

AN INTEGRATED SOFTWARE ENVIRONMENT OF SIMULATION EXPERIMENT DESIGN, ANALYSIS AND EVALUATION

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ABSTRACT

This paper presents an integrated software environment named HIT-SEDAES (Harbin Institute of Technology-Simulation Experiment Design, Analysis and Evaluation System). HIT-SEDAES can aid users to design simulation experiments, monitor and control simulation process, manage and analyze simulation data, evaluate system effectiveness/performance and simulation credibility. During the software environment design and implementation, several methods were applied, including the intelligent method of simulation experiment design, flexible evaluation method of operational effectiveness, multivariate simulation result validation method and simulation optimization method based on meta-model and intelligent algorithm. The software environment was well used and endorsed by some institutes.

1 INTRODUCTION

Simulation technology has become the efficient and effective tool in many fields, such as system analysis, education and training, acquisition and system acceptance, research and entertainment. Meanwhile, simulation applications become more and more complex for their large scale, complex interactions, and numerous uncertainties. So many problems are brought forth, such as high dimensional experiment space, simulation result analysis, complex simulation credibility evaluation, efficient simulation tools, etc.

The existing simulation platforms, such as Arena, ExtendSim, Micro Saint, SIMUL8, Witness, etc., have limited functions of simulation experiment design, analysis and evaluation. And traditional experiment design and analysis tools are not fully suitable for simulation, meanwhile existing simulation tools also have deficiencies in their interfaces, reusability and expandability.

To solve the problems described above, HIT-SEDAES was designed and implemented to support simulation experiment design, simulation data monitoring, management and analysis, effectiveness/performance evaluation and simulation result validation.

2 SOLUTIONS

In order to improve the efficiency and solve the deficiencies of the existing simulation tools, HIT-SEDAES is designed and implemented. HIT-SEDAES contains seven subsystems: simulation experiment design tool, simulation monitoring and control system, simulation data management system, simulation credibility evaluation system, effectiveness/performance evaluation system, simulation results analysis system and resources library.

Overall, each subsystem of HIT-SEDAES can interact data automatically, and HIT-SEDAES can interact with simulation systems friendly. HIT-SEDAES has the ability to deal with problems of simulation experiment design, analysis and evaluation. Besides, new methods of simulation experiment design, analysis and evaluation can be extend easily for HIT-SEDAES. Next, several methods used by HIT-SEDAES are discussed briefly.

Intelligent method of simulation experiment design. To solve the problem of how to choose Design of Experiments (DOE) method, a hybrid approach using rule-based reasoning (RBR) with case-based reasoning (CBR) is proposed. Firstly, extract the features of the problem according to the purpose of experiment and the information of factors. Then retrieve case in the case database whether the similar cases exist. If there are some cases acceptable, DOE methods will be recommended and their similarity will be provided for users' selection. However, if there is no case satisfied, using RBR instead, and the new case will be added into the case database.

Flexible evaluation method of operational effectiveness. Most of existing effectiveness/performance evaluation tools can only be applied to specific or limited range of evaluation purposes or objects, which influences the tools' reusability and expansibility. To make the tools applied to different evaluation purposes or objects, a flexible method of evaluation process establishments and evaluation index extraction was proposed.

Then the evaluation knowledge was divided into three kinds, namely character data extraction knowledge, evaluation index algorithm knowledge and evaluation indexes integration knowledge. The models of each kind knowledge are given based on framework theory for they are structured and factual knowledge. Then, the general framework of the evaluation system are proposed, and the storage models of expert knowledge, simulation experiment database and evaluation project database are designed.

Multivariate simulation result validation method. The outputs of simulation model and actual system are divided into three types, static data, slow-changed data and fast-changed data. The models to measure feature differences of the three kinds of data are given respectively. Then the correlation among the feature differences is eliminated via principal component analysis and several independent principal components containing the most information are gained from the correlative feature differences to construct the data feature difference vector. Furthermore, the outputs of simulation models are divided into K kinds of clusters based on K-means clustering according to the data feature difference vector. Which cluster the output of actual system belongs to is judged based on Fisher discriminant analysis. So the method reduces the subjectivity of the results relative to the classical methods.

Simulation optimization method based on meta-model and intelligent algorithm. For the optimization on complex simulation systems is inefficient, a simulation optimization method based on meta-model and intelligent algorithm was proposed. In the method, an improved Particle Swarm Optimization algorithm was adopted, and the selection of meta-models and optimization algorithms is automated according to the cost, the nonlinear degree and data size.

HIT-SEDAES is implemented based on the methods described above, and it has been successfully applied to several simulation systems to aid operational effectiveness evaluation, system performance analysis, consistency analysis, etc. In the future, the software environment will provide the function of cooperation evaluation and analysis.

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