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APPLICATION OF SIMULATION MEANS IN COMPUTER AID OF MANUFACTURING SYSTEMS CONTROL

Abstract:
The paper deals with the options of simulation means exploitation in the applications usable for the aid of the manufacturing systems controlling. There are shown the aspects recommended for building, validation and verification of the simulation model as also the procedures of exploitation of simulation outputs in practice. The paper deals with advantages and disadvantages of described software technology with respect to the concrete environment and conditions of simulated model.

Keywords:
operation, simulation, validation, implementation

INTRODUCTION

Modeling and simulation play increasingly important roles in modern society. They contribute to our understanding of how things function and are essential to the effective and efficient design, evaluation, and operation of new products and systems. Modeling and simulation results provide vital information for decisions and actions in many areas of business. There are some formal approaches to be kept to ensure both model and simulation correctness and credibility; and the simulation has some limitations, especially to validity and credibility issues.

BUILDING SIMULATION MODEL

The primary reason for modelling and simulation is to reduce costs on new projected system and/or finding the critical aspect of real system and their optimization. Approach to data acquisition related to solve problem entity is shown in Figure 1.

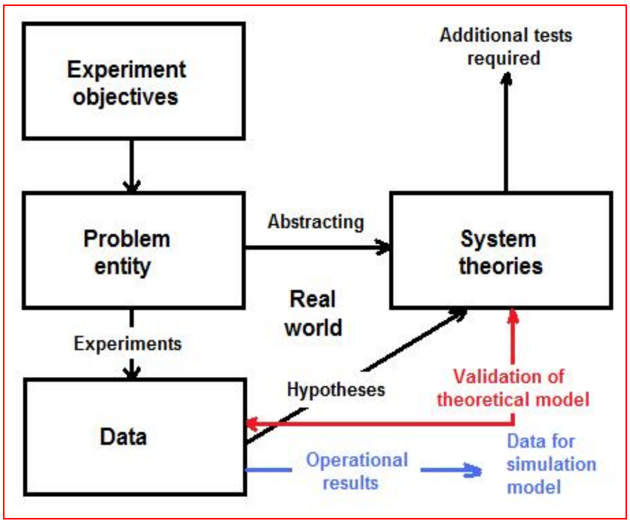

Figure 1 Problem entity analysis in real world

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System theories are the interface, which are connecting the real and simulation worlds. For successful realization of simulation model, it is necessary to make data acquisition, verification and validation as precise as possible. The primary motivation for modelling, simulation, verification and validation is risk reduction; and the relation between costs spent on model development and benefits from it, is the core issue in the question of how much the simulation is needed. Limitations in items required for effective simulation (required data and detailed characterization of associated uncertainties and errors, simulation/software details, etc.) must be addressed, with many of the management processes in many areas of simulation application. After making these procedures, the initial data for simulation model can be abstracted and derived from real world. After that, the preparation phase is finished and development of simulation model can be initiated. Approach to building simulation model is shown in Figure 2.

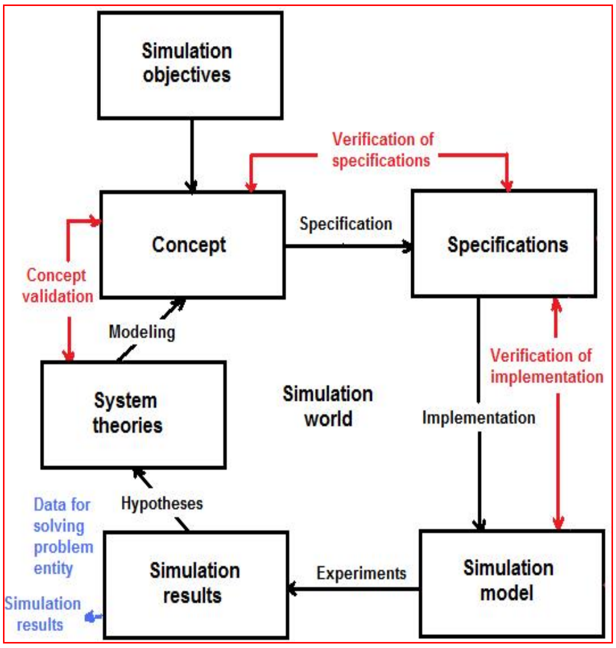

Figure 2 Simulation world

Under concept of simulation model, we can understand computer simulation model imitating behavior of some real system created on the base of mathematical computer model under the frame of system theories. Simulation model enables to create predictive scenarios of possible occurs in modeled system under some conditions. Simulation project usually includes several steps, which can be summarized, as follows:

