System Modelling & Simulation

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Assignment - 1

1) What is Simulation ? when Simulation is the appropriate tool and when it is not appropriate ?

→ A Simulation is the limitation of the operation of a real world process or system over times.

<1> when Simulation is the appropriate tool:

The availability of special - purpose simulation language of massive computing capabilities at a discussing operation, Simulation can be used for the following purposes.

ⓐ Simulation enables the study of and experimentation with the internal interactions of a complex system.

ⓑ Informational, organizational and environmental changes can be simulated, and the effect of these attractions on the models behaviour can be observed. Simulation can be used as a pedagogical devices to reinforce analytic solution methodologies.

<2> when Simulation is not Appropriate:

ⓐ Simulation should not be used when the problem can be solved by Common sense.

ⓑ Simulation should not be used if the problem can be solved analytically.

ⓒ Simulation should not be used if it is less expensive to perform direct experiments.

ⓓ Not to use simulation if the cost exceeds the savings.

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2) Advantages and disadvantages of simulation.

→ ① New policies, operating procedures, decision rules, information flows, organizational procedures and so on can be explored without disrupting ongoing operations of the real system.

② New hardware designs, physical layouts, transportation systems and so on can be used without commiting resources for their acquistion.

③ hypothesis about how or why certain phenomena occur can be tested for feasibility.

④ Insight can be obtained about the interaction of variables.

⑤ Time can be compressed or expanded to allow for a speed-up or slow-down the phenomena under indvestigtion.

Disadvantages:

① Model Building requires special training. It is an art that is learned overtime and through experience. Furthermore, if two models are connected by different compedent indiuduals, they might have similarities, but it is highly unlikely that they will be the same.

② simulation results can be difficult to interpret. Most simulation outputs are eventually random variables. So it can be trasid to distinguish whether can observation is the result of system inter relations.

③ Simulation modelling an analysis can be time consuming and expensive. Skimping on resources for modelling and analysis could result in a simulation model or analysis that is not sufficient to the task.

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3) Area of Applications.

→ The application of Simulation are vast. Some are explained below.

ⓐ Manufacturing Application:

→ Methodology for selecting the most suitable bottleneck detection method.

→ Automating the development of stipyard manufacturing models.

→ Emulation in manufacturing engineering process

ⓑ Water fabrication:

→ A paradigm shift is assigning lots to tools

→ scheduling a multi-chip package assembly lens with central process

ⓒ Business Processing:

→ A new policies for the services request assignment problem.

→ A process execution monitoring and adjustment schemes.

ⓓ Conetection Engineering and project management:

→ Scheduling of limited Bar-Bendes over multiple Buildings.

→ Process execution, monitoring and adjustment schemes.

(e) logistics, Trasportation a distribution:

-> operating policies for a Bag transpotation System.

-> Dispensing plan for emergeny medical supplies in this event of biotes.

(f) Militory Applications:

-> Multinational Intea - theater logistics outerbution.

-> Training joint forces for assymetric operations.

(g) health care:

-> Supporting smart thinking to improve hospital performance.

-> Infections disease control policy.

-> Reducing emergency department overcrowding.

4) Systems and System Environment.

-> A System is defind as a group of objects that are joined together in some regular instructions on independence toward the accomplishment of some purpose. A System is often affected by changes occuring outsides the system. Such changes are said to occur in the system environment in modelling systems, it is necessary to decide on the boundry between the system and its environment.

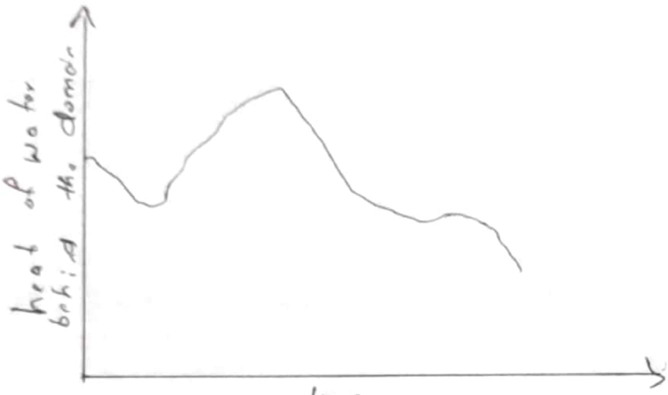
5) Components of a system.

