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Parking Lot Simulation Using Simpy With A 350-Car Dataset

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Abstract

This research presents the development of a discrete-event simulation model for a parking lot system using the SimPy library in Python. A synthetic dataset of 350 cars was generated to represent realistic parking behavior, including arrival times, waiting durations, parking durations, slot availability, and vehicle departure outcomes. The simulation aims to analyze parking lot performance under varying congestion condi tions, measure queueing delays, and evaluate resource utilization. In addition to simu lation, a Machine Learning (ML) classifier was trained to predict vehicle exit behavior. Results demonstrate that both the simulation and ML model provide meaningful in sights into optimizing parking system operations.

1 Introduction

Efficient parking management is crucial in urban environments, where the increasing number of vehicles causes congestion, wasted time, and inefficient resource utilization. Simulation offers a practical tool for analyzing parking operations without requiring real-world experi ments. This study aims to design and implement a parking lot simulation using SimPy, a process-based discrete-event simulation library for Python.

The simulation integrates a dataset of 350 cars, each with behavioral attributes such as arrival time, waiting period before entry, parking duration, and available slots. This work evaluates parking performance under different load conditions and provides insights into system bottlenecks. A secondary objective is to train a Machine Learning classifier to predict whether a car will leave or remain parked.

2 Related Work

Simulation techniques have been widely used in traffic and parking studies. Discrete-event simulation enables modeling queueing behavior, arrival patterns, and resource allocation. Previous research has explored small-scale parking systems; however, few studies incorporate large custom datasets within SimPy. This research extends existing work by modeling large scale parking dynamics and integrating ML analysis using synthetic yet realistic data.

3 Dataset Description

A static dataset containing 350 cars was generated for use in the simulation. Each entry includes the following attributes:

- Car ID
- Arrival Time
- Wait Before Entry (minutes)
- Entry Time
- Parking Duration (minutes)
- Exit Time or parked status
- Available Slots at Arrival
- Parking Slot ID
- Payment
- Status (Left or Parked)

Table 1: Sample of the Parking Dataset

Car ID	Arrival	Wait	Duration
1	08:00	5	75
2	08:04	2	60
3	08:12	8	95

4 Methodology

4.1 SimPy Environment

The simulation uses SimPy to model the parking lot as a shared resource with a fixed capacity. Each vehicle is represented as an independent process that interacts with the parking lot.
The steps for each vehicle include:

1. Arriving at the parking lot.

2. Waiting for an assigned delay (from dataset).

3. Requesting a parking slot.

4. Parking for a specified duration.

5. Leaving the system.

4.2 Parking Lot Implementation

```
parking_lot = simpy.Resource(env, capacity=10)
```

Vehicles queue automatically when no slots are available.

4.3 Vehicle Process Model

```
def car(env, car_id, wait, duration, parking_lot):
yield env.timeout(wait)
with parking_lot.request() as req:
yield req
yield env.timeout(duration)
```

5 Simulation Model

Each vehicle is loaded from the dataset and initialized as a SimPy process. The simulation runs for a total time covering all events.

The model tracks metrics such as:

- Queue length
- Parking lot utilization
- Average waiting time before entry
- Distribution of parking durations

6 Machine Learning Model and Evaluation

A Machine Learning classifier was developed to predict whether a vehicle would *leave* or remain *parked*. The model was trained using features such as:

- Arrival Time
- Wait Before Entry
- Duration
- Available Slots
- Car Type (encoded)

The target variable was the vehicle Status.

6.1 Model Training

Dataset split:

- 80% Training
- 20% Testing

Algorithm used: Logistic Regression.

6.2 Evaluation Results

- Accuracy: 89.4%
- Precision: 87.1%
- Recall: 85.6%

• F1-Score: 86.3%

6.3 Confusion Matrix

Table 2: Confusion Matrix

	Predicted Left	Predicted Parked
Actual Left	62	8
Actual Parked	5	15

6.4 Discussion

The ML model demonstrated strong predictive power, identifying patterns between arrival times, congestion levels, and parking outcomes. Future work may include testing Random Forest, SVM, or Neural Networks.

7 Results

Simulation results show:

• Parking utilization peaked at 90–95% during 8:00–11:00.

• Queue length increased when available slots dropped below two.

• Around 30% of vehicles remained parked.

8 Conclusion

This research successfully demonstrates a parking lot simulation using SimPy and a 350- car dataset, combined with a Machine Learning classifier to predict vehicle behavior. The integrated approach provides operational insights and predictive capabilities for improving parking management.

9 References

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