- *conception formulation and analysis of the problem;*
- *data and information collection;*
- *building model;*
- *verification and validation;*
- *design of experiments;*
- *performance of experiments and analysis of results;*
- *improvement of designed experiments;*
- *final analysis of results;*
- *documentation of process.*

Time most demanding of all steps are data and information collection and then validation. Dynamic processes are regularly to much complex to totally precise analytical description, since they include wide spectrum and low volume of items, too much aims of planning, flexibility of scheduling, etc. In these cases, the simulation is ideal candidate for performing analyses and optimization. [1], [4]

SOME ASPECTS OF SIMULATION USE

The following recommendations should be considered before building correct and useful simulation model:

- ***Qualitative Assessment of Problem Entity:*** *In many operation areas, such as medical and technical diagnoses, knowledge engineering, the problem entity mainly depends on qualitative assessment. In various disciplines, the qualitative assessments are generally credible and repeatable. Qualitative assessment in modeling and simulation commonly provides unstructured, vague, and incomplete evaluations, therefore the feedback debugging of the model and its calibration is required.*
- ***Costs of simulation:*** *Before using simulation, it is necessary to estimate the benefits of modeling and simulation for concrete intended solution. Costs of simulation can increase by lack of information about modeling and simulation and improper ways of data acquisition and implementation. Despite the increasing reliance on models and simulations as well as more effective and creative ways to use existing systems, sometimes provided simulation results do not meet the*

requirements of end user, and the costs of simulation are then increasing with its validation and verification.

- ***Inference:*** Description and quantification of uncertainty in the model or simulation and in the experimental data is very important.
- ***Adaptation:*** Models and simulations using adaptive programming are changing during operation. Changes can be relatively minor or major, affecting the structure of the program as well as individual processes within the program, which need to be a subject of validation and verification.
- ***Aggregation:*** Models and simulations normally aggregate some representational aspects to make the mode easier to use or to allow the simulation to execute in a reasonable time. Such aggregation is not primary interest. But some models and simulations can aggregate aspects that are of primary interest and could significantly influence the simulation effectiveness. [1], [6]

Tab. 1 Application areas of computer simulation systems.

Application area	%
Transportations systems	7
Supply chain management	10
Manufacturing systems	14
Military	4
Health care	4
Financial modelling	4
Education and training	4
Risk analysis	3
Computer and communication networks	8
Business process workflow	11
Aerospace	3
Other	28

APPLICATION AREAS

Typical goals set for simulation experiments are [5]:

- reduction of costs;
- increase of performance;
- testing of newly designed processes before their implementation in practice;
- reaching optimal exploitation of resources (machines, production lines, equipment, personnel, etc.);
- reaching better logistic performance inside the system;
- exploitation of model for forecasting of future behavior;
- studies of capacity exploitation, level of stocks, logistic control, integrating studies, bottlenecks, better scheduling of processes.

Most frequent application areas of computer simulation systems are shown in Table 1.

SIMULATION OF MANUFACTURING SYSTEMS

One of the largest application areas for simulation modeling is simulation of manufacturing systems. Specific issues addressed in manufacturing systems control are as follows:

The need for and the quantity of resources:

- number and type of machines for a particular objective,
- number, type, and physical arrangement of transporters, conveyors, and other support equipment such as pallets and fixtures,
- location and size of inventory buffers,
- evaluation of a change in product volume or mix,
- evaluation of the effect of a new piece of equipment on an existing manufacturing system,
- evaluation of capital investments,
- labor-requirements planning.

Performance evaluation:

- Throughput analysis,
- Time-in-system analysis,
- Bottleneck analysis.

Evaluation of operational procedures:

- production scheduling,
- inventory policies,
- control strategies [for example for an automated guided vehicle system (AGVS)],
- reliability analysis (for example such as studying effects of preventive maintenance),
- quality control policies.

