Simulation Modelling

Q What is Mathematical Model?

Ans. We define a mathematical model as a mathematical construction which is designed to study a particular real-world system or phenomenon.

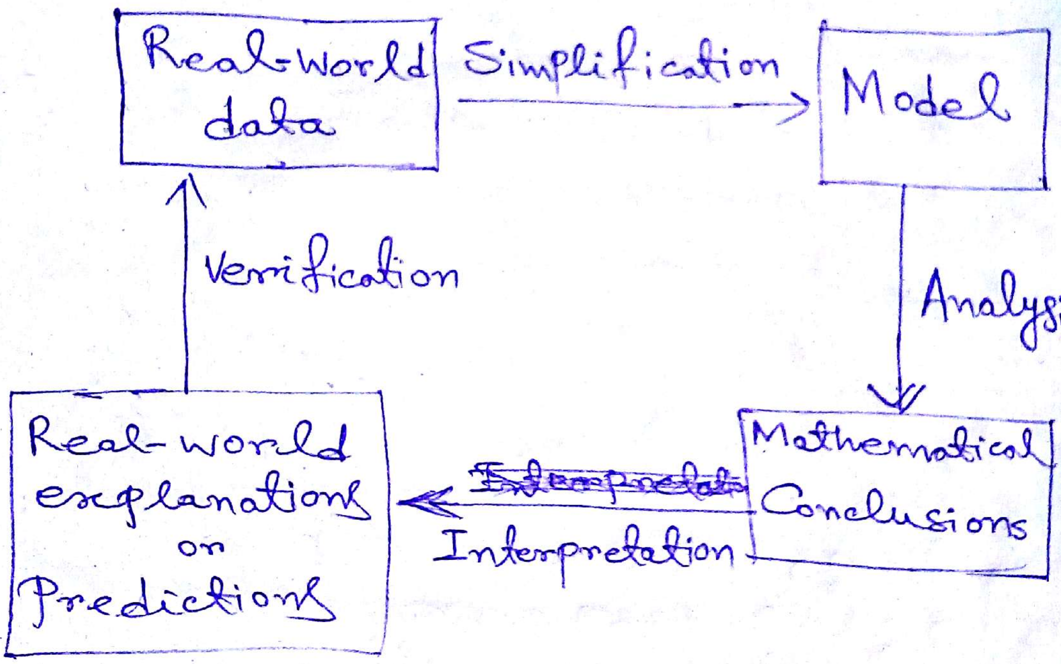

Fig.1: The modelling Process.

Example:- Let us consider a real world problem such as; Predicting the global effects of the interaction of a population, the use of resources and Pollution.

In such cases we may attempt to replicate the behaviour directly by conducting various experimental trials. Then we collect data from these trials and analyze the data in some way, possibly using statistical techniques or curve-fitting procedures. From the analysis, we can reach certain conclusions.

Note: Using Simulation:- We may attempt to replicate a behaviour on a digital computer — for instance, simulating the global effects of the interactions of population, use of resources, and pollution.

i.e, we may attempt to replicate the behaviour indirectly.

Q. Write down the steps for Construction of a mathematical model.

Soln.

Step-1: Identify the problem.

Step-2: Make assumptions.

~~Step-3,~~ (a) Identify and classify the variables.

(b) Determine inter-relationships between the variables and submodels.

Step-3: Solve the model.

Step-4: Verify the model.

(a) Does it address the problem?

(b) Does it make common sense?

(c) Test it with real world data

Step-5: Implement the model

Step-6: Maintain the model.

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Q What is Simulation Modelling?

Soln Simulation modelling is the Process of creating and analyzing a digital prototype of a physical model to predict its performance in the real world.

Simulation modelling is used to help designers and engineers understand whether, under what conditions, and in which ways a part could fail and what loads it can withstand. It can also help to predict fluid flow and heat transfer patterns.

Q Why use Simulation Modelling?

