Dynamic Pricing for Urban Parking Lots - Final Report

1. Problem Overview

Urban parking lots face fluctuating demand throughout the day, influenced by traffic, vehicle types, and special events. Static pricing leads to either under-utilization or overcrowding. This project aims to build a real-time dynamic pricing engine for 14 parking lots using a dataset collected over 73 days at 30-minute intervals.

2. Dataset Summary

The dataset includes:

- **Timestamped data** for each lot
- **Occupancy**, **Capacity**, **QueueLength**
- **VehicleType** (car, bike, truck)
- **TrafficConditionNearby** (low, medium, high)
- **IsSpecialDay** (binary)
- **Latitude/Longitude** for each lot

3. Pricing Models

Model 1: Baseline Linear Model

This simple model adjusts price based on occupancy:

Formula:

- Price_t+1= Price_t+α·(CapacityOccupancy)
- Base price starts at $10
- Price increases smoothly as occupancy grows
- Acts as the reference model

Model 2: Demand-Based Model

This model accounts for multiple factors:

Demand Function:

Demand = (alpha * (occupancy / capacity) +

beta * queue_length -

gamma * traffic_val +

delta * is_special_day +

epsilon * vehicle_val)

Where:

- Traffic is encoded as: low=1, medium=2, high=3
- Vehicle weights: bike=0.5, car=1.0, truck=1.5

Price Function:

Price= base_price * (1 + lambda_*(normalised_demand))

- Normalized_demand = clamp(Demand / 10, 0, 1)
- Final price is clamped between and of the base price
- are tunable parameters

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4. Assumptions

- Base price is fixed at $10 for all lots
- Demand factors are linearly combined
- Mapping of categories (traffic, vehicle type) is done via static dictionaries
- No real-time rerouting implemented
- Price is updated for every timestamped record, not continuously

5. Visualization Strategy

Using **Bokeh**, we create line plots for each parking lot:

- X-axis: Timestamp
- Y-axis: Price ($)
- Two lines: Baseline model vs. Demand-based model

These visualizations show how smarter pricing adapts better to demand conditions and avoids overcharging.

6. Conclusion

This dynamic pricing system is capable of adapting to real-time features like congestion, special days, and vehicle load. While basic, it sets the foundation for a deployable smart pricing engine.

Further work:

- Full Model 3 implementation
- Real-time system with Pathway and vehicle rerouting suggestions
- Integration with real sensor/streaming data