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Introduction to Simulation and Modeling

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Abstract – The main objective of this paper is to describe the overview of simulation and modeling and analysis. Many critical question are answered in this paper .Like What is simulation and modeling and why it is important in our daily lives, in our professional life and in research or even in our personal life? When is simulation and modeling is appropriate or when it is not? So the objective of this module to gain the knowledge about system and its behavior so that a person can transform the physical behavior of system into a Mathematical model that can in turn transform into a efficient algorithm for simulation process.

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WHAT IS SYSTEM AND ENVIORNMENT

Before we are able to model anything (modeling),we need to have some basic concepts. These are two basic concepts of importance, which are system and system boundary.

SYSTEM

A System is defined as group of objects joined together in some regular interaction. For example:-.A manufacturing factory produce various products like electronic devices, all this behave like a system. Another example is a car production system contains robotics or robotic assembly in which all the car system is built, that all combined make a system.

COMOPENTS OF SYSTEM

In this module, we shall examine the concept of system components:-

ENTITY

A object of interest in the system is called an entity.

ATTRIBUTE

A attribute is the property of an entity.

ACTIVITY

Aactivity represent a time period of specific length.

STATE

Collection of variable necessary to describe the system at any time, relative to the objective of the study. For example if we talk about the human, may be in happy state or unhappy state.

EVENT

Instantaneous occurrence that might change the state of system.

For easy understand about all the components of a system, we take examples :-

SYSTEM	ENTITIES	ATTRIBUTES	ACTIVITIES
Banking	Customers	Checking account balance	Making Deposit
Communication	Message	Length; Origin; Destination;	Transmitting
Production	Machines	Speed; Capacities; breakdown rate	Welding; Stamping

ENVIORNMENT

"Change in System Environment" occur based on changes outside the system.

For example:- In a factory system, arrivals of orders can be considered as outside the influence of the factory. Therefore it can be a part of the environment. If the effects of supply on demand are important, then this must be a part of system.

WHAT IS MODELING

Already we discuss about the system, after discussing that now in this module we shall examine what it mean by developing a system model? or how do we model a system. Because coming from an implicit model(that model which in our mind) to an explicit model(that model which we communicate to others) is a complex task.

Why Model

Sometimes it is of interest to study a system to understand the relationship between its components or to predict how the system will operate under a new policy. It is sometimes possible to experiment with the system itself. For example:-In Traffic System, for this we have to visit the road and analysis the traffic of vehicles in which time more and in which time less. So we have to interact the system and then we model the system.

The MODELING is derived from the word 'Model'. A Model is a representation of an actual system. A model is an abstraction of the real system or we can say that model should be close approximation of real system. Modeling is always starting with cognitive (process of understanding).It is theory of mind. Example of Modeling is when if we talk about a child, a child who see a cat in mobile devices, which is not real it is like a simulation which shown in electronic device but child think it is reality that cat is original who talk with him or interact with him and that thinking concept of child's mind is also modeling.

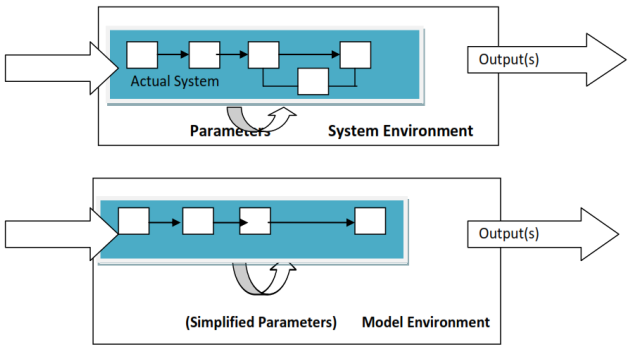

Figure 1: Pictorial Representation of System Model

WHAT IS SIMULATION

In general, simulation means something which simulates system environment in order to predict actual behavior or we can say that simulation is simulated system imitates operation of actual system overtime. Simulation enables the study of and experiment with the internal interaction of a complex system. The overall approach in computer simulation is to represent the dynamic characteristics of a real world system in a computer model. The knowledge gained during the designing of a simulation model could be a great value towards suggesting improvement in the system under investigation. Artificial history of system can be generated and observed. Internal behavior of system can be observed.

DEFINITION OF SIMULATION

Simulation can be broadly defined as a technique for studying real world dynamical system by imitating their behavior using a mathematical model of the system implements on a digital system.

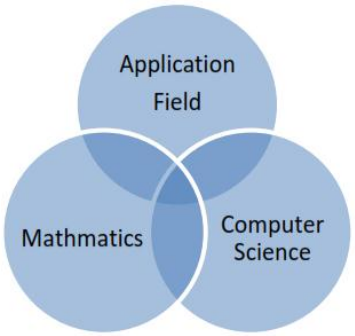

Figure 2:-Simulation include all this

Changing simulation inputs and observing the resulting outputs can produce valuable insight into which variables are the most important and into how variables interact.

