Bringing curbs to light; estimating the value of digital curb availability data

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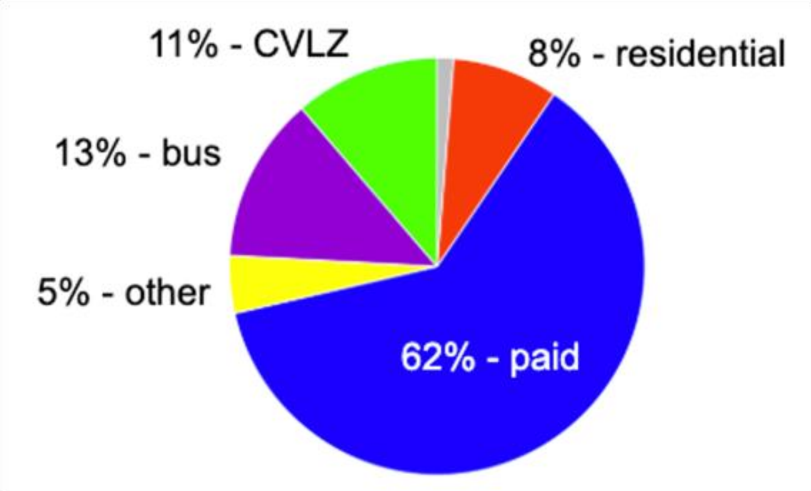
- Delivery challenges in urban areas
- Intelligent parking systems
- OpenPark: a real-time curb availability information system
- Real-time experimental design & data collection
- Value of historical data

Delivering in urban areas is increasingly challenging

Freight parking demand

U.S. E-commerce retail sales represents 11.2 % of total sales (U.S. Census Bureau, 2019)

Freight parking supply



11% of allocated curb-space in Seattle is dedicated to commercial vehicles

(Seattle DOT, 2019)

NY Times

Conal Thomas

Cruising for parking

Parking demand → parking supply = cruising for parking

Cost of cruising for parking

- Internal cost: 30 seconds to 15.4 minutes of mean cruising time
- External cost: 7-74% share of traffic is cruising, 1h parked ⟶ 3.6 cars to cruise

Do commercial vehicles cruise for parking?

YES! Using GPS data from two different carriers we estimated that a parcel delivery driver spends on average <u>50 minutes a day</u> cruising for parking

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Do commercial vehicles cruise for parking? Empirical evidence from Seattle

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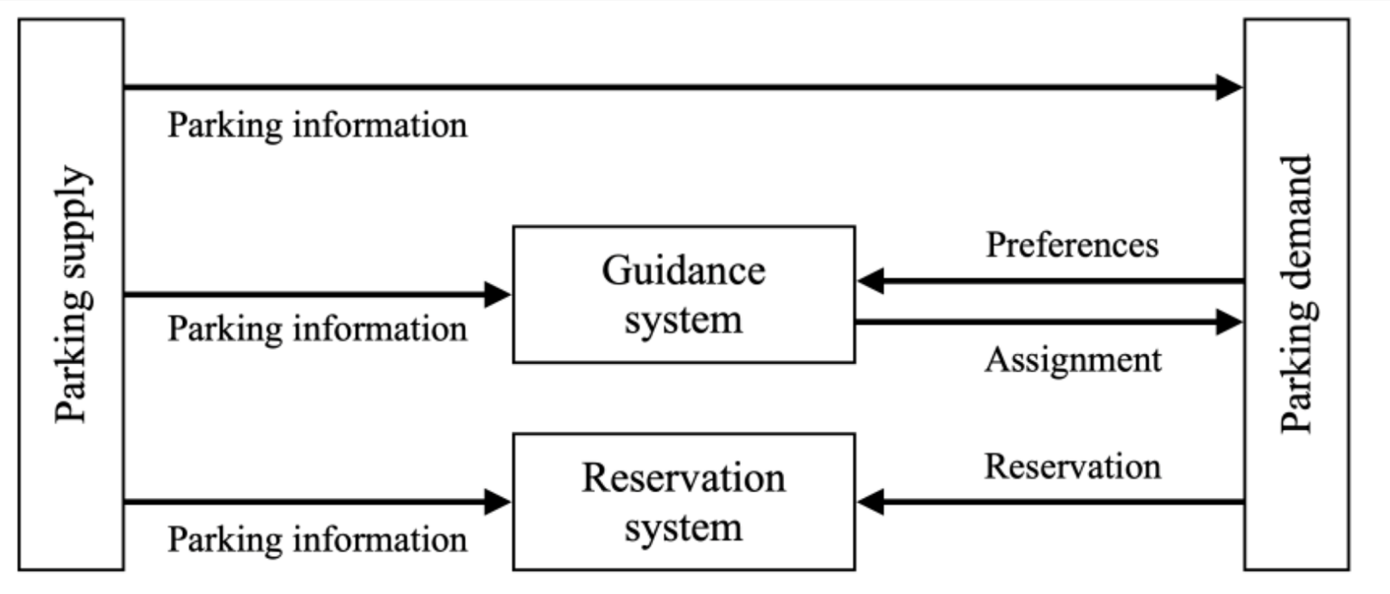
Intelligent parking systems

