Dynamic Pricing for Urban Parking Lots

Summer Analytics 2025 – Capstone Project Report
Hosted by Consulting & Analytics Club × Pathway

Objective:

To build an intelligent, real-time pricing system for urban parking spaces that adjusts prices dynamically based on demand, congestion, vehicle type, and competitor pricing.

Dataset Overview:

- 14 Parking Lots
- 73 Days of Data
- 18 Time Slots/day (every 30 mins, 8 AM to 4:30 PM)
- Each row includes:
    - Capacity, Occupancy
    - Queue Length
    - Traffic Condition
    - Vehicle Type
    - Special Day Indicator
    - GPS coordinates

Pricing Models:

Model 1: Baseline Linear Model
P_t+1 = P_t + alpha * (Occupancy / Capacity)

- Smooth linear increase based on occupancy
- Acts as a reference

Model 2: Demand-Based Model
Demand = alpha * (Occupancy / Capacity) + beta * Queue - gamma * Traffic + delta * SpecialDay + epsilon * VehicleType
P = BasePrice * (1 + lambda * NormalizedDemand)

- Demand values are normalized
- Prices are clipped between $5–$20

Model 3: Competitive Model

- Distance between lots calculated using Haversine Formula
- Logic:
    - If current lot is full & nearby is cheaper → Reduce price / Suggest rerouting
    - If nearby lots are expensive → Increase price within bounds

Assumptions

- Vehicle weight: truck > car > bike
- Special days increase demand
- High traffic discourages parking
- Prices change smoothly, not abruptly

Real-Time Streaming (via Pathway)

- Streamed using pw.debug.table_from_pandas()
- Real-time pricing logic with @pw.udf
- Output prices emitted per 30-minute interval

Visualizations

- Real-time Bokeh line plots for each lot
- Comparison between baseline and adjusted prices
- Grid layout for multiple lots

Example Price Behavior:

Scenario	Pricing Effect
High occupancy	Increase
High traffic	Decrease
Long queue	Increase
Special event	Increase
Bike arrival	Slight increase
Truck arrival	Large increase
Nearby lots cheaper	Drop price
Nearby lots expensive	Raise price

Tools Used:

- Python, Pandas, NumPy
- Pathway for streaming
- Bokeh for visualization
- Google Colab environment

Files Submitted:

- Colab notebook
- PDF Report
- dataset.csv

Conclusion:

This system dynamically adapts parking prices based on demand and real-world signals.
It demonstrates how real-time data pipelines and smart logic can optimize urban infrastructure.