Identifying Parking Demand Hotspots and Predicting Rate Surge

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Urban Transitions Conference
5 - 7 November 2024

VIRGINIA TECH

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ELSEVIER

ML-driven Parking: From Reactive Management to Predictive Solutions

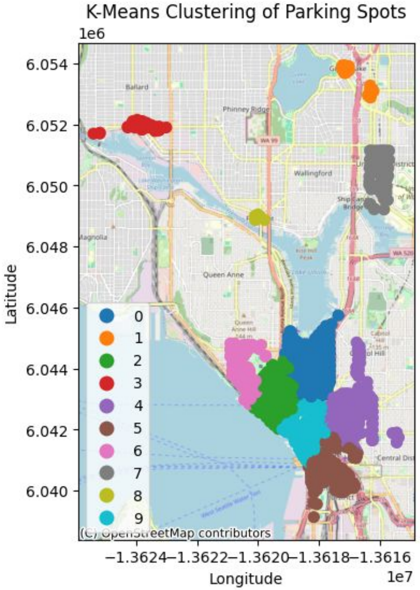
Why wait to circle for a parking spot in a area?

What if we could **predict** parking spot availability nearby?

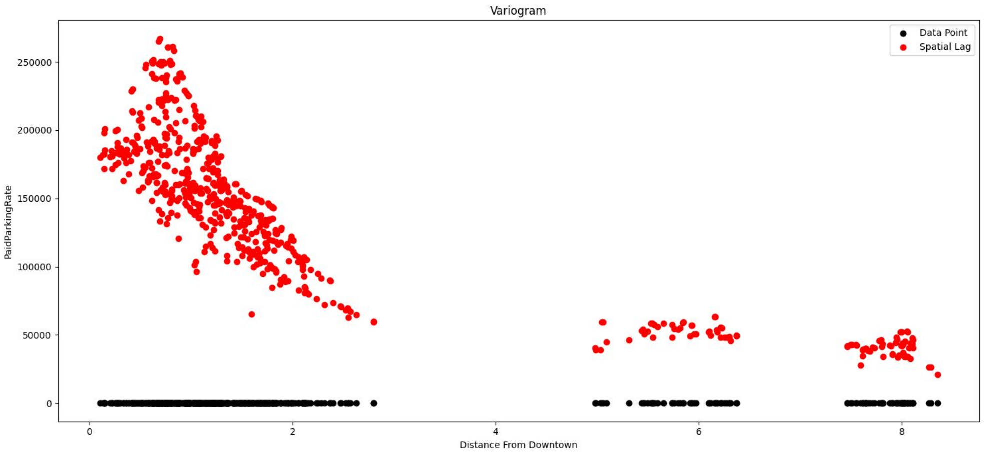

CNBC
WHY THE U.S.
HAS TOO MUCH
PARKING
PARK

Integrating data science with urban planning

Predict behavior:
Where is parking demand highest?



Optimize resources:
How to manage parking efficiently?



➜ Big data analytics & machine learning

➜ Dynamic interventions (smart pricing)

Data Sources: Building a Comprehensive View

Seattle Open Parking Data 2015

Visual Crossing API

Offerings

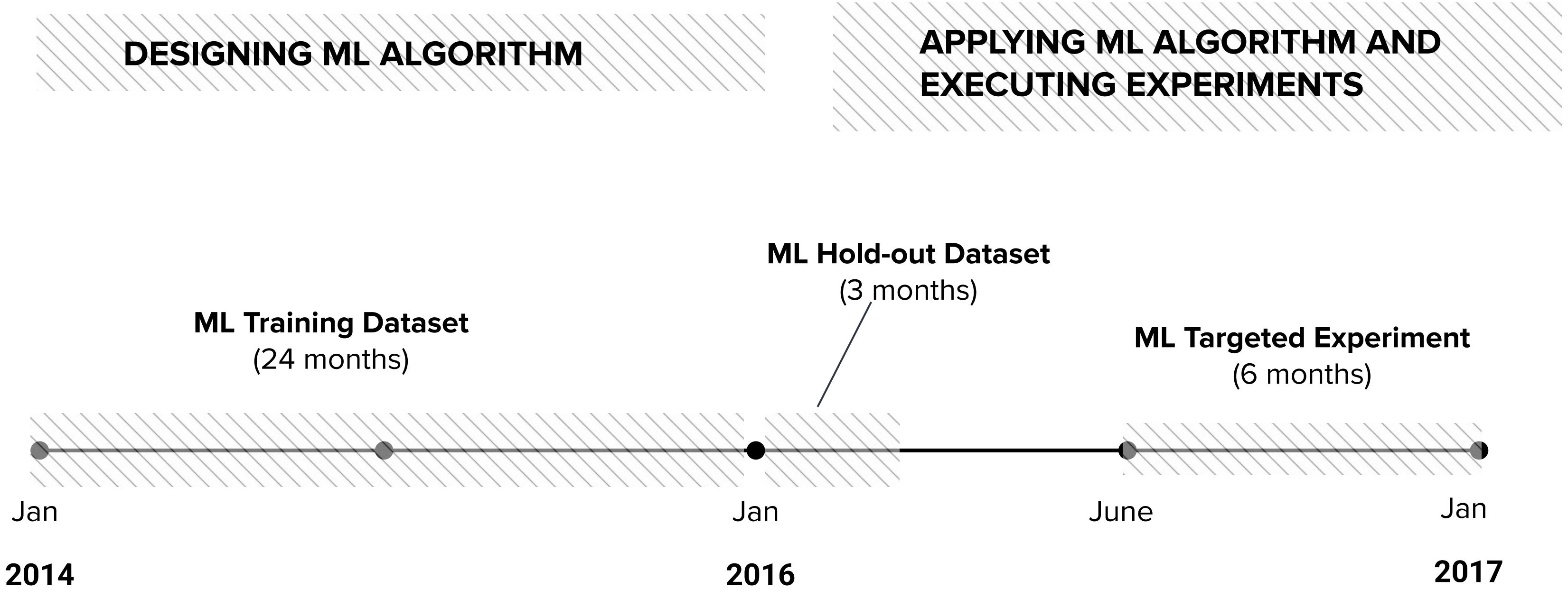
Seattle

visualcrossing Weather Data

OpenStreetMap

Study Overview and Timeline

- Phase 1: ML Algorithm Development
- Phase 2: Implementation & Analysis



Key Findings from ML Models

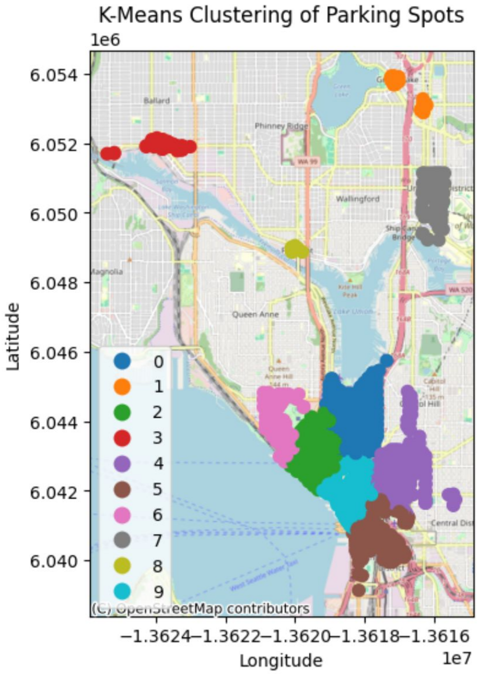
Identify parking demand hotspots

K Means Clustering -

To pinpoint areas in Seattle with high and low demand for parking.

High rates in cluster 4 & 9 (Avg rates 3.50$)

Low demand clusters 1 & 3 (Avg rates 1.20$)



Key Findings from ML Models

Predicting Parking Rate Surges

Forecast rate changes, especially during peak times, to optimize urban parking management.

Model Performance:

- Random Forest: Highest accuracy (92.73%) – effective for rate surge prediction.

- Polynomial Regression: R-squared of 0.89 – captures non-linear demand patterns.

- Decision Tree: 84% accuracy – identifies high demand areas.

These models offer reliable insights for dynamic pricing, congestion management, and targeted urban planning.

Triage by Impact Level

How do our findings translate to different stakeholder priorities?

High Priority Areas: Belltown & First Hill Clusters

Monthly revenue: $96K-$107K I Commercial zones, high-traffic areas, event venues

Medium Priority Areas: Chinatown & University District

Monthly revenue: $65K-$87K | Shopping districts, entertainment areas, mixed residential

Low Priority Areas: Green Lake & Residential Zones

Monthly revenue: $20K-$35K | Residential areas, low-turnover zones

Practical Applications

For City Planners	For Businesses	For Residents
Dynamic pricing strategies	Location optimization	Real-time availability
Infrastructure optimization	Customer accessibility	Reduced search time
Resource allocation	Revenue potential	Better urban experience

Future Research

- Real-Time Data Integration
- Create a user friendly mobile application
- Advanced model optimizations with deep learning models (LSTM’s) to capture complex patterns.

Thank you

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