-> An entity is an object of interact in the system. An attribute is a property of an entity. An activity respresent a time period of specified length. The state of a system defined to be that collection of variables necessary to describe the system at any simulations to the objectives of the study. An event is defined as an instructions occurence that might change the state of the system.

6) Discrete and continuous Systems.

-> A discrete system is one in which the state variable change only at a discrete set of points in time.

A continous system is one which the state variables change continuosly over time.



7) Model of a system

-) A model is defined as a representation of a system for the purpose of studying that system. For more studies it is only necessary to consider those aspects of the system that affect the problem under investigation. These aspects are represented in a model of the system, the model by defination is a simplication of the system. On the other hand, the model should be sufficiently detailed to permit valid conclusions to be drawn about the real system. Different models of the same system could be required as the purpose of investigation changes.

8) Types of models: models can be clasified as being mathematical or physical. A mathematical model uses symbollic notation and mathmetical equations. to represent a system. A physical model is a larger or small versions of an object such as the enlargement of an atom or a scaled-down of the solar system. A static simulation model sometimes called as monte-carlo simulation. represents a system at a perticular time. Dynamic simulation model represents system as they change over time. Simulation models that contain no random variables are clasified as deterministic.

9) Discrete Event System simulation

→ Discrete - event system simulation is the modelling of systems in which the state variable changes only at a discrete set of points in terms this Simulation models are analyzed by numerical rather than analytical methods. Analytical methods employ the conductors reasoning of matimatic to solve the model. Real world simulation model are rather large and the amount of data stored and manipulated is vast, so such runs are usually conducted with the aid of a computer.

10) Steps in a simulation study.

→ ① problem formulation:

In many instances, policy makers and analytics are aware that there is a problem long before the maker of the problems known.

② Setting of objectives and overall project plan:

The objective indicate the questions to be answered by simulation. At this point, a determination should be made concerning whether simulation is the appropriate methodology for the problem as formulated and the objectives as stated

③ Model conceptualization:

The conantration of a model of a system is probably as much as art science. The are of modeling is enhanced by an ability to abtract the essential features of a problem to select and modify base assumption that charactarizing the system and there to exit and elaborate the model until approimation results.

④ Data collection:

There is a constant interplay between the conantration of the model and the collection of the needed input data. As the complexity of the model changes. the required data elements can also change.

⑤ Model translation:

Marc real wald systems results in model that requires a great-deal of information storage and compilation. So the model must be entered into a computer recognizable format.

⑥ Verified:

verification pertains to the complete program that has been prepared for the simulation model. The computer program performing poopaly. with computer models.

⑦ validated:

Validation usually is achieved through the calibration of the model an iterative process of comparing the model against actual system behaviour and using the discrepancies between the two, and the insights gained to improve model

⑧ Experimental design:

The alternatives that are to be simulated must be determined. Often the decision concerning which alternatives to simulate will be a function of runs that has been completed and Analyzed.

⑨ Production runs and analysis:

Production runs and this subsequent analysis, are used to estimate measure of performance for the system design that are being simulated.

⑩ More runs:

Given the analysis of runs have been completed, the analyst determines whether additional runs are needed and what design these additional experiment should follow.

⑪ Documentation and Reporting:

There are 2 types of documentation program and progress. If the program is going to be used again by the same or different analysis. it could be necessary to understand how the program operates. This will create a confidence in the program. So that model users and policies makers can make decisions based on the analysis. Also, if the program is to be modified by the same or a different analyst, this step can be greatly facilitated by adequate documentation.

