Simulation and Modeling

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A **simulation** is the execution of a model, which is commonly represented, now-a-days, by a computer program that gives information about the system being investigated.

The simulation approach of analyzing a model is opposed to the analytical approach, where the method of analyzing the system is purely theoretical.

Simulation provide the flexibility to modify and analyze the impact of various parameters and components of the system.

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Simulation **embodies the principle of “*learning by doing*”. To learn about the system we must first build a model of some sort and then operate on the model. The use of simulation is an activity that is as natural as a child who plays. Children understand the world around them by simulating most of their interactions with other objects and entities. As adults, we lose some of this childlike behaviour but recapture it lateron through computer simulation.**

Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operations of system.

Simulation a very powerful tool, is used in almost every field to provide systematic approaches in solving problems. It requires model be constructed which represents the system behavior in terms of mathematical and logical relationship between parameters. Thus model must adequately represent the primary effects which relate to the problem under study.

In most of the cases, models cannot be analyzed by standard mathematical techniques because of non-linear interaction between parameters and/or presence of random effects in the system. In such cases simulation is very powerful method.

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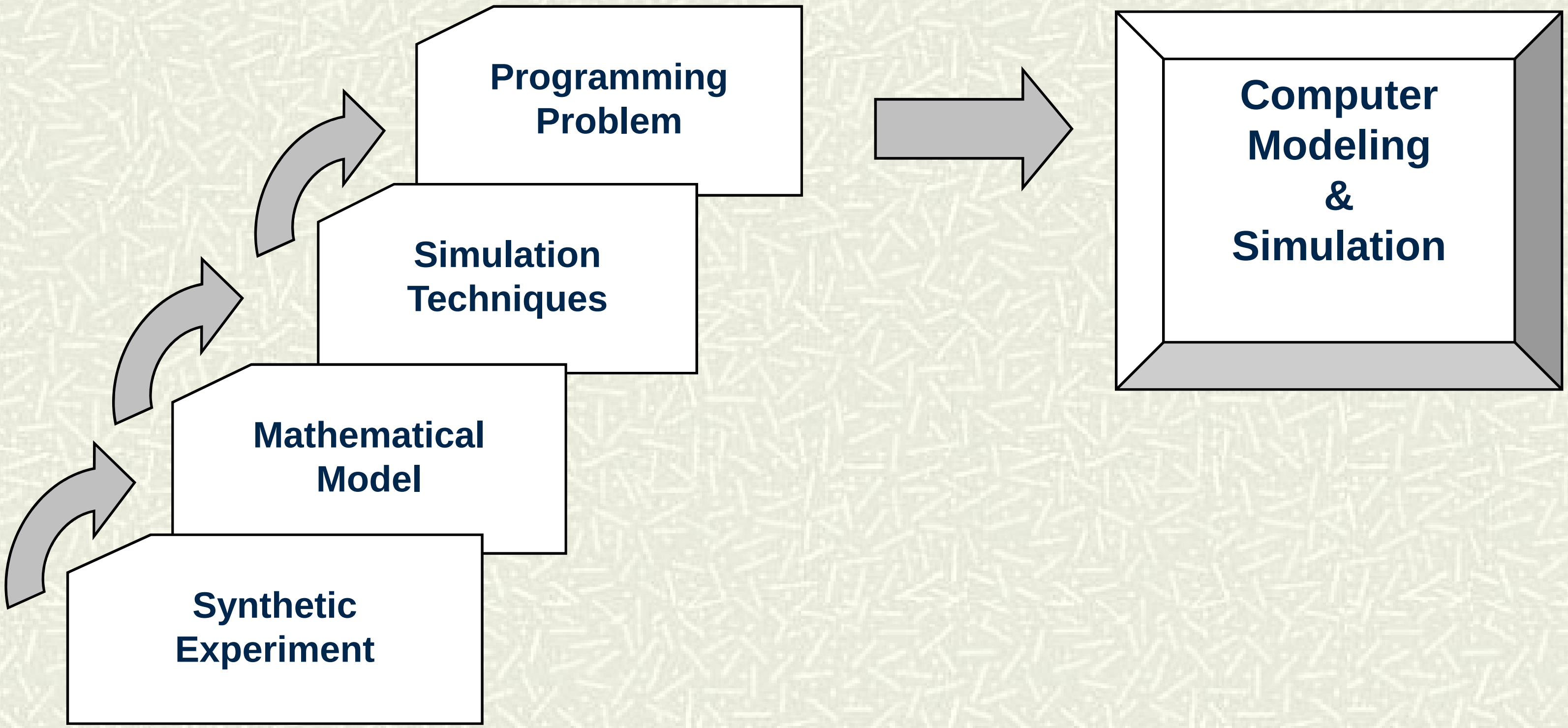

Understanding and applying the basic methods of simulation is easy but drawing accurate conclusion is difficult because of :

(i)complexities in developing model and
(ii)drawing meaningful statements from simulation result.

