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QUALITY ASSURANCE IN COGNIZANT SIMULATIVE DESIGN

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ABSTRACT

Computer assistance in engineering design can be enhanced by cognizant techniques having abilities such as perception, interpretation, reasoning, goal-setting, and learning. Simulative design provides ability to experiment using the model which results from the design process. Hence, simulative design provides a powerful way to test the acceptability of the design. Combined effects of embedded simulation ability and cognizant techniques in a computer aided design result in cognizant simulative design.

Traditional quality assurance issues of modelling and simulation are applicable in simulative design. Artificial intelligence in simulative design has two implications in quality assurance: 1) cognizant quality assurance and 2) quality assurance issues of cognizant techniques. Following a brief introduction of cognizant simulative design, a glossary of basic terms is provided.

1. INTRODUCTION

In early days of scientific computation, the role of computers were merely number crunching. The advent of symbolic processing provided computer assistance in design, leading us to CAD (computer aided design). Nowadays, it is taken for granted that design has to be computer aided. Therefore, the question is no longer whether or not design should be computer aided but what type of advanced features computer aided design should have.

There are a few levels of advances we can have in computer aided design for engineering applications. They are: simulative design, cognizant design, and cognizant simulative design.

A **simulative design environment** is a computer aided design environment with embedded simulation abilities. In such an environment there may be more than one type of simulation ability as it is the case in VLSI design and simulation systems.

In **simulative design** the purpose is design but one also has the ability to perform simulation with the design on hand.

Simulation is evolving towards **cognizant simulation** where modelling and simulation environments and/or simulation system have cognitive abilities such as perception, interpretation, reasoning, explanation, goal setting, and learning (Ören 1986a).

In general, a **cognizant system** is a computer or computer embedded system which has cognitive abilities such as:

1) knowledge processing abilities including perception, acquisition, interpretation, learning, reasoning, and dissemination of knowledge,
2) asking and answering questions in a computer or a natural language including spoken language,
3) explanation including the trace of its own knowledge processing,
4) goal-setting,
5) adapting to new situations,
6) improving performance, and
7) monitoring itself, its environment and its user.

(Ören 1986b).

A **cognizant simulation design environment** is a computer aided design environment which has both cognizant and simulative abilities.

In **cognizant simulative design,** the purpose is design but one also has ability to perform simulation with the design on hand. Furthermore, design and simulation environment can have cognizant abilities. Cognizant simulative design (CSD) would bring the advantages of cognizant systems to simulative design.

2. QUALITY ASSURANCE

Issues related with quality assurance of simulation studies are well documented in Balcı and Sargent (1984) and Ören (1981). A taxonomy and a glossary of twenty basic terms of quality assurance in traditional simulation and modelling are given in Ören, Elzas, and Sheng (1985). A discussion of artificial intelligence in quality assurance of simulation studies can be found in Ören (1986a).

Due to simulative design, quality assurance issues relevant to modelling and simulation are equally applicable in computer aided design. However, the problem does not stop at this point. Knowledge which can be used for the generation of models has to be assessed for adequacy which leads to adequacy of modelling-knowledge and correctness of use of modelling-knowledge.

Cognizant aspects of simulative design brings additional quality assurance problems into perspective, such as cognizant quality assurance and built in cognizant quality assurance as well as knowledge-base integrity, including model-base integrity and rule-base integrity. In a self-modifying rule-base, for example, one needs techniques to assure consistency and correctness of the rule-base after each modification. Even a static rule-base, i.e. one which does not change, also needs techniques to assure its integrity as a safeguard.

3. A GLOSSARY OF QUALITY ASSURANCE

A glossary of quality assurance terms relevant to cognizant simulative design is provided. Most of the terms are taken from Ören, Elzas, and Sheng (1985), some others are from Ören (1986a). New terms are added as deemed necessary.

Applicability of experimental conditions
Evaluation of experimental conditions with respect to the real system.

Behavioral comparison of models
Comparison of behavior of a model with the behavior of another model generated under the same conditions.

Behavioral validity of a model
Comparison of model behavior and real system behavior observed or generated under the same conditions.

Built-in cognizant quality assurance
Use of cognizant techniques to guide the user in the specification phase of activities or elements for the purpose of eliminating some types of errors, such as morphological errors. This is in contrast of having additional techniques including cognizant ones to detect and eliminate errors which exist in the specifications.

Cognizant quality assurance
Application of cognizant techniques to quality assurance problems. It consists of assurance of quality or enhancement of quality assurance operations via cognizant techniques.

Computational validity
Evaluation of run-time library with respect to the computational requirements of the (experiment, model) pair.

Data relevance
Evaluation of data collected from the real system with respect to the goal of the study.

Descriptive assessment
Evaluation of an element of a simulation study with respect to the value-free rules used to represent it. It consists of syntactic, morphological, and semantic assessments.

Ethical assessment
Evaluation of an element of a simulation study with respect to a set of moral codes.

Experimentation error
Evaluation of the procedure of collecting data from real system with respect to the experimental conditions.

Experiment/model compatibility
Evaluation of the compatibility of computerized (experiment, model) pair.

Formal checks
Evaluation of the model specification with respect to the modelling formalism used. It includes consistency checks and completeness checks.

Instrumentation error
Evaluation of data collected from the real system with respect to the source of data, taking into account error tolerance.

Knowledge-base integrity
The condition of a dynamically changeable knowledge-base, including a self-modifying or learning knowledge-base, in which all knowledge remains correct and consistent.

Model-base integrity
The condition of a dynamically changeable model-base in which all models remain correct.

Model qualification
Evaluation of a model with respect to the goal of the study.

Model realism
Evaluation of a model with respect to the real system.

Model verification
Evaluation of a computerized model with respect to its conceptual model.

Morphological assessment
Evaluation of an element of a simulation study with respect to norms to represent relevant forms and structures. Both problem-dependent and methodology-based elements can be subject to scrutiny of morphological assessment.

Normative assessment
Evaluation of an element of a simulation study with respect to some norms of a value system which can be pragmatic or ethical.

Pragmatic assessment
Evaluation of an element of a simulation study with respect to practical results such as implementability, useability, usefulness, clarity, comprehension, sensitivity, cost effectiveness.

Qualification of experimental conditions
Evaluation of experimental conditions with respect to the goal of the study.

Rule-base integrity
The condition of a dynamically changeable rule-base, including a self-modifying or learning rule-base, in which all rules remain correct and consistent.

Semantic assessment
Evaluation of an element of a simulation study with respect to the meaning attached to it.

Sensitivity of model behavior
Comparison of model behavior under different scenarios where all conditions are kept the same except for the parameter and initial condition for which sensitivity is being assessed.

Software quality assurance of computerized model
Evaluation of a computerized model with respect to software quality assurance requirements.

Software quality assurance of run-time simulation library
Evaluation of the run-time simulation library with respect to software quality assurance requirements.

Software quality assurance of experimentation program
Evaluation of an experimentation program with respect to software quality assurance requirements.

Structural comparison of models
Evaluation of the structure of a model with respect to the structure of another model.

Structural validity of model
Evaluation of the structure of a model with respect to the *perceived* structure of the real system.

Syntactic assessment
Evaluation of an element of a simulation study with respect to the rules of representing the symbols or the expressions constructed from these symbols.

Verification of experimental conditions
Evaluation of computerized experiments with respect to experimental conditions.

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