

MONTE CARLO SIMULATION BENCHMARKING STUDY: PYTHON, R, AND GO

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## I. Abstract

This benchmarking study provides a comparative analysis of the performance of three widely-used programming languages; Python, R, and Go. Data from the “Apartment for Rent Classified” dataset is utilized to identify variables affecting rent prices and determine their probability distributions. The study assesses the speed of each of these three languages in generating machine learning models through Monte Carlo simulations to predict apartment rent prices. The results of this study are a valuable resource for investment firms or policy institutions seeking the most effective programming language to perform similar analytical tasks.

## II. Introduction

When determining the approach to a data science problem, it is essential to select the programming language that will optimize time allocation to expedite decision making and improve business performance. Despite the established or growing popularity and machine learning capabilities of Python, R, and Go programming languages, there are variations in their syntax, scalability, and the data structures they support (edX 2021). Python, being a general-purpose programming language, provides accessibility in its intuitive syntax and offers an array of libraries that can support a variety of machine learning objectives (IBM 2021). R is a more specialized programming language focusing heavily on statistical analysis and mathematical algorithms in its machine learning functionality (IBM 2021). Go is a relatively new programming language that aims to offer enhanced speed in comparison to other languages and supports machine learning capabilities, but requires more familiarity with coding, especially in C++ and C#, and does not have as extensive libraries, requiring a larger volume of code to be written to achieve a desired result (Radavicius 2023).

It is crucial for investment firms and policy institutions to not only have the most accurate models in rent forecasting, but also the most efficient way to implement and execute the models for timely and effective decision making. This benchmark study provides a comprehensive comparison of the performance capabilities of the programming languages Python, R, and Go. Monte Carlo simulation is employed in each of these scenarios to generate possible rent prices based on historical data and taking into account state multipliers. The key performance indicator that the study focuses on to determine the effectiveness of each model is the speed at which they execute the desired simulations. In assessing this element of three popular machine learning languages, the results of this study will serve as an essential guideline for organizations making data-driven decisions in the housing and rental industry.

### III. Literature Review

A 2022 International Conference on Informatics article performs a side-by-side computational time comparison between Python and Go using various Nature-Inspired algorithms. The authors outline the characteristics of each programming language and explain why many researchers choose Python as their chosen language due to its ease of use and cross-platform functionalities, but explain that the complexities of the algorithms have significant impact on Python's speed and memory usage (Shukla et al 2022). After performing nine benchmark functions within the four separate algorithms through Python and Go environments, they conclude that Go performs at a significantly faster rate, with Python results lasting multiple seconds and Go results being delivered in microseconds (Shukla et al 2022).

A 2017 article from the Institute of Electrical and Electronics Engineers conference analyzed five data science frameworks; Python, R, PostgreSQL, PySpark, and Dask through micro and macro benchmarking. The micro benchmarking tasks included reading and writing basic

files, data wrangling, descriptive statistics, distribution and inferential statistics, time series, and machine learning, while macro benchmarking employed a demand prediction application and a sport analytics application (Watson et al 2017). Their results indicated that Python and R were both high performing amongst the other options with python getting the competitive edge in performing benchmarking tasks faster.

#### IV. Methods

This study utilizes a Monte Carlo simulation to predict rent prices within various states using the programming languages Python, R, and Go. Each experiment begins with loading and preparing the "Apartment for Rent Classified" dataset from the UC Irvine Machine Learning Repository. This step is achieved in each language by employing the ucimlrepo Python library to fetch data and pandas for data manipulation, directly reading and manipulating using base R functions, and manually processing the data in Go. The data includes variables such as rent price, number of bedrooms and bathrooms, square footage, and the state in which the unit is located. By identifying the average rent price per state relative to the overall average price, state multipliers are calculated using Python's pandas library and base functions in R and Go. These multipliers are used to adjust rent prices to correct for variations amongst states and regions in each of the 10,000 iterations performed. Executing a Monte Carlo simulation is achieved with Python's numpy and scipy, base R functions, and Go's gonum/stat/distuv to generate base rent prices in a normal distribution with a mean \$955.96 and a standard deviation of \$365. The execution time is measured and recorded through the time library in Python, using base R functions, and the time library in Go. This is accomplished by initiating a start time in each language, running the simulation, then recording the end time.

#### V. Results

Running the monte carlo simulation 100 times yields the below results. Each programming language runs relatively quickly, finishing under a second each. However, running a ANOVA test produces an F-value of 20.99 and a p-value of 3.65e-08, suggesting significant differences between execution times.

Execution Times	Python	Go	R
Mean	0.00065	0.0009	.0006
Standard Deviation	0.00021	0.0000	.00027
Maximum	0.002	.0013	.0031

## VI. Conclusions

This study compares the performance of Python, R and Go in forecasting apartment rent prices through machine learning models and Monte Carlo simulations. The key performance indicator with which the programming languages are assessed is the computational speed. The results of this study indicate that there are performance differences amongst the three chosen languages and their execution.

Overall, R had the lowest average execution time but with the largest standard deviation. It also had the longest time in the trials. Go had the lowest standard deviation but the largest mean. Python was somewhere in between.

These findings can act as a foundational guide for policy institutions and investment firms that wish to explore the most effective method of predicting the rental market. Our recommendation, based on the findings presented above, is to utilize the Python programming language.

This study can be expanded by implementing additional models that vary in complexity and exploring larger datasets. Another consideration that could be further explored is how the

performance of each language is affected by the device and hardware being used to run the models.

## VII. References

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## VIII. Images