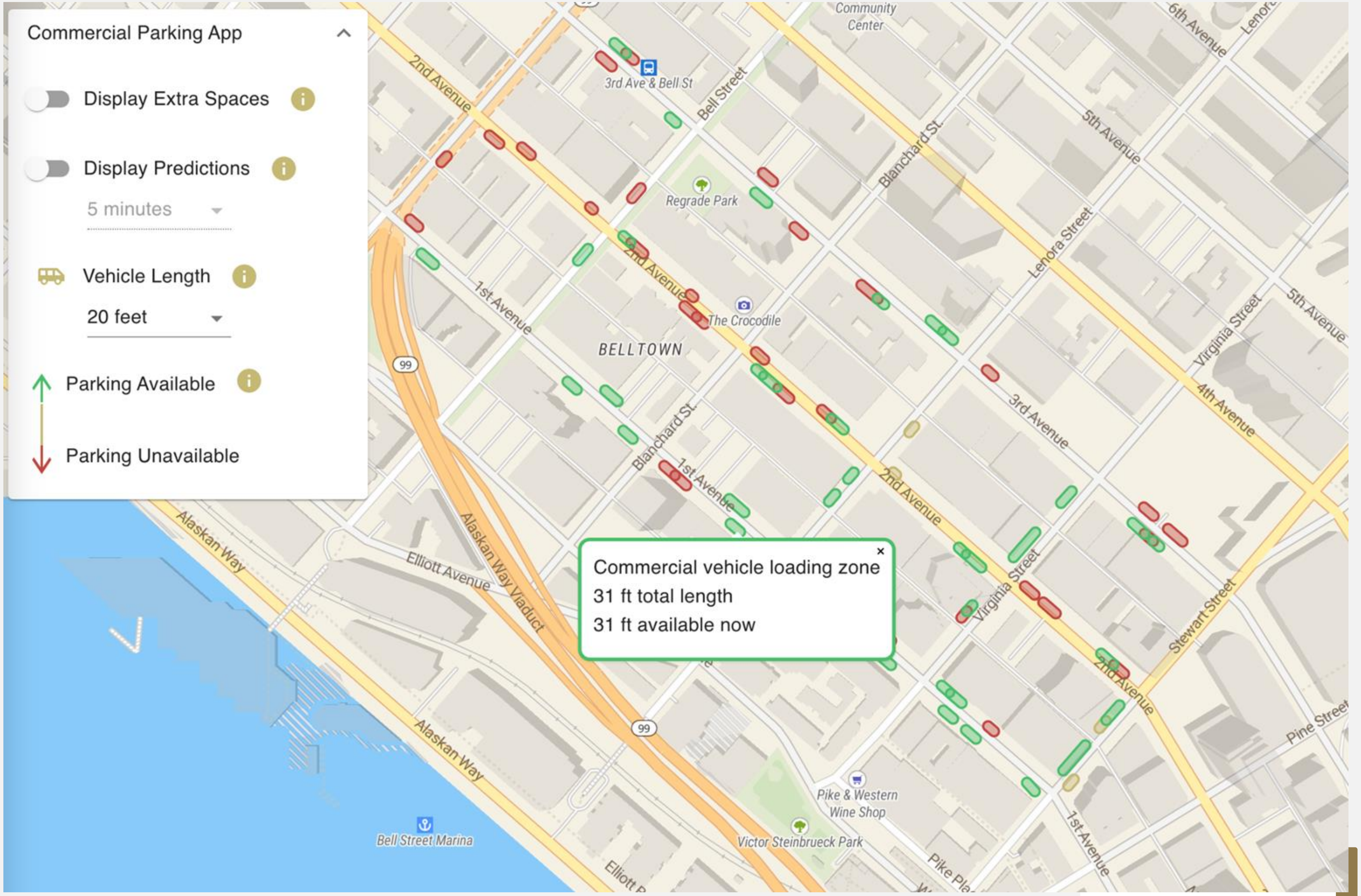
Intelligent parking systems use real-time curb availability information to improve drivers' parking experience and reduce parking externalities



→ Can **parking availability information** reduce delivery vehicles cruising for parking and improve delivery efficiency?

Open park

Real time & predicted parking occupancy of CVLZs and PLZs

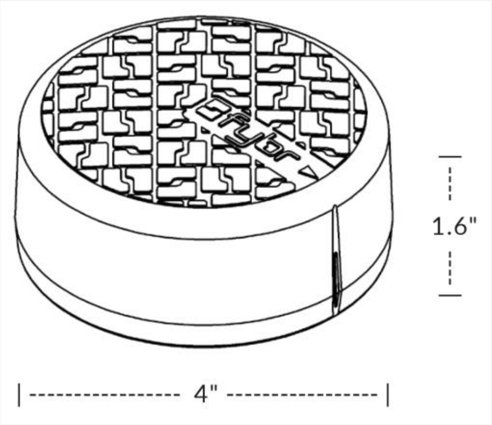


Methodology

1) Deploy curb proximity sensors in a study area → 2) Create a curb availability information system **OpenPark** → 3) Experiment design → 4) Collect data & evaluate system

Study area

- Belltown neighbourhood, Seattle
- Vendor: Fybr
- 273 magnetic field sensors
- CVLZs + PLZs



Sensor

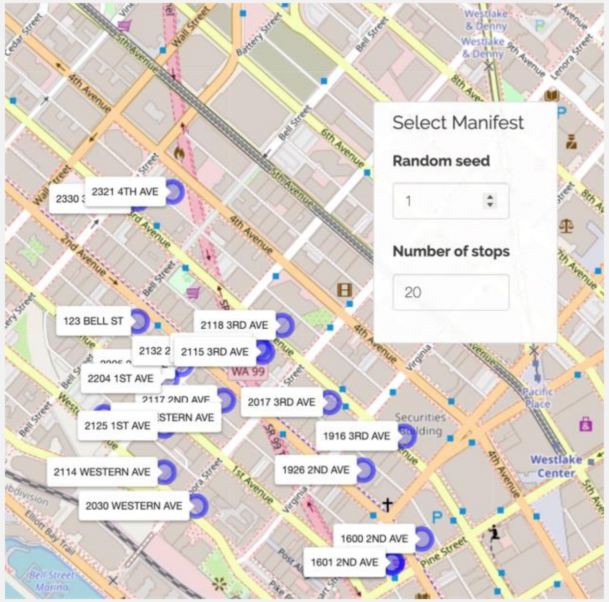
Deployment

Gateway

Evaluation

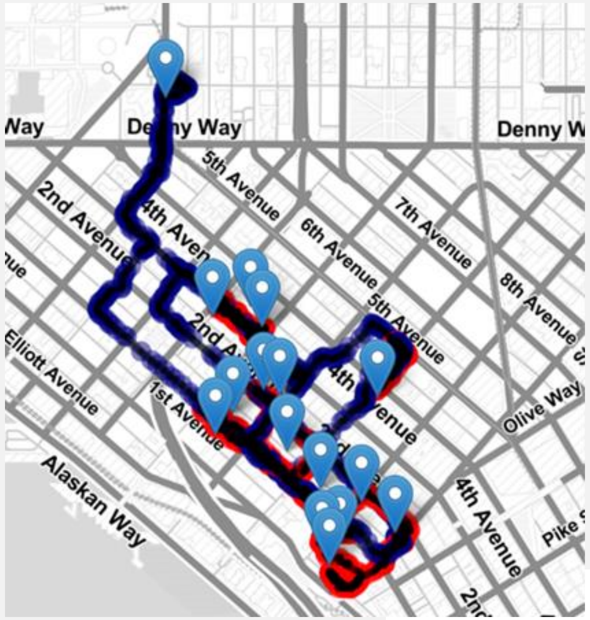
→ Randomized experiment (treatment=app, control=no app.)

1) Created synthetic delivery manifests



2) Hired drivers to perform deliveries w/o app

3) Data collection & analysis (app vs. no app)



Data collection

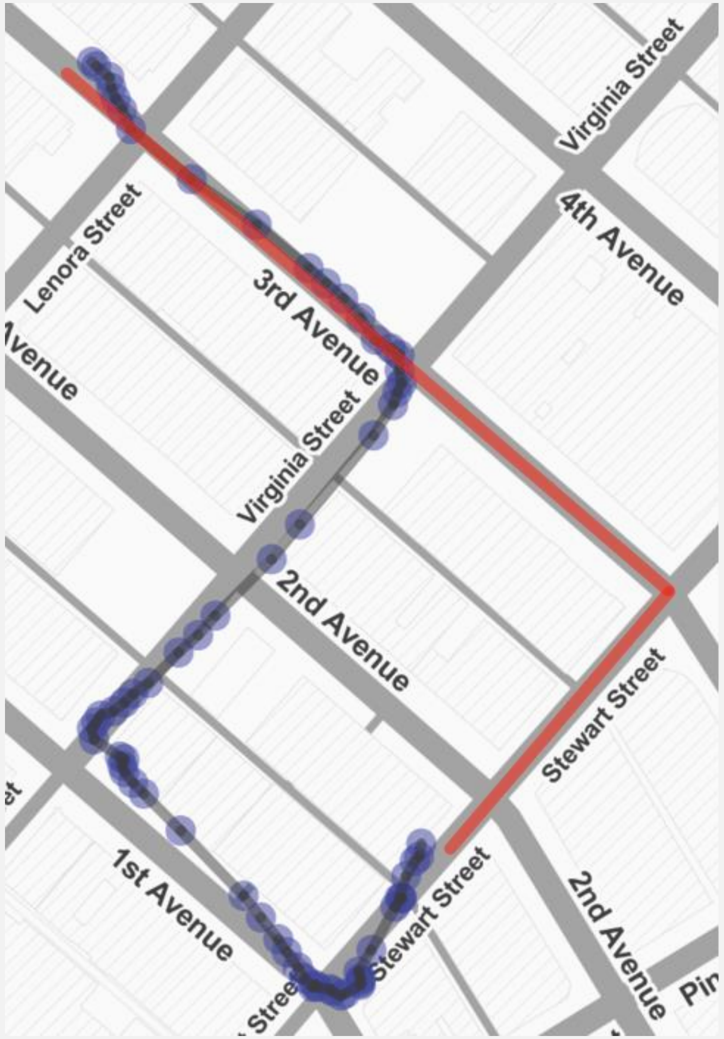
Observers rode along with drivers and collected GPS data

Performance metrics

- Cruising for parking time
- Cruising for parking distance
- Route time
- Route distance

Performed

- 33 routes
- 495 deliveries
- 177 trips



Experimental design

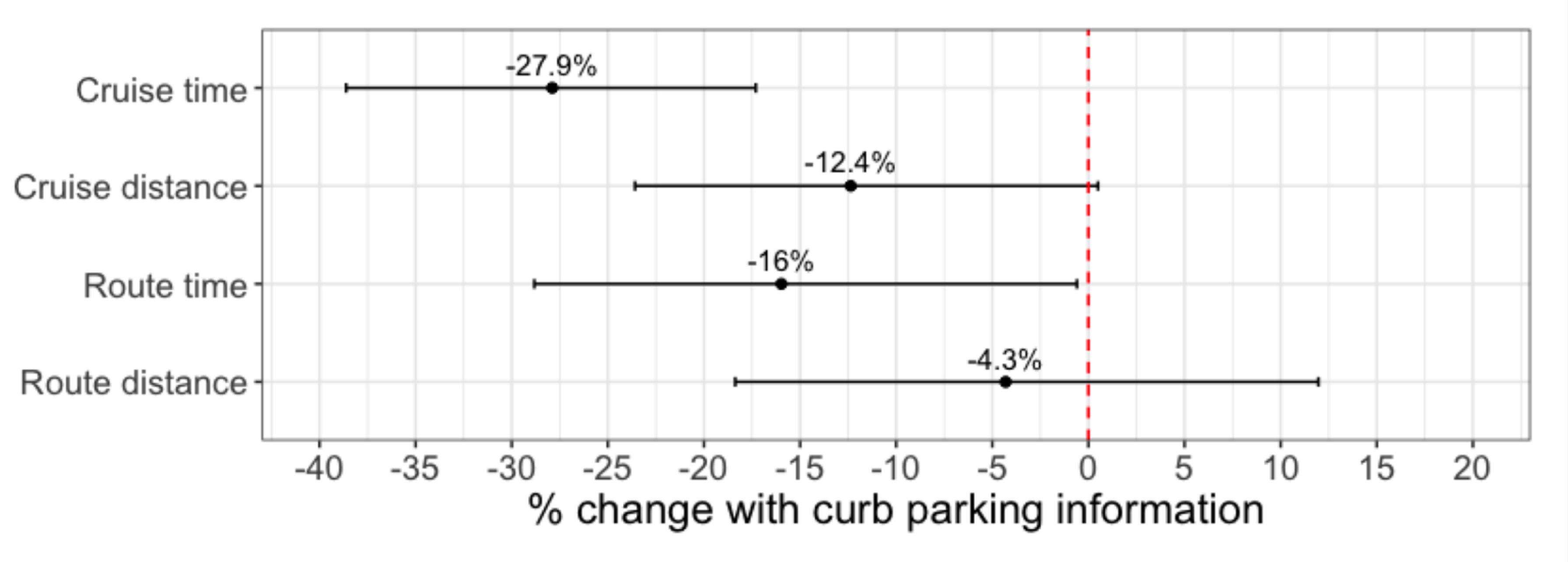
- Hired 11 delivery drivers
- Each driver performed 3 different manifests (3 routes), each containing 15 delivery addresses
- Each driver performed at least 1 manifest using OpenPark for real-time curb availability information, and 1 without

Drivers	**Manifests**										**Total no. routes**
	M1	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	
D1	No app	No app							App		3
D2		App	App	No app							3
D3			App		No app	No app					3
D4	App					App	No app				3
D5		No app		No app				App			3
D6				No app	App		No app				3
D7						App	No app	App			3
D8			No app		App				No app		3
D9	No app			App			App				3
D10				App				No app		No app	3
D11							App	No app		App	3
Total no. routes	3	3	3	5	3	3	5	4	2	2	33

No app = route was performed without access to OpenPark app
App = route was performed with access to OpenPark app

Results

- Estimated four mixed-effect random intercept regression models
- Each model contained a binary variable $1_{[App]}$ which takes value 1 whenever OpenPark was used
- The estimated coefficients for $1_{[App]}$ quantify the impact of using OpenPark on the performance metrics



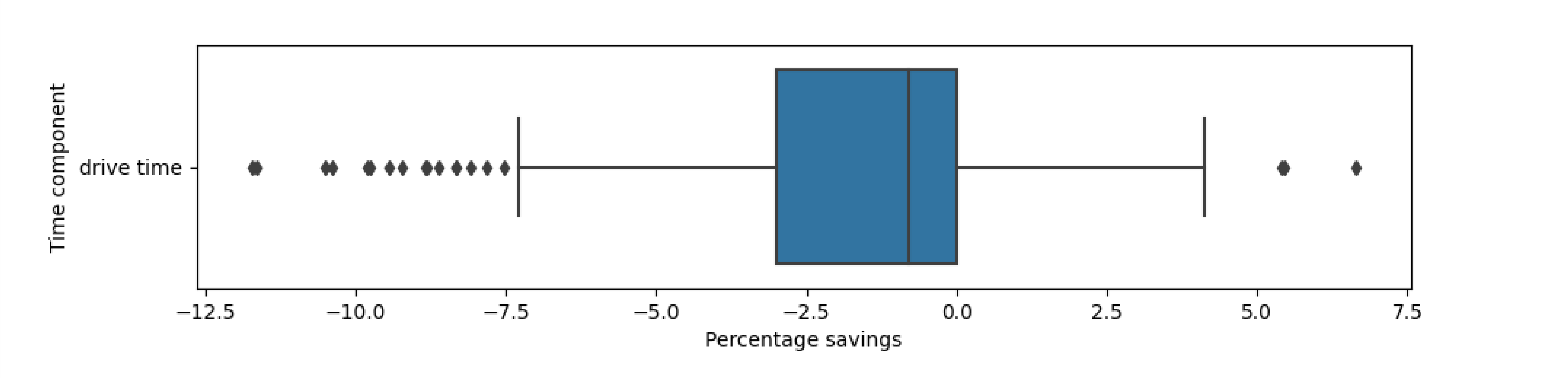
Two options for using data:

What value does information on curb parking availability provide to urban delivery drivers and can it increase the cost efficiency of delivery routes?

Approach

	Real world Data	Synthetic Data
How	Use historic manifests and travel times	Use sampled manifests and estimated travel times
Goal	Case study to quantify including parking within route optimization	Evaluate contribution of environmental characteristics

Real World Study



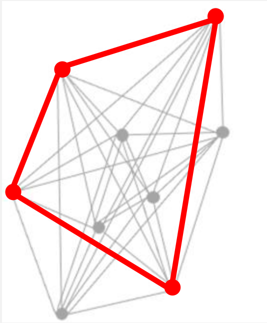
Using cruising information to improve routes

INPUTS:

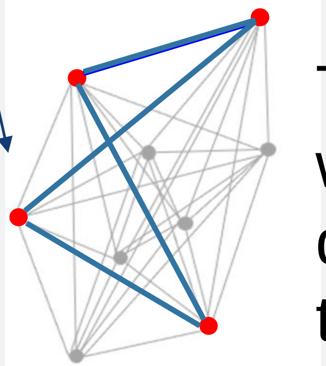
List of orders, TWs, nodes

Time-dependent travel time matrix

Time-dependent travel and cruising time matrix



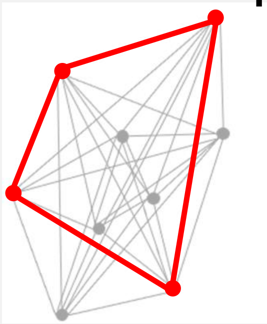
TD-TSP-TW with time-dependent travel times **only**

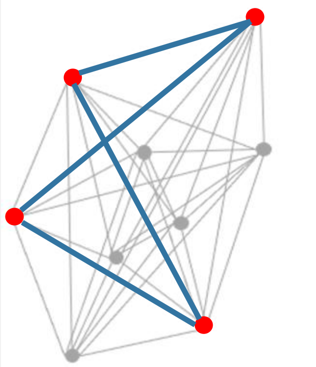


TD-TSP-TW with time-dependent travel **and** cruising times

Simulate "today" by adding estimated cruising delays to existing route plan

Difference in route time shows effect of considering historic parking information

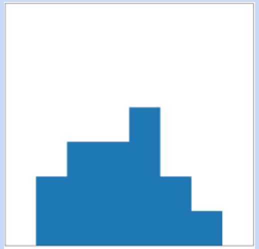
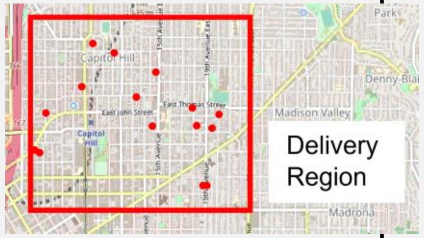
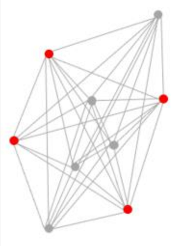
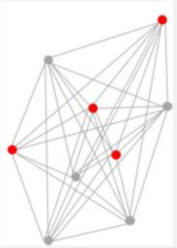