⑫ Implementation:

The success of implementation phase depends on how well the previous process step have been performed. It is also confident upon how thoroughly the analyst has investigated the document ultimate model uses during the entire simulation process.

11) Preview of terminology and concepts

→ ① Discrete random variables:

let x be a random variable of the number of possible values of x is finite or countably infinite and is called discrete random variables. The possible values of x may be listed as $x_1, x_2 \ldots x_m$ etc.

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② Continious random variables:

if the range space R_x of the random variable x is an interval or a collection of intervals. x is called a continious random variable. For continious random x, the probability that x lies in interval $[a,b]$ is given by

$$p(a \leq x \leq b) = \int_a^b f(x)\,dx$$

The function $f(x)$ is called probability density function of the random variable x. The probability density function satisfies the following conditions.

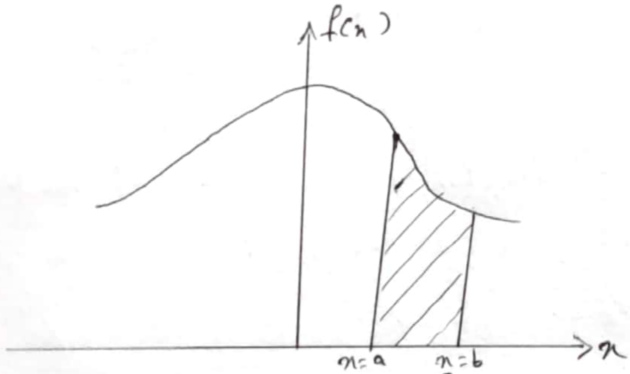
a. $f(x) \geq 0$ for all x in R_x

b. $f_x(dx) = 1$

c. $f(x) = 0$ if x is not in R_x

As a result of equation ①, for any specified value x_0, $p(x = x_0) = 0$ because

$$\int_{x_0}^{x_0} f(x)\,dx = 0$$



$p(x = x_0) = 0$ also means that the following equation hold

$$p(a \leq x \leq b) = p(a < x \leq b) = p(a \leq x < b) = p(a < x < b)$$

③ Cumulative distribution function:

The cumulative distribution function (df) denoted by $F(x)$ measures the probability that the random variable x assumes a value less than or equal to x that is,

$$F(x) = p(x \leq x)$$

$$F(x) = \sum_{x_i} p(x_i)$$

if x is continious, then

$$F(x) = \int_{-\infty}^{x} f(t)\,dt$$

All the probability questions about x can be answered in terms of

$$p(a < x \leq b) = F(b) - F(a) \text{ for all } a < b$$

④ Expectation :

An important concept in probability theory is that of the expectation of a random variable of x is a random variable. The expected value of x denoted by $E(x)$ for discrete and continious variable is defined as follows.

$$E(x) = \sum_i x_i \, P(x_i) \text{ if } x \text{ is discrete.}$$

and

$$E(x) = \int_{-\infty}^{\infty} x f(x)\, dx \text{ if } x \text{ is continious}$$

The expected value $E(x)$ of a random variable x is also refered to as the mean, is or the first moment of x. The quantity $E(x^n)$, $n \geq 1$ is called the n^{th} moment. of x and is compluted as :

$$E(x^n) = \sum_i x_i^n \, P(x_i) \text{ if } x \text{ is discrete.}$$

and

$$E(x^n) = \int_{-\infty}^{\infty} x^n f(x)\, dx \text{ if } x \text{ is continious.}$$

⑤ The mode :

The mode is used in describing several statistical models in the discrete cases, the mode is the value of the random variable the occurs most frequently. In the continous case, the mode is the value of which the pdf is maximised.

1(c) Useful Statistical models :

→ ① Queuing Systems :

In queuing examples, interval and service time patterns, the times between arrivals and the services time are often probabilistic. However it is possible to have a constant interarrival time, or a constant service time.

② Inventory and Supply-chain System :

In reactive inventory and supply chain system, these are atleast three random variables, the number of units demanded per order or per time period The time between demands and time.

