Monte Carlo Simulation

Description

In this exercise we use the Monte Carlo method to approximate the value of π.

Exercise:
We all know, that π is 3.14159...
Write a Java program, which approximate the value of π better and better by using one of Javas random number generators.
Compare your result with the real value of π.

Classes

- *Main* - Handles user input from the console to get iteration count.
- *PiEstimator* - Contains the estimation method with a given iteration count as parameter.

Problem solving

Estimating the value

The equation of a circle with a radius r:

$$x^2 + y^2 = r^2 \tag{1}$$

Given a circle with a radius of $r = 1$ and center of $(0,0)$, and a square around it with a side length of 2. The equation of the circle we will then be using to approximate the value of π:

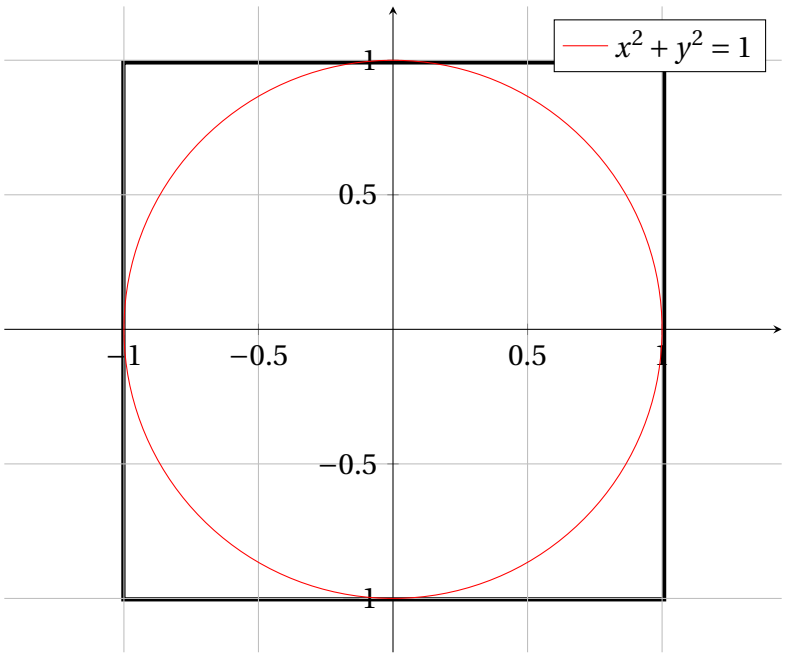

Figure 1

The Java library used to calculate the numbers will be *Math.random()* as it generates a random number between 0 and 1. This will be used to fill out the square on the upper-right part of the circle.

Here's an example of 3000 randomly generated (x_o, y_o) points inside the upper-right square. The *blue* dots represent points outside the circle, and the *green* dots are inside the circle.

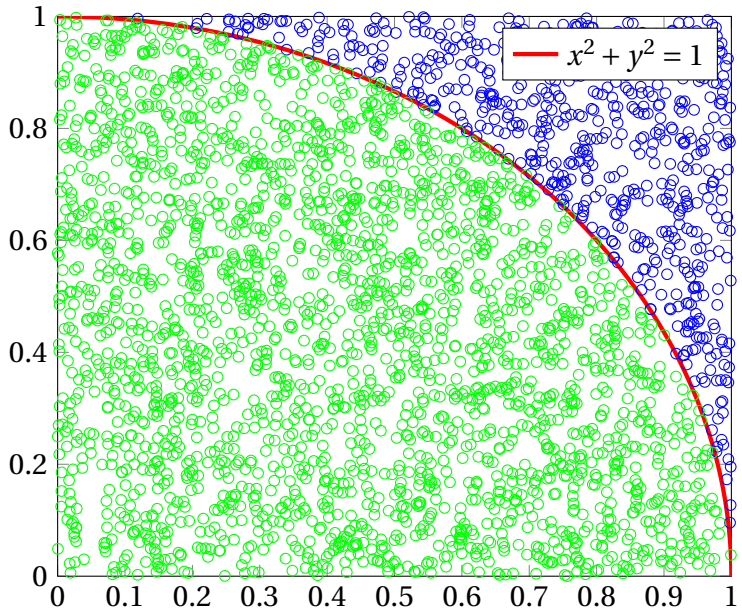

Figure 2

In order to determine if the point fell within the circle, we calculate the distance d as radius from the center and compare it to the value of actual radius $r = 1$.

$$d = {x_o}^2 + {y_o}^2 \tag{2}$$

If the distance $d \leq r$, it is within the circle.
Given that the dots from figure 2 can represent the area of the circle A_c and the area of the square A_s, we can approximate the value of π using this formula:

$$\pi = \frac{4 \cdot A_c}{A_s} \tag{3}$$

The A_s will be the total count of both the *blue* and the *green* dots, and the A_c will be the count of all the *green* dots.

Using this method, with the results shown above, as the total amount of green dots = 2371 and green + blue dots = 3000, this is the final equation to solve:

$$\frac{4 \cdot 2371}{3000} = 3.161333... \tag{4}$$

So the value of π estimated is ≈ 3.16.

Because the area of the square and circle will be more populated with more randomly generated numbers, the estimation of π is likely to be more precise with a higher amount of points covering the area.