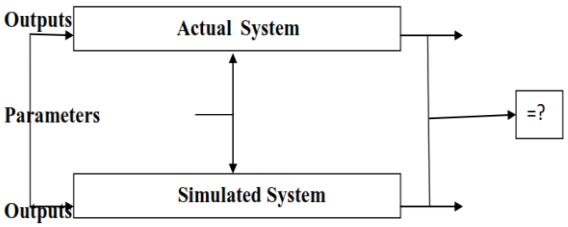

Figure: 3 Simulation vs. Actual System

When is it an appropriate tool:-In this module, we shall see how simulation can be an appropriate tool in certain cases. Because every tool has a different purpose .For example: A Hammer cannot be used in a place of screw driver**.** Simulation can be used to experiment with new designs or policies before implementation, so as to prepare for what might happens**.** It can be used to verify analytic solutions. Simulation models designed for training make learning possible without the cost and disruption of on-the-job instruction. For example: Flight Simulator. Simulators can be used as an effective means for teaching or demonstrating concepts to students. This is particularly true of simulators that makes intelligent use of computer graphics and animation. Animation of simulation shows a system in simulated operation so that the plan can be visualized. The modern system (factory, water, fabrication plant, service organization etc) is so complex that its internal interaction can be treated only through simulation. There are other many more reasons to use a simulation.

When is it not an appropriate tool:-In this module, we shall see when simulation may not be the most appropriate tool. There is a typical misconception often in some persons that everything can be, or should be simulated. But simulation is not a silver bullet!

1. Simulation should not be used when the problem can be solved by common sense. For example::In a factory, we want to investigate how many customers arrive in factory. For this, rather than using a simulation, we investigate this by standing himself there.

2. Simulation should not be used if the problem can be solved analytically or mathematically.

3. Simulation should not be used if it is easier to perform direct experiments.

4. Don't use simulation if the costs exceed the savings.

5. Simulation should not be performed if the resources or time are not available.

6. Simulation takes data, sometimes lots of data, if not data is available, not even estimates, simulation is not advised.

SIMULATION: ADVANTAGES AND DISADVANTAGES

In this module, we shall see both sides of the coin:

Advantages:-

1. Simulation is best suited to analyze complex and large practical problems.

2. Simulation is feasible, hence changes in the system variable can be made to select the best solutions among various alternatives.

3. In the Simulation, the experiments are carried out with the model without disturbing the system.

4. Easy to perform 'what if' analysis.

Disadvantages:-

1. Simulation doesn't generate optimal solution.

2. It may take a long time to develop a good simulation model.

3. In certain cases, simulation model can be very expensive.

4. Sometimes, it is difficult to interprets the simulation results.

STEPS IN SIMULATION

In this module, we shall examine steps in a simulation study. Although there is a logical ordering of steps in a simulation study, much iteration at various sub-stages may be required before the objectives of a simulation study are achieved. Not all the steps may be possible and/or required. The following question should be answered in this.

1. How a simulation study conducted?

2. What are the steps?

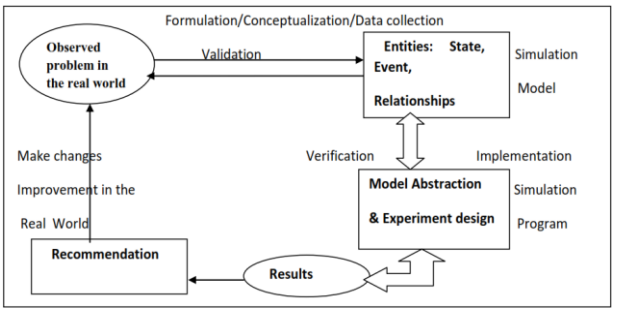

Figure: 4 Steps in Simulation

The steps of modeling process are as follows:-

1. **Problem Formulation:**-Every Study should begin with a statement of the problem. In this we study the situation sufficiently to identify the problem precisely and understand its fundamental question clearly. Only with the clear precise problem identification, we can translate the problem into mathematical symbol and develop or solve the model.

2. **Objective and project plan:-**Objective indicates the question to be answered by simulation. Without objective, it make little sense to develop a simulation model, In the project plan, we set project objectives. In this we also check that simulation is right tool or not.

Project planning also include the plan for the study in terms of:

- The number of peoples involved.
- The cost of the study.
- The no. of the days required to accomplish each phase of the work.
- The result expected at end of each stage.

