

Dynamic Pricing for Urban Parking Lots - Final Report

Objective

This project aims to develop a real-time dynamic pricing engine for 14 urban parking spaces. Static pricing often leads to underutilization or overcrowding. We designed intelligent pricing models that adapt based on real-time data like occupancy, queue length, traffic, and competition - improving utilization and user experience.

Dataset Overview

- Time Span: 73 days
- Sampling: 18 time steps/day (30-min intervals)
- Features: Occupancy, Capacity, Queue, Traffic, Special Day, Vehicle Type, Latitude, Longitude

Model 1: Linear Pricing Model

Price increases linearly with occupancy.

Formula:

$$Price_{t+1} = Price_t + \alpha \cdot (Occupancy / Capacity)$$

- Base Price: \$10
- $\alpha = 2$

Model 2: Demand-Based Pricing

Demand combines multiple factors:

$$Demand = \alpha \cdot (Occ/Cap) + \beta \cdot Queue - \gamma \cdot Traffic + \delta \cdot SpecialDay + \epsilon \cdot VehicleWeight$$

Pricing:

$$Price = BasePrice \cdot (1 + \eta \cdot NormalizedDemand)$$

- Normalization: Sigmoid
- Clamp: [0.5, 2 base]
- $\eta = 0.3$

Model 3: Competitive Pricing

Proximity checked via Haversine distance.

Pricing adjusted by comparing nearby lots within 0.5 km.

- If nearby lots cheaper: lower price
- If costlier: raise price slightly

Real-Time Simulation (Pathway)

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Used Pathway to stream data row-by-row, applying pricing logic via UDF.
Output streamed using `pw.io.csv.write`.

Visualization (Bokeh)

Plotted real-time pricing with Bokeh:

- Linear vs Demand-Based vs Competitive models
- Interactive exploration enabled

Assumptions

- Vehicle weights are fixed
- Special days are binary
- Competitor prices are available instantly

Observations

- Demand-based pricing adapts better to traffic and queues
- Competitive model offers fairness and pricing balance

Future Improvements

- Learn weights using ML/RL
- Add time-of-day trends
- Smart rerouting suggestions

Deliverables Summary

- Dataset processed
- Three pricing models built
- Real-time simulation
- Visualization
- Report complete

Credits

Prepared by: Your Name - Summer Analytics 2025
Tools Used: Python, Pandas, NumPy, Pathway, Bokeh