Thus, simulation is a numerical technique for conducting experiments with certain types of mathematical models which describe behaviour of complex systems on a digital computer over extended period of time.

Advanced computer programs can simulate different situations like weather conditions, chemical reactions, atomic reactions, biological processes etc. In theory, any phenomena that can be reduced to mathematical data and equations can be simulated on a computer.

The objective of the simulation modeler would then be not only to simulate the system satisfactory, but to demonstrate how the control parameters can be manipulated to solve the problems.

Many problems which we encounter in daily lives even though look mathematical in nature, are too complex to tend themselves to meet the workplace requirement through mathematical analysis. The performance of such a system may be difficult to predict. This is due to many reasons like :

(i) the system itself is complex,

(ii) the theory is not yet sufficiently developed, etc.

The difficulties in handling such problems may arise because of the following reasons :

(i) the effect of uncertainties,

(ii) dynamic interactions between decisions and subsequent events,

(iii) complex interdependencies among variables in the system etc.

Formerly, in such type of situations either an intuitive decision is made, or elaborate laboratory experiments are to be conducted, which are usually expensive and time consuming.

Basic steps in Simulation :

***Problem Formulation*

*** Data Collection and Analysis*

*** Model Validation, Verification and Calibration*

*** Input and output analysis*

*** Performance Evaluation and What-if Analysis*

*** Sensitivity Estimation*

*** Optimization*

*** Report Generating*

Criteria for applying Computer Modeling & Simulation :

(i) whenever analytical tools are unavailable or inappropriate for the problem solution.

(ii) when we have reasonable assurance that the concept, system, or operation can be successfully simulated.

(iii) whenever there is a large volume of computations necessary.

(iv) whenever all other approaches have been investigated & are considered inappropriate.

(v) whenever the mere process of constructing a simulation of a system itself be a beneficial learning experience of the system processes.

(vi) whenever the problem is a part of a new scientific area.

(vii) whenever the experiments are too dangerous, too expensive, take too long, or are totally impossible.

Advantages of Simulation :

- New policies, operating procedures, decision rules, information flows, organizational procedures, and so on can be explored without disrupting ongoing operations of the real world.
- Hypotheses about how or why certain phenomena occur can be tested for feasibility.
- Time can be compressed or expanded allowing for a speed up or slow down of the phenomena under investigation.
- Insight can be obtained about the interaction of parameters.
- Insight can be obtained about the importance of parameters on the performance of the system.
- A simulation study can help in understanding how the system operates rather than how individuals think the system operates.
- ‘What if’ questions can be answered. This is particularly useful in the design of new systems.

Types of Simulation :

There are fundamentally two different types of simulation :

(i) Continuous system simulation and

(ii) Discrete system simulation.

Continuous System Simulation :

Continuous system simulation is applied to systems whose state changes continuously. These systems are typically, but not necessarily, described by differential equations, and are mostly from the natural sciences, such as physics, chemistry, electronics, electrical engineering and so on. Normally, the models are deterministic, with no or very few stochastic elements in them. Up to now, any simulation concerned with natural processes could be called a continuous simulation, but normally this term is applied solely to models that are too complex to be solved analytically, so that numerical methods must be used.

Discrete System Simulation :

Discrete system simulation is the modeling of systems in which the state variables changes only at a discrete set of points in time. Discrete system simulation is commonly used by Operations Research workers to study large, complex systems which do not lend themselves to a conventional analytical approach. This is more diverse and has less of a theory than continuous systems simulation.

In simulation of discrete system, there are fundamentally different models for moving a system through time : the fixed time-step model and event-to-event (next event) model. In a ***fixed time-step*** a 'clock' is simulate by the computer. This clock is updated by a fixed time interval (∂t) and the system is examined to see if any event has taken place during this time interval. In ***next-event*** simulation model the computer advances time to the occurrence of the next event.

Here, Random number generation also plays important role.

Simulation Languages:

There are basically two categories of simulation languages :

(i) Continuous simulation languages (designed for simulation of continuous models. e.g. MIDAS, MIMIC, DYNAMO etc.) and,

(ii) Discrete simulation languages (designed for discrete models, e.g. GPSS, SIMSCRIPT SIMULA etc.).