Following are some of the performance measures commonly estimated by simulation:

- throughput studies,
- time in system for parts,
- bottlenecks identification and solution,
- times parts spend in queues,
- frequency of orders and demands
- probability studies,
- work in process time studies,
- queue sizes,
- timeliness of deliveries,
- gantt studies,
- storage utilization,
- material handling studies,

- *utilization of equipment or personnel.*

Randomness of manufacturing systems:

The following issues are sources of randomness in manufacturing systems:
- *arrivals of orders, parts, or raw materials*
- *processing, assembly, or inspection times*
- *machine times to failure*
- *machine repair times*
- *loading/unloading times*
- *setup times*

Generally, each source of system randomness needs to be modeled by an appropriate probability distribution; sources of randomness in practice are very rarely normally distributed. Before modeling, there is necessity to specify the probability distribution for each of randomness sources.

SIMULATION EXPERIMENTS

The simulation input has usually random nature, which means that the results of simulation runs can be considered as a statistical estimate of reality. It means that every simulation measure is not the true performance, but its statistical calculation. To avoid high variances, a thus to ensure the correlation of simulation runs with reality, it is necessary to design appropriate choices for the following:
- *length of each simulation run,*
- *number of independent simulation runs.*

Their correct specifications provide statistically precise bias free results.

The proper selection of type of study is also very important, general division of the simulation experiments can be as follows:
- *static or dynamic simulation,*
- *deterministic or stochastic simulation,*
- *continuous or discrete event simulation.*

It is recommended to perform from three to five independent runs for each system design. The average of the estimated performance measures from the individual runs is then used as the overall estimate of the performance measure.

Every independent run should use different random numbers and probability distributions settings. Each of the run should start in the same initial time, with reset of simulator statistical counters before each run [2], [7].

The overall estimate should be more statistically precise than the estimated performance measure from one run. For most of the simulation studies of manufacturing systems, the long-run of behavior of the system is more reliable as a short runs. It means, the behavior of system is simulated in "normal" production manner. Simulation output data from the analysis should be correctly treated and interpreted.

SIMULATION ADVANTAGES

Simulation is often used as a research methodology for problem solving, and provides especially low costs on experiments in the comparison with real tests and measurements. Some of the simulation advantages are as follows:
- *low costs on experiments in comparison with the real measurements,*
- *saving time necessary on experiments,*
- *high flexibility of simulation tests,*
- *options to do variant solutions and specification in batch mode, which is much faster than optional real experiments,*
- *discrete event simulation enabling to perform simulation runs in real time,*
- *option of adaptive models and optimization,*
- *exploitation of simulation in design of new manufacturing systems,*
- *options of calibration of the models during implementation of results into practice and continuous improvement.*

SIMULATION DISADVANTAGES

A lot of pitfalls can be identified and these can cause simulation studies fail and result in projects missing their deadlines or overspending the costs. Some of pitfalls can be identified as follows:
- *not sufficient definition of the problem by problem owner, which often does not understand what the simulation expert wants or is trying to do,*
- *not sufficient definition of results that are expected by problem owner,*
- *low skills of the simulation expert regarding specific domain of problem topic issues and knowledge,*
- *weak statistical background of data and information needed as a simulation input,*
- *lack of time to complete the study,*
- *the implemented simulation model does not correspond to the conceptual model,*

- *the simulation environment leads to unclear structure of the model,*
- *the simulation model is too inflexible and has a limited set of options for experimentation,*
- *output data are not correctly implemented or are not usable for the reality.*

CONCLUSIONS

Useful approach to spread use of simulation in manufacturing systems depends on size and complexity of solved system. For small and medium enterprises is efficient to share expertise in simulation developed by many research centers. For large and complex manufacturing systems, it is more efficient to build concrete specific solutions on own base. Solving industrial problems by simulation reduces times and costs, and makes it affordable for many enterprises. Simulation studies are a part of the planning process in manufacturing systems. Simulation tools are rarely applied as single tools; they usually serve as a testbed for production planning and control (PPC) systems. The simulation also allows performing cost simulation studies in the first steps of the planning and thus calibrating business plan.

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