Monte Carlo Simulation to Estimate Pi

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2024-05-17

```
estimate_pi <- function(num_samples) {
  points_inside_circle <- 0

  for (i in 1:num_samples) {
    x <- runif(1, -1, 1)
    y <- runif(1, -1, 1)

    # Check if the point (x, y) is inside the unit circle
    if (x^2 + y^2 <= 1) {
      points_inside_circle <- points_inside_circle + 1
    }
  }

  # Estimate pi as the ratio of points inside the circle to total points, multiplied by 4
  pi_estimate <- 4 * points_inside_circle / num_samples
  return(pi_estimate)
}

main <- function() {
  sample_sizes <- c(100, 1000, 10000, 100000, 1000000, 10000000, 100000000)
  real_pi <- pi

  for (num_samples in sample_sizes) {
    start_time <- Sys.time()

    estimated_pi <- estimate_pi(num_samples)

    end_time <- Sys.time()
    elapsed_time <- as.numeric(difftime(end_time, start_time, units = "secs"))
    error_percent <- abs((estimated_pi - real_pi) / real_pi) * 100

    cat("Samples:", num_samples, "\n")
    cat("Estimated value of pi:", sprintf("%.100f", estimated_pi), "\n")
    cat("Error percent:", format(error_percent, digits = 10), "%\n")
    cat("Elapsed time:", format(elapsed_time, digits = 4), "seconds\n")
    cat(rep("-", 60), "\n")
  }
}
```

```
main()
```

```
## Samples: 100
## Estimated value of pi: 3.040000000000000035527136788005009293556213378906250000000000000000000000000000000000000
000000000000000
## Error percent: 3.2337946 %
## Elapsed time: 0.02283 seconds
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - -
## Samples: 1000
## Estimated value of pi: 3.140000000000001243449787580175325274467468261718750000000000000000000000000000000000000
000000000000000
## Error percent: 0.05069573829 %
## Elapsed time: 0.002087 seconds
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - -
## Samples: 10000
## Estimated value of pi: 3.144000000000001278976924368180334568023681640625000000000000000000000000000000000000000
000000000000000
## Error percent: 0.07662821618 %
## Elapsed time: 0.02295 seconds
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - -
## Samples: 1e+05
## Estimated value of pi: 3.132000000000001172395514004165306687355041503906250000000000000000000000000000000000000
000000000000000
## Error percent: 0.3053436472 %
## Elapsed time: 0.2515 seconds
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - -
## Samples: 1e+06
## Estimated value of pi: 3.142151999999999834045638635871000587940216064453125000000000000000000000000000000000000
000000000000000
## Error percent: 0.01780454922 %
## Elapsed time: 2.356 seconds
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - -
## Samples: 1e+07
## Estimated value of pi: 3.141249600000000086197360360529273748397827148437500000000000000000000000000000000000000
000000000000000
## Error percent: 0.01091973491 %
```

```
## Elapsed time: 23.75 seconds
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - -
## Samples: 1e+08
## Estimated value of pi: 3.14167811999999990746346156811341643333435058593750000000000000000000000000000000000
000000000000000
## Error percent: 0.002720480331 %
## Elapsed time: 233.5 seconds
## - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - -
```