Simulation life-cycle

Overview

• What is a software life-cycle?
  ✓ Depicts the phases or activities of a software project from conception until the product is retired.
  ✓ Typically, a life cycle model addresses all the phases of a software project

• What is a simulation life-cycle?
  ✓ The steps/ phases involved in simulation creation, including:
    o The problem definition
    o The models development
    o The simulation setup
    o The analysis of the results
Creating simulations

• In simulation, human decision making is required at all stages:
  ✓ Model development
  ✓ Experiment design
  ✓ Output analysis
  ✓ Conclusion formulation
  ✓ Decisions to alter the system under study

• The only stage in simulation where human intervention is not required is in the running of the simulation.

Creating simulations

• Having powerful simulation software is important.
  ✓ Its absence can hurt a simulation study.

• However having powerful simulation software will not ensure success.

• Experienced problem formulators and simulation modellers and analysts are indispensable for a successful simulation study.
Three basic phases of computer simulation

- Develop simulation models.
- Design a simulation experiment.
- Perform simulation analysis.

Phases of computer simulation (expanded)

Real System under study → Simulation Models → Simulation Experiment → Simulation Analysis → Conclusions → Altered System
**Simulation life-cycle**

**Steps in creating simulations**

1. Identify the problem
2. Formulate the problem
3. Collect and process real systems data
4. Formulate and develop the models
5. Validate the models
6. Document the models
7. Select appropriate experimental design
8. Establish experimental conditions for runs
9. Perform simulation runs
10. Interpret and present results
11. Recommend further course of action

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**Develop simulation models**

- Modelling is the most important part of a simulation study.

- The next few slides explains the steps involved in developing simulation models.

**Step 1**

- Identify the problem
  - Identify problems with an existing system.
  - Produce requirements for a proposed system
Develop simulation models

Step 2

• Formulate the problem
  ✓ Select the bounds of the system, i.e. the problem to be studied.
  ✓ Define the objective of the study and issues to be addressed.
  ✓ Formulate hypotheses about system performance
  ✓ Decide the time frame of study – e.g. will the system be used for a one time decision or over a period of time on a regular basis?
  ✓ Identify the end user of the simulation.

Step 3

• Collect and process real system data
  ✓ Collect data on system specifications
    o Input variables
    o Performance of the existing system
    o Sources of randomness in the system (if they exists)
  ✓ If there is a randomness element in the system, select an appropriate input probability distribution for each stochastic variable
Step 4

- Formulate and develop the models
  - Develop schematics and network diagrams for the system.
  - Define data flow between the different modules (possibly using DFDs).
  - Translate the conceptual models to simulation models.
  - Verify that the simulation models executes as intended.
    - Varying input parameters
    - Substituting constants for random variables and manually checking results.

Step 5

- Validate the models
  - Compare the model’s performance under known conditions with the performance of the real system.
  - Perform statistical inference tests and get the model examined by domain experts.

Step 6

- Document the models for future use
  - Document objectives, assumptions and input variables in detail.
Design a simulation experiment

- A simulation experiment is a test or a series of tests in which meaningful changes are made to the input variables of the simulation models.
  - To observe and identify the reasons for changes in the performance measures.

- The number of experiments in a simulation study is greater than or equal to the number of questions asked about the system.

- The next few slides explain the steps involved in designing a simulation experiment.

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Design a simulation experiment

**Step 7**

- Select an appropriate experimental design
  - Select a performance measure, a few input variables that are likely to influence it.
  - Document the experimental design.
Design a simulation experiment

Step 8

• Establish experimental conditions for runs.
  ✓ Address the question of obtaining accurate information and the most information from each run.
  ✓ Ascertain whether a terminating or non-termination simulation run is appropriate.
  ✓ Select the run length and appropriate starting conditions.
  ✓ Decide on the number or runs (possibly each run with different starting conditions).

Step 9

• Perform simulation runs
  ✓ According to steps 7 and 8.

Simulation analysis

• Simulation results are sometimes difficult to interpret.

• Most off-the-shelf simulation packages provides capabilities to run statistics on the simulation predefined performance measures.

• The next few slides explain the steps required for the analyses of simulation output data.
Step 10

- Interpret and present results
  - Compute numerical estimates of the desired performance measure for each simulation of interest.
  - Test the hypothesis about system performance.
  - Construct graphical displays of the outputted results.
    - Pie charts
    - Histograms
  - Document results and conclusions.

Step 11

- Recommend further course of action.
  - This may include further experiments to increase the precision and reduce the bias of estimators, to perform sensitivity analysis, and more.
Simulation life-cycle (conclusions)

- In these 11 steps of the simulation life-cycle, many iterations at various sub-stages may be required before the objectives of a simulation study are achieved.
- Not all the 11 steps may be possible and/or required.
- Additional steps may have to be performed.
- The explained life-cycle is not a rigid standard, however it provides good guidelines for simulation development.

Bibliography

Papers


Books