3. **Model Conceptualization:-** The construction of a model of a system is probably as much art as science. Although it is not possible to provide a set of instructions that will lead to building successful and appropriate model. In every

instance, there are some general guidelines that can be followed.

The art of modeling is enhanced by:

- An ability to abstract the essential features of a problem.
- To select and modify basic assumption that characterizes the system.
- To enrich and elaborate the model until a useful approximation results.
- Thus it is best to start with a simple model and build toward greater complexity.
- Violation of this principle will only add to model building and computer expenses.
- It is not necessary to have one-one mapping between the model and real system.
- Only the essence of real system is needed.
- It is advisable to involve the model user or stakeholders in model conceptualization. Involve the user will both enhance the quality of the resulting model. Increase the confidence of the user in the application of the model.

4. **Data Collection:-**We collect the relevant data to a information about the system's behavior.

5. **Model Abstraction:-**In this, the analyst abstract relevant features of the system to be represented in the model. Depending on the goals of the simulation study, the analysts decide an appropriate level of detail or granularity of the model.

Determining variables and units:-We must determine and name the variables. The variables are of two types

a) Independent Variables:- That variable on which other depends.

b) Dependent Variables:- That variables depend on other variables.

- Establish relationship among variables and sub models.
- Determine equation and function.

6. **Solve the Model:-**This stage implements the model. It is important not to jump to this steps before thoroughly understanding the problem and designing the model. Otherwise we might waste much time, which can be most frustrating.

7. **Model Implementation:-** The conceptual model generated during the earlier phase must be implemented in the form of simulation program. During implementation, an analyst can use a simulation language such as C,C++or java and special simulators tailored for specific applications.

8. **Verification & Validation:-** The basic question is "Is the computer program performing properly'. If the input parameters and logical structure of the model are correctly represented in a computer, verification has been completed. Validation is usually achieved through calibration of the model. An Integrative process of comparing the model against the actual system behavior. This process is repeated until model accuracy is judged acceptable. Output must be match the real system in validation.

9. **Experimental Design:-**In this, when the model is made, we done experiment on it, for experiment, we take some variables in which value of some variable is fix and in some we do change. And analysis the effect of this changed variable on constant variable. There is example of hospital, let suppose we fix no. of doctors as before but if the patient comes in more, then we examine the effect on various departments of hospital. Experimental design is done as follows:-

a) **Product runs and analysis:-**Production runs and their subsequent analysis, are used to estimate measure of performance. For the system design that are being simulated. There is also possibility to use software to help in this step.

For example:- opt quest, Net Logo etc.

b) **More runs:-**Given the analysis of runs that have been completed, the analysts determine whether the additional runs are needed.

10. **Report on the model:-** Reporting on a model is important for its utility. Perhaps the scientific report will be written for colleagues at a laboratory or will be presented at a scientific conference. A report contains the following components:-

- Analysis of the problem
- Model design

- Model solution
- Results and conclusion

11. **Recommendation:-** This may include further experiments to increase the precision and reduce the bias of estimators, to perform sensitivity analyses, etc.

APPLICATION OF SIMULATION & MODELING

In this module, we shall examine various applications. Wintersim conference (**www.wintersim.org**) is great place to look simulation application. Various applications are:-

- Manufacturing Application
- Construction Engineering and Project Management
- Military Application
- Business Process simulation
- Transportation modes and traffic
- Learning Environment
- Health Care
- Network Simulation

MODEL CLASSIFICATION:-

In this module, we shall examine different categories of modeling & simulation. Basically models are classified into:-

Mathematical Model:- A Mathematical model use symbolic notation and mathematical equation to represent the System.

Physical Model:- A Physical model is a smaller or larger physical copy of an object. The object being modeled may be small (for example: an atom) or large(for example :Solar System).These types of model required large amount of resources, lot of money, lot of people to build them.

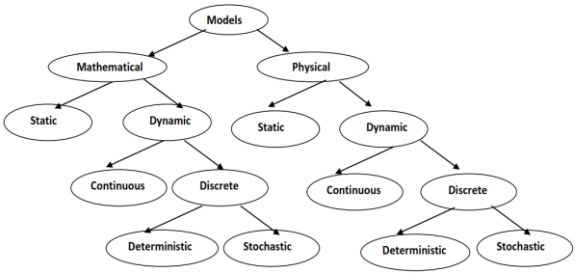

Figure: 5. Model Classification

Simulation Model:- Simulation model is a special type of Mathematical model because simulation model are represented in symbol form or in programming language. Simulation model further classified as:-

- Static Vs Dynamic Simulation Model
- Discrete Vs Continuous Simulation Model
- Stochastic Vs Deterministic Simulation Model
- Discrete Event Simulation Model

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