PRACTICAL FILE

MODELING AND SIMULATION LAB

(CS 603)

BE CSE 6TH SEM

(GROUP-4)

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Practical 7

Aim

Estimating **π (Pi)** using Monte Carlo simulation.

Introduction to Determination of value of Pi by Monte Carlo Method

The value of Pi can be determined by using the relation for area of a circle.

Area of circle= pi*r^2

Area of the quadrant is pi*r^2/4 =pi/4

AII points satisfying the equation x^2 + y^2 <= 1 x, y >= 0 lie in this quadrant. Now if we have a pair of random numbers R1 and R2 in the range (0, 1), then the point R1 and R2 may lie within the quadrant or outside the quadrant but within the square enclosing the quadrant. If we generate a large number of such points (say N) by taking pairs of random numbers, and out of them M lie within the quadrant, then the ration M/N will approach the area under the curve, which is pi/4.

This method uses a **randomly generated set of points** to approximate the area of a circle inscribed within a square. The ratio of points that fall inside the circle to the total number of points helps us determine the value of **π**.

The computations for 33 points are being used in the code. For each pair of random numbers, the point is within the quadrant, when R1^2 + R2^2 <= 1.

R2 <=square root 1-R1^2

The **Monte Carlo method** is a **stochastic (randomized) computational technique** used to solve mathematical and scientific problems through **random sampling**. It is widely applied in fields such as **numerical integration, optimization, risk analysis, and physics simulations**.

In the context of **π estimation**, the Monte Carlo method works by **randomly generating points** and checking whether they lie inside a **unit circle** inscribed within a **square**. By analyzing the ratio of points inside the circle to the total number of points, we can derive an approximation of **π**.

Code for Implementation of Estimating π (Pi) using Monte Carlo simulation

```
clc; clear; close all;
R1 = [0.82, 0.34, 0.48, 0.51, 0.16, 0.69, 0.37, 0.50, 0.51, 0.48, ...
      0.82, 0.36, 0.50, 0.38, 0.51, 0.27, 0.55, 0.84, 0.95, 0.62, ...
      0.57, 0.51, 0.55, 0.12, 0.95, 0.39, 0.32, 0.35, 0.69, 0.59, ...
      0.38, 0.16, 0.33];

R2 = [0.95, 0.14, 0.37, 0.72, 0.33, 0.59, 0.74, 0.72, 0.76, 0.63, ...
      0.57, 0.40, 0.74, 0.81, 0.80, 0.86, 0.93, 0.86, 0.81, 0.77, ...
      0.57, 0.69, 0.74, 0.99, 0.99, 0.81, 0.94, 0.86, 0.86, 0.78, ...
      0.65, 0.87, 0.16];

N = length(R1);

Root_1_R1_sq = sqrt(1 - R1.^2);

inside_circle = (R1.^2 + R2.^2) <= 1;

M = sum(inside_circle);

pi_estimate = (M / N) * 4;

fprintf('---------------------------------------------------------\n');
fprintf('|  R1  |  R2 | sqrt(1-R1^2) | In/Out  |\n');
fprintf('---------------------------------------------------------\n');


for i = 1:N
    if inside_circle(i)
        status = 'In ';
    else
        status = 'Out';
    end
    fprintf('| %.2f | %.2f |   %.4f   |   %s   |\n', R1(i), R2(i), Root_1_R1_sq(i), status);
end
fprintf('---------------------------------------------------------\n');


fprintf('\nTotal Random Points (N) = %d\n', N);
fprintf('Points inside Quarter Circle (M) = %d\n', M);
fprintf('Ratio (M/N) = %.4f\n', M / N);
fprintf('Estimated value of Pi = (M/N) * 4 = %.4f\n', pi_estimate);
```

Output

R1	R2	sqrt(1-R1^2)	In/Out
0.82	0.95	0.5724	Out
0.34	0.14	0.9404	In
0.48	0.37	0.8773	In
0.51	0.72	0.8602	In
0.16	0.33	0.9871	In
0.69	0.59	0.7238	In
0.37	0.74	0.9290	In
0.50	0.72	0.8660	In
0.51	0.76	0.8602	In
0.48	0.63	0.8773	In
0.82	0.57	0.5724	In
0.36	0.40	0.9330	In
0.50	0.74	0.8660	In
0.38	0.81	0.9250	In
0.51	0.80	0.8602	In
0.27	0.86	0.9629	In
0.55	0.93	0.8352	Out
0.84	0.86	0.5426	Out
0.95	0.81	0.3122	Out
0.62	0.77	0.7846	In
0.57	0.57	0.8216	In
0.51	0.69	0.8602	In
0.55	0.74	0.8352	In
0.12	0.99	0.9928	In
0.95	0.99	0.3122	Out
0.39	0.81	0.9208	In
0.32	0.94	0.9474	In
0.35	0.86	0.9367	In
0.69	0.86	0.7238	Out
0.59	0.78	0.8074	In
0.38	0.65	0.9250	In
0.16	0.87	0.9871	In
0.33	0.16	0.9440	In

```
Total Random Points (N) = 33
Points inside Quarter Circle (M) = 27
Ratio (M/N) = 0.8182
Estimated value of Pi = (M/N) * 4 = 3.2727
```