③ Reliability and maintainability : Time to filure has been modelled with numerous distribution, including the exponential, gamma and weibull. If only random failure occurs, the time to failure distribution may be modelled as exponential. The gamma distribution arises from modelling stand by redundancy to have each component has an exponential time to failure.

④ Limited data:

In many instance, simultaneous begin before data collection has been completed. There all these distribution that have application to incomplete or limited data. There are the uniform, triangular and beta distributions.

⑤ Other distributions:

Several other distributions may be useful in discrete system simulation. The Bernolli and binomial distributions are two discrete distributions which might describe phenomena of interest. The hyper exponential distribution is similar to the exponential distribution, but its greater variability might make it useful in certain instances.

13) Discrete distributions

→ ① Bernolli trials and the Bernolli distribution:

Consider an experiment consisting of n trials, each of which can be a success or a failure. Let $x_j = 1$ if the jth experiment resulted in a success and let $x_j = 0$, if the jth experiment resulted in a failure. The n Bernolli trials are called a Bernoli process if the trials are independent, each trial has the two possible outcomes, and the probability of a success remains constant from trial to trail. Thus

$$P(x_1, x_2, x_3 \dots x_n) = P_1(x_1), P_2(x_2), P_3(x_3) \dots P_n(x_n)$$

and

$$P_i(x_i) = P(x_j) = \begin{cases} p & x_j = 1, j = 1, 2 \dots n \\ 1-p = q & x_j = 0, j = 1, 2 \dots n \\ 0 & \text{otherwise.} \end{cases}$$

② Binomial distribution:

The random variables x that denote the number of success in n Bernallis trials has a binomial distribution given by $P(x)$, where

$$P(x) = \begin{cases} \binom{n}{x} p^x q^{n-x}, & x = 0, 1, 2 \dots n \\ 0 & \text{otherwise} \end{cases}$$

③ Geometric and Negative binomial distributions:

The geometric distribution is related to a sequence of Bernolli trial, the random variable of interest x, is defined to be the number of trials to achieve the first success the distribution of x is given by

$$P(x) = \begin{cases} q^{x-1} p, & x = 1, 2 \dots n \\ 0 & \text{otherwise} \end{cases}$$

④ Poisson distribution:

The poisson distribution describes many random process quite well and is mathematically quite simple. The poisson distribution was introduced in 1837 by S-D poisson in a book concerning criminal & civil justice matters.

$$p(x) = \begin{cases} \frac{e^{-a} \alpha^{x}}{x} & , x = 0, 1, \dots \\ 0 & , \text{otherwise} \end{cases}$$

14) Continious distribution:

→ ① Uniform distribution: A random variable x is uniformly distributed on the interval $[a,b]$ if its pdf is given by

$$f(x) = \begin{cases} \frac{1}{b-a} & , a \le x \le b \\ 0 & , \text{otherwise} \end{cases}$$

The pdf is given by

$$F(x) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a} & , a \le x \le b \\ 1 & , x \geq b \end{cases}$$

② Exponential distribution:

A random variable x is said to be experimentally distributed with parameter $x > 0$ if its pdf is given by

$$f(x) = \begin{cases} \lambda e^{\lambda x} & , x > 0 \\ 0 & , \text{otherwise} \end{cases}$$

③ Gamma distribution:

A function used in defining the gamma distribution is the gamma function, which is defined as $B > 0$ as

$$\gamma(\beta) = \int_0^{\infty} x^{B} e^{1-x} \, dx$$

15) Poisson process.

→ Consider random events such as the arrival of job shop, the arrival of email service the arrival of boats to a clock, the arrivals of calls to a call center, the breakdown of machine in a large factory, and so on. These events may be divided by a counting function $N(2)$ defined for all $x \geq 1$. This counting function will represent the number of counts that occured in $(0, r)$

16) Empirical distributions

→ An empirical distributions which may be either discrete inform, or a distribution whose parameter with the observed values in a sample of data. This is in contrast to parameter distribution families, which are characterised by specifying using number of parameters. Such as the mean and variance. An Empirical distribution may be used when is impossible or unnecessary to establish that a random variable has any particular parameter. Distributions are advantage of an empirical distribution is that nothing is assumed beyond the observed values in the sample.

17) Characteristics of queing System.

→ ① The calling population: The population of potential customers, referred to as the calling population may be assigned to the finite or infinite. In Systems with a large number of potential customers the calling population is usually seemed to be finite.

② System Capacity: In many queing systems, there is a limit to the number of customers that may be in the waiting line of system. As arriving customer who finds the system full doesnot enter but returns immediately to the calling position.

③ The arrival process: The arrival process for infinite population models is usually characterised of inters of inter times of sucessive customer. Arrivel may occur at scheduled times or at random times. When at random times the interval times are usually charcterised by a probability distribution.

④ Queue behaviour & Queue disciplane: Queue behaviour refers to the actions of customers while in Queue waiting for servic to begin. There is a possibility that incoming customers will talk. Queue discipline refers to the logical order of customers in a queue and determines which customer will be choosen.

(18) Queuing Notation.

→ Recognizing the diversity of queuing systems, and all prepared a notational systems in parallel server System which has been widely adopted. An abriged version of this conversation is based on the format A/B/c/N/k. These letter represent the following System charactorics.

A represents interarrival time distribution, B represents service time distribution.

C represents number of parallel service, N represents system capacity.

k represents size of the calling population.

19) long-run measures of performance of queuing system.

→ The primary long-run measures of performance of queuing systems are the long-run time-average number of customers in the systems and in the queue. The long run average time spent in system and in queue (wq) per customer and the service utilization or proportion of time that server is busy (ρ). The term system overall refers to the waiting line plus the service mechanism in and can refer to any subsystem of the queuing system on the other hand, the term queue refers to the waiting line alone. Other measure of performance of interest it include the long-run proport of customer.

20) Steady-state behaviour of M/G/1 queue.

→ For any M/G/1. queue if lines are too long, they can be reduced by decreasing the services utilization or by decreasing the service time variability. There marks hold for almost all queues not just the M/G/1. queue. The utilization factor ρ can be reduced by decreasing the arrival rate, by increasing the service rate or by increasing the number of services, because in general $\rho = \lambda(cm)$, where c is number of parallel services.

21) Network of Queue

→ Many systems are naturally modeled as networks of single queues in which customer departing into one queue may be routed to another. The following results assume a stable system with an infinite calling population and no limits as system capacity.

① Provided that no customer are created or destroyed in the queue, then the departure rate of a queue in the same as the ~~the~~ arrival rate into the queue over the long run.

② If customer arrive to queue i at rate λ_i and ~~and~~ a fraction $0 \le 1$ of them are routed to queue j upon departure, then the arrival rate from queue i to j is λ_{ij} over the long run.

③ The overall arrival rate into queue j, λ_j is the sum of the arrival rate from all sources. if customer, arrive from outside the network at rate a_j, then

$$\lambda_j = a_j + \sum_{all} \lambda_i P_{ij}$$

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① if queue j has $c_j < \infty$ parallel service, each working at rate μ then in the long run utilization of each service is,

$$\rho_j = \frac{\lambda_j}{C_j N_j}$$

22) Models, optimization via simulation.

→ ① Optimization via simulation refer to the problem of maximizing or minimizing the expected performance of a discrete event, stochastic system that is represented by a computer simulation model.

② optimization usually deals with problems with certainity, but in stochastic system that is represented by a computer simulation model.

③ let $x_1, x_2 \dots x_m$ be the m controllable design variable and $y(x_1, x_2 \dots x_m)$ be the observed simulation output performance on one run.

④ To optimize ~~or~~ ~~m~~ $y(x_1, x_2, \dots x_m)$ with respect to $x_1, x_2 \dots x_m$ is to maximize or minimize the mathematical expectation of performance.