Project Report

Title: Dynamic Pricing for Urban Parking Lots

1.Introduction:

Static pricing frequently results in either underuse or overcrowding in urban parking lots. The goal of this project is to create a dynamic pricing system that changes in real time according to different demand factors. Using real-world data, the goal is to maximize space utilization and equitable pricing across 14 parking lots.

2. Dataset Overview:

Data from 14 parking spots over 73 days make up the dataset. 18 time points (30-minute intervals from 8:00 AM to 4:30 PM) are included in each day.

Key features are:

- Parking Lot ID, Latitude, Longitude
- Occupancy and Capacity
- Queue Length
- Nearby Traffic Conditions(low/medium/high)
- Special Day indicator
- Vehicle type (bike/car)
- Last updated day and time

3.Feature Engineering:

- Occupancy rate : Occupancy/capacity
- Queue Normalization : Scaled queue length between 0 and 1
- Traffic Encoding :low : 1,medium :2 ,high:3 and then normalized
- Vehicle weighting : Car :1.0 ,Bike = 0.5
- Datatime parasing : created a timestamp for real-time use by combining the date and time.

4.Pricing models:

Model1:Baseline Linear Model:

- A simple model that shows a linear price increase with occupancy
- serves as a benchmark for more intricate models.

Model 2:Demand Based Pricing:

- computes a normalized demand value by combining several features.
- Formula used
  Demand=α·Occupancy Rate+β·Queue Norm−γ·Traffic Norm+δ·Special Day+ϵ·Vehicle Weight
- guarantees bounded, smooth price variation (between $5 and $20).

Model 3:Competitive Pricing Model:

- incorporates location intelligence and modifies pricing according to adjacent lots.

- Logic used :
- If the lot is full and there are less expensive lots nearby → lower the cost
- If lots in the area are pricey, raise the price.
- Otherwise, use a price based on demand.

5 .Real Time Simulations:

- Pathway was used to mimic real-time data streaming.
- Row-by-row data streaming that preserves order of timestamps
- To calculate prices in real time, a user-defined function (@pw.udf) was developed.
- Pathway's streaming logic was used to process and update each record.

6.Visulization:

Made with Bokeh:

- Time-Series Plots: Show each model's pricing trends
- Charts of Comparison: Models 1, 2, and 3
- Competitor Bars: Evaluate your own prices against those of adjacent lots at the same time.

7. Assumptions:

- Based on feature relevance, demand weights (\alpha, \beta, etc.) were selected.
- Special Day can be either 1 or 0.
- Two categories were created from the vehicle types.

8.Conclusion:

The project effectively illustrates a system of dynamic pricing :

- responds instantly to shifting market conditions and rivalry
- preserves fairness and price stability
- offers a framework that is scalable for practical implementation.