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Project Report

Dynamic Pricing for Urban Parking Lots

Problem Statement:

Efficiently manage urban parking by implementing a dynamic pricing system that adapts to demand in real-time. The objective is to encourage optimal parking distribution, reduce congestion, and maximize lot utilization through intelligent pricing.

Dataset Overview:

- **Source**: Provided CSV file with real-time parking data
- **Features**:
    - SystemCodeNumber, Latitude, Longitude
    - Capacity, Occupancy, VehicleType
    - TrafficConditionNearby, QueueLength, IsSpecialDay
    - LastUpdatedDate, LastUpdatedTime

We created a unified Timestamp column by merging date and time for chronological processing.

Modelling Approach:

Model 1: Baseline Linear Pricing

Simple linear model that increases price as occupancy increases.

price = prev_price + alpha * (occupancy / capacity)

Model 2: Demand-Based Dynamic Pricing

A contextual model using traffic, queue length, event days, and vehicle type weight.

Demand Function:

demand = (α * (occupancy / capacity) + β * queue_length - γ * traffic_level + δ * is_special_day + ε * vehicle_weight)

Where:

- α = 0.5, β = 0.3, γ = 0.2, δ = 0.1, ε = 0.15
- Demand is normalized and price is bounded between 0.5x and 2x base price.

Assumptions:

- Traffic condition is mapped to numeric scale: low=1, average=2, high=3
- Vehicle types are weighted to represent expected duration/impact
- Queue length reflects pending demand pressure
- A special day may increase demand due to events or holidays
- Maximum price is capped at base_price * 2.0 to ensure affordability

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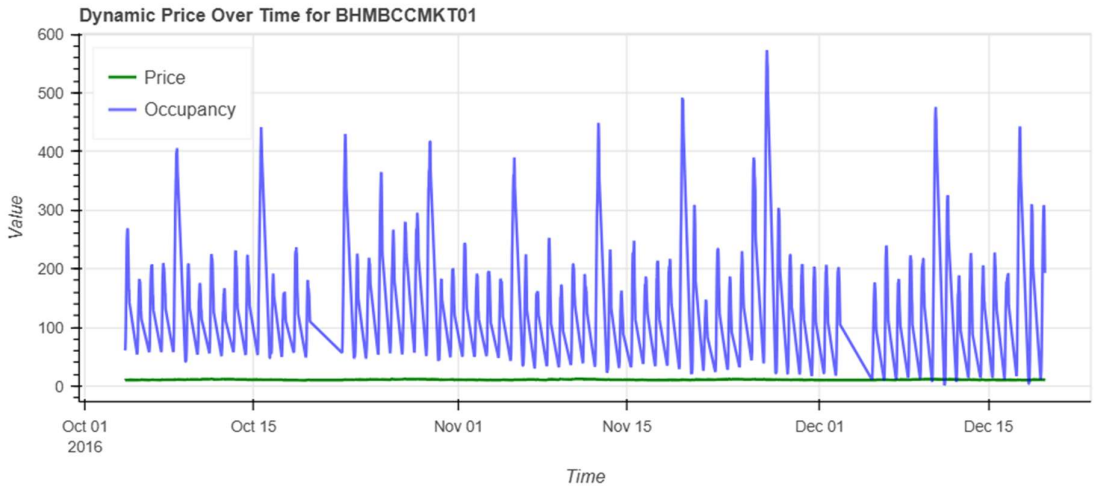
Real-Time Simulation:

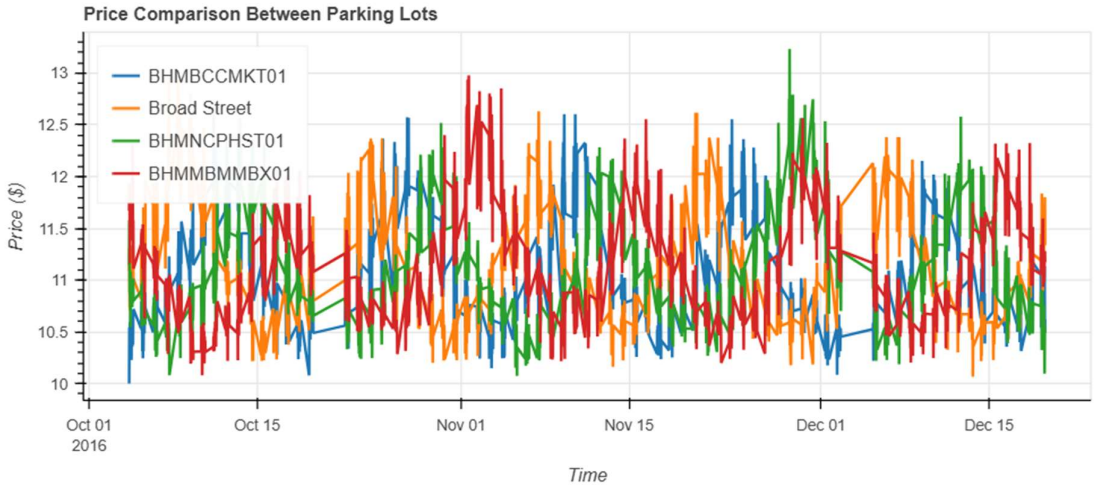
Simulated batch-wise data ingestion (10 rows at a time) to imitate streaming behavior. Prices were calculated and logged per lot with time delays to reflect real-time updates.

Visualizations:



Plot 1: Dynamic Pricing for a Single Lot

- Shows how price changes in real-time for one parking lot
- Includes occupancy overlay for context



Plot 2: Competitor Price Comparison

- Compares price behavior across 4 nearby lots
- Helps evaluate competitive pricing spread and fairness

Output Logs:

- Prices were saved in dynamic_prices.csv

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- Each row includes timestamp, lot ID, occupancy, and computed price

Results & Observations:

- Prices increase smoothly during high occupancy, traffic, or events
- Lots with higher vehicle weight (trucks, cars) show elevated pricing
- The model maintains price fairness by limiting volatility
- Competitive pricing patterns are visible in Bokeh Plot 2