Modelling and Simulation

Simulation

Simulating systems

- Involves the generation of artificial history of a system and the observation of that artificial history to draw conclusions concerning the operating characteristics of the real system.

- The more we know about the system, better will be the simulation and therefore more reliable results.

- The behaviour of a system as it evolves over time is studied by developing a simulation model.
Simulation

• There are three major elements in modelling and simulation.
  ✓ The real systems that has to be modelled.
  ✓ The model or models themselves
  ✓ The computer (or network of computers) on which to run the simulation.

• The concern is not only with the elements themselves but also with establishing certain relationships among them.

• There are two relations:
  ✓ The modelling relation
  ✓ The simulation relation

Simulation

• Modelling deals primary with the relations between the real system and the models.

• Simulation deals with the relationships between the computers and the models.
• The real system block represents some part of the real world which is of interest.

• The system may be natural, artificial, in existence or planned for the future.

• Examples
  ✓ An engineer interested in improving trajectories for airliners
  ✓ A natural scientist interested in the developmental process of flowers.

A model is basically a set of instructions for generating the behavior data of the real system.

• Models provide *someone or something* for generating data.

  The modeler him/herself  A computer program
Simulation

- A computer is therefore required for:
  - Generating behavioral data
  - Executing the programs with encoded model instructions

- A computer is also required to act as a platform for the models to run on
  - A simulation framework might be necessary.

- The modeling relationship concerns the validity of the models:
  - How well the model represents the real system.

- The simulation relationship concerns the correctness with which the computer carries out the instructions (program) intended by the model.
Simulation models

What is a simulation model?

• A model is a representation of the construction and working of some system of interest.

• Although some times the model is simpler than the system it represents, it should:
  – Be a close approximation to the real system.
  – Incorporate most of its main features.
  – Not be so complex that it is imposable to understand/experiment with.
  – Be a trade-off between realism and simplicity.

Simulation models

• Generally a simulation model is a mathematical model developed either with the help of simulation packages or with high level languages.

• Usually a model only models one real system. Therefore a sophisticated simulation can be composed by more than one model.
Simulation models

• For example, a very basic flight simulator is composed of the following systems:
  – The atmosphere
  – The airplane DOF
  – The airplane engines
  – The airplane emissions
  – The graphics rendering

• The above systems are totally independent from each other but should liaison with each other to simulate a realistic flight.

(Show some examples of real model programs)

Classification of models

Models can be classified as:

• Static or dynamic
• Stochastic or deterministic
• Continuous or discrete-event
• Local or distributed
Classification of models

Static or dynamic

• In dynamic models, state variables change over time.
  ✓ Dynamic models are in the form of differential equations.
  ✓ Can describe the dynamic relationships between the input and the output

• A static model models a snapshot as a single point in time.
  ✓ Static models are in the form of algebraic equations.

Stochastic or deterministic

• A stochastic model is a model whose behaviors cannot be entirely predicted.
  ✓ Evolves randomly in time and space.
  ✓ The behavior is non deterministic, since a system’s subsequent state is determined by a random element.

• Deterministic models describe behavior on the basis of some physical law.
  ✓ E.g. The planets move around the sun according to Newton’s laws and their position can be predicted with great accuracy well into the future.
Classification of models

Continuous or discrete

• Continuous models concerns the modeling of systems by representation in which state variables change continually with respect to time.

• In discrete-event models, models, the operation if a system is represented as a chronological sequence of events.

• Discrete simulation are more popular since they are usually faster while also providing a reasonably accurate approximation of a system’s behavior.

Local or distributed

• Local simulation is a type of simulation where all the elements that make up that particular simulation reside on one single machine only.

• Distributed simulations run on a network of interconnected hosts, also possibly through the internet.
  - Very useful where the models that make up the simulation are very computationally intensive.
  - There are several standards and protocols for distributed simulation, such as HLA, ALSP and DiS.
### Bibliography

**Papers**


K, Mohandas. P. Introduction to simulation.


**Books**