has to include the following modules:

- QL-expressions editing;

- control and analysis of QL-expressions syntax;

- simulation experiments execution (for functions corresponding primary knowledge included in expression analyzed);

- execution of experiments results analysis (for secondary knowledge included in expression analyzed);

- computation of expression value (using primary and secondary knowledge values).

5 Problem oriented SS with experiments design controlled by user's questions

A problem oriented language for description of user's questions (PLQ) may be defined for a given problem oriented simulation system. Compilation of PQL to QL has to be carried out. The answer of user's question is formulated in terms of problem area.

In problem oriented simulation systems, where the set of user questions is known beforehand, it is possible to define the list of questions and appropriate formulas for calculation of values (obtaining of knowledge). Thus the process becomes simpler. Expression analysis and translation are not needed in this case. There is the only task of obtaining the necessary primary and secondary knowledge as results of appropriate experiments run and analysis.

6 Language independent units used in SS controlled by user's questions

As the theory of compilers construction is enough advanced [6, 1] and taking into account authors' experience in methods of multilanguage compilation systems development [5, 9] it is supposed in this technique to use uniform units of lexical, syntactical and partially of semantic analysis for the model description language, PQL and QL.

7 Conclusions

The proposed technology will allow to create intellectual simulation systems capable to solve the problems of design, analysis and learning of complex systems in various areas: industry, transport, business, public health services, etc. The use of language-independent items of lexical, syntax and semantics analysis for model description language, QL and PQL will decrease expenses of such simulation system implementation.

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