Few languages have been designed for both discrete as well as continuous models, such a languages are called Combined simulation languages (e.g. GASP IV, GSL-A etc.).

Object Orientation in Simulation :

The concept of discrete-event simulation is that of objects operating within a bounded system. Using object-oriented programming to support the writing of a model is simply an extension of the system being modeled.

Describing a system as a collection of interacting components or objects is a natural way of breaking down any problem, large or small. Each object module describes the object behaviors, called methods. In addition, the characteristics of the object are contained in its fields or variables. This structure maps well to real world objects. It provides encapsulation which is the basis of software engineering.

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Those considering object-oriented technology must consider such items as Object-Oriented Requirement Analysis (OORA), Object-Oriented Design (OOD), Object-Oriented Domain Analysis (OODA), Object-Oriented Database Management System (OODBMS) & Object-Oriented Computer Aided Software Engineering (OOCASE). Object-oriented (frame-based / block-based) simulation languages had opened doors for software development for many complicated system. This may be one of the reasons for the popularity of object concepts today. With object-oriented technology, several complicated systems like queuing systems, manufacturing systems etc. have been developed.

Since simulation is founded on the study of real world objects undergoing change, a natural confluence now exists between OO-based design and simulation model design.

Web-Based Simulation :

The web technology is also having a significant impact in the field of computer simulation. Web-based simulation reflects more of a technology transfer than a robust theoretical development; rapid advances are achieved through practical applications. Web-based simulation represents a convergence of computer simulation methodologies and applications within the World Wide Web.

The emergence of the web and the proliferation of web-oriented technologies have driven engineers and scientists in many disciplines to re-evaluate the way they do business. Those involved with computer simulation are no exception to this phenomenon. The growing global use of the WWW and the rising acceptance of Internet-based systems have a strong influence on simulation, animation, and visualization applications.

The web's ability to service large and diverse audience allows the simulation community to legitimately provide models and simulations as end products. Recent advances in web technology have made the web a viable mechanism for performing, publishing, and distributing simulation. This interest in web-based simulation is a natural outgrowth of the proliferation of the WWW and its attendant technologies, e.g. HTML, HTTP, CGI etc.

Some of the advantages of web-based simulation are as follows :

- It can be accessed through Internet or Intranet using any web browser
- It can be run on a local or remote computer
- It can provide excellent graphical animation and interface
- It is platform independent and operating system independent
- It needs minimum maintenance etc.

Fuzzy Simulation :

Fuzzy logic is an approach to computing based on “degrees of truth” rather than the usual “true (1) or false (0)” Boolean logic on which the modern computer is based. Using fuzzy arithmetic, one uses models and makes a subset of the system components fuzzy so that fuzzy arithmetic must be used when executing the model.

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We often need to perform a simulation of a system without knowing precise values for model parameters, state variables, state values and initial conditions. There is a method called “Fuzzy Simulation” that permits one to simulate a model using linguistic values such as ‘very low’, ‘near nominal’ and ‘small’. By using fuzzy methods in modeling, our goal is to bridge a gap between the current expert systems technology in artificial intelligence and mathematical models that are used routinely in science and engineering. It is applicable where no exact data are accessible or where the use of linguistic values is practical. Therefore so called expert systems very often use fuzzy logic. These systems must provide answers for a user who is not a computer expert and who will have only linguistic variables as data. The knowledge of experts is used for this purpose by transforming it into fuzzy rules.

Visual Simulation :

Interaction with the surrounding environment based on visual observations is often a critical part of a task. The unaided eye or sensors and other aids such as binoculars and night vision goggles may be used in task performance. For real-time interactive, these visual scenes must be simulated. Some would consider sensor simulation to be a separate category, but the technology is fundamentally the same. Visual simulation consist of image display, image generation, and image data base subsystems. A mathematical description to the visual environment is stored in the visual data base. The image generator processes the data base using very fast special purpose computers and provide video to the display device which finally presents the image to the viewer.

Different methods of Visual Simulation & its comparison

Method	Realit y	Flexibilit y	Change of the Viewpoint	Persuasi ve Power
Illustration	X	Δ	X	X
Photomontage	O	X	X	O
Computer Graphics	Δ	O	O	X
Model	X	X	O	Δ
High vision TV	O	O	X	O

X → Absent   O → present   Δ → Average

Now a days, Visual simulation is also used highly in the developed countries like Japan, USA etc. This visual simulation technology can be used in auto industry, aerospace industry, shipbuilding, general industrial machinery etc. Even it can be used in tree plantation also, where the displayed images can be evaluated from any viewpoint, and the trees can be changed accordingly to the passage of time of seasons.