Soln Simulation modelling solves real world problems safely and efficiently. It provides an important method of analysis which is easily verified, communicated and understood. Across ~~int~~

industries and disciplines, Simulation modelling provides valuable solutions by giving clear insights into complex systems.

The advantages of simulation modelling are given below:

1. Risk free environment.
2. Save money and time.
3. Visualisation by animation in 2D / 3D.
4. Increased accuracy.
5. Unpredictable data, Uncertainty can be easily represented.

* Monte Carlo Simulation

* Read carefully the given Pdf file of the introduction Section of Chapter 5, Pages → 186 − 187.

* Monte Carlo Simulation to model a deterministic behaviour — $\boxed{\text{The area under a curve.}}$

We have to find an approximate value to the area under a ~~the~~ non-~~ng~~ negative curve.

Let $y=f(x)$ be a given continuous curve s.t. $0 \le f(x) \le M$ over the closed interval $a \le x \le b$. Where, M is a constant and an upper bound of $f(x)$.

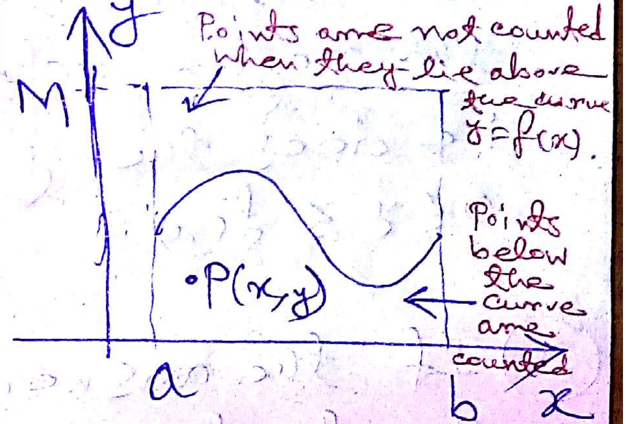

Fig: 5.2: The area under the non-negative curve $y=f(x)$ over $a \le x \le b$ is contained within the rectangle of ~~hie~~ hight M and base length $b-a$.

The area under $y=f(x)$ is totally contained in the rectangular region of height M and length $(b-a)$.

Method:-

1. We select a point $P(x,y)$ at random from within the rectangular region. We will do so by generating two random numbers, x and y, satisfying $a \leq x \leq b$ and $0 \leq y \leq M$, and interpreting them as a point P with coordinates x and y.

2. Once $P(x,y)$ is selected, we ask whether it lies within the region below the curve. i.e. does the y coordinate satisfy $0 \leq y \leq f(x)$?

3. If the answer is $\boxed{\text{yes}}$, then count the point P by adding 1 to some counter.

4. Also we have to count the total points generated.

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(5) Now we can calculate an approximate value for the area under the curve by the following formula:

$$\frac{\text{area under the curve}}{\text{Area of rectangle}} \approx \frac{\text{Number of Points counted below curve}}{\text{Total number of random Points}}.$$

— O —

Now the Algorithm is given below:-

<u>Monte Carlo Algorithm for area under a curve</u>

Input:- Total number of n of random Points to be generated in the Simulation.

Output:- Area under $y = f(x)$ where $0 \le f(x) \le M$ and $a \le x \le b$.

Step 1:- Initialize: COUNTER = 0.

Step 2:- For $i = 1, 2, \ldots, n$, do steps 3 – 4.

Step 3:- Calculate random coordinates x_i and y_i Satisfying $a \le x_i \le b$ and $0 \le y_i \le M$. and calculate $f(x_i)$.

Step 4: If $y_i \le f(x_i)$, the increase COUNTER by 1. Otherwise leave COUNTER as it is.

Step 5: Calculate AREA = $M(b-a) \times$ COUNTER/n.

Step 6: Output (AREA).

STOP

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See Examples in Page-189.

"Volume under a Surface

See Page-189-190.

Similar procedure and Algorithms.

Read carefully.