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AUTOMATION OF SIMULATION MODEL GENERATION FROM SYSTEM SPECIFICATIONS

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ABSTRACT

Major advances in simulation techniques have in the past resulted from refinement of our understanding of the modeling process itself. The encapsulation of frequently used functions into standard packages gave rise to the original simulation languages. The recognition of frequently used concepts gave rise to current model-based simulation systems. The separation of the model frame from the experimental frame is just beginning to see implementation in commercially available decision support systems. We believe the next major advance will come from a better understanding of the relationship between the representation (or description) of the system itself and the models/experiments which are performed to satisfy a particular goal. We are currently working towards a modeling paradigm in which a system specification frame and a goal specification frame are formally recognized as distinct from the simulation modeling, experimental, and implementation frames.

OVERVIEW

Simulations represent an implementation of a design (often referred to as the simulation model) in a particular programming language within an experimental frame. Current activities in simulation languages and simulation development environments have focused on the model design and implementation resulting in significant improvements in both areas. The problem which we are concerned with, however, is the process of problem analysis and environment specification. The development of an appropriate model structure and experimental design depends on the goals of the analysis study and on the structure of the system being analyzed. We believe significant benefits can be derived from modeling of these goals and system structures from a system description point of view using requirements modeling techniques, and then automatically translating these descriptions into simulation models with appropriate experimental designs. In order to accomplish this, one must understand the relationships between the world modeling viewpoints of both disciplines. We have analyzed seventeen different world modeling structures. Roughly half from information and requirements modeling methods, the others from existing simulation modeling methods. We are developing a formalization for the classification of the modeling constructs and for the generation of translations between constructs.

PREMISE

Since the initial creation of simulation languages (essentially simulation function macros) a considerable amount of research effort has been directed towards creating better ways for the end user of a simulation to directly express his observations of the system dynamics and then have a simulation performed of these dynamics over time. Unfortunately most of the work to date has not looked at how the user actually thinks about the system dynamics. Rather most of the effort has been spent in taking advantage of advances in terminal graphics capabilities and interactive forms driven or command driven programming. These efforts have improved interfaces to existing modeling techniques and represent a valuable technology; however, the process of gathering a users description of the environment and translating that into a simulatable form is still largely an unexplored area. If significant in-roads are to be made in bringing simulation to wide spread use by non-simulation analysts then the following problems must be addressed:

1) Users must be able to describe their systems in a form which is natural with respect to the way they think about their environment.

2) Systems must be constructed which interact with the users as they provide this description in a consulting mode to help them provide the information required to actually perform the simulation.

3) Users must be able to describe desired experiments in the form of 'what if' scenarios as they conceptualize these ideas.

4) The system must be able to provide necessary consultation to the users to elicit from them sufficient information to be able to evaluate the 'what if' scenarios using simulation as the experimental tool.

5) The simulation software systems must be able to directly tie into the manufacturing or business data bases and extract the volumes of information which today are generally hand loaded (or worse yet encoded into the structure of the model).

GOALS

The ultimate goals of this effort are:

1) Develop a system which could help a user construct his own model of his environment (i.e., provide better abstraction features for the end user.)

2) Translate that model automatically into a simulatable form.

3) Assist the user in formulating both solution concepts, and analysis strategies for evaluating those concepts within a simulation framework.

APPROACH

The approach that has been taken consists of the following activities:

1) Identify the objects, concepts, language subset, and grammar structures used by manufacturing personnel in describing their problem domain.

2) Identify the concepts of modeling typically used by operations and line management in a manufacturing situation.

3) Analyze existing 'world models' (semantic data models) in the literature which are used to model information in a users environment.

4) Characterize these semantic 'world models' with existing simulation 'world models' found in the literature.

5) Analyze existing simulation languages and system dynamics modeling languages to ascertain what constructs they support.

6) Analyze existing systems/methods for natural language processing particularly the development techniques used for determining:

a. The allowable categories and subcategories of the words and the lexicon of categorized words.

b. The grammar rules and definitions of well formed text in discourse analysis.

c. The analysis procedure (or parsing approach) used.

d. The procedure for associating semantic actions with the parse and executing those actions.

7) Investigate the confusion of inferencing versus simulation versus optimization typical in user generated 'what if' questions.

8) Design and construct a prototype system to translate natural language descriptions of manufacturing situations and 'what if' scenarios into a formal system specification.

9) Design and construct a prototype system for translation of the system specifications into a simulation model design.

Progress/Status

Efforts to date directed towards activities 1, 2, and 6 have focused on performing discourse analysis of seven natural English system description using the cohesion and linguistic analysis techniques described in [Halliday 76]. This analysis identifies the cohesive items used, their types, and as a side effect, the primary concept and object classes.

Efforts to date directed towards activities 3, 4, and 5 have focused on documenting and classifying the world modeling structures. The framework we are developing for translation between these different views is based on six concepts: Realms, Objects, Properties, Events, States, and Binding agents.

Efforts to date directed towards activities 7, 8, and 9 have focused on the functional design of the system and the grammar specification for the languages required. We currently see the need for four different language structures:

a) A restricted subset of natural English.
b) An object oriented natural language used to interact with the user.
c) A formal system specification language.
d) A simulation modeling language.

We have constructed a prototype parser for the natural language processing, and we are working on the generation of the object oriented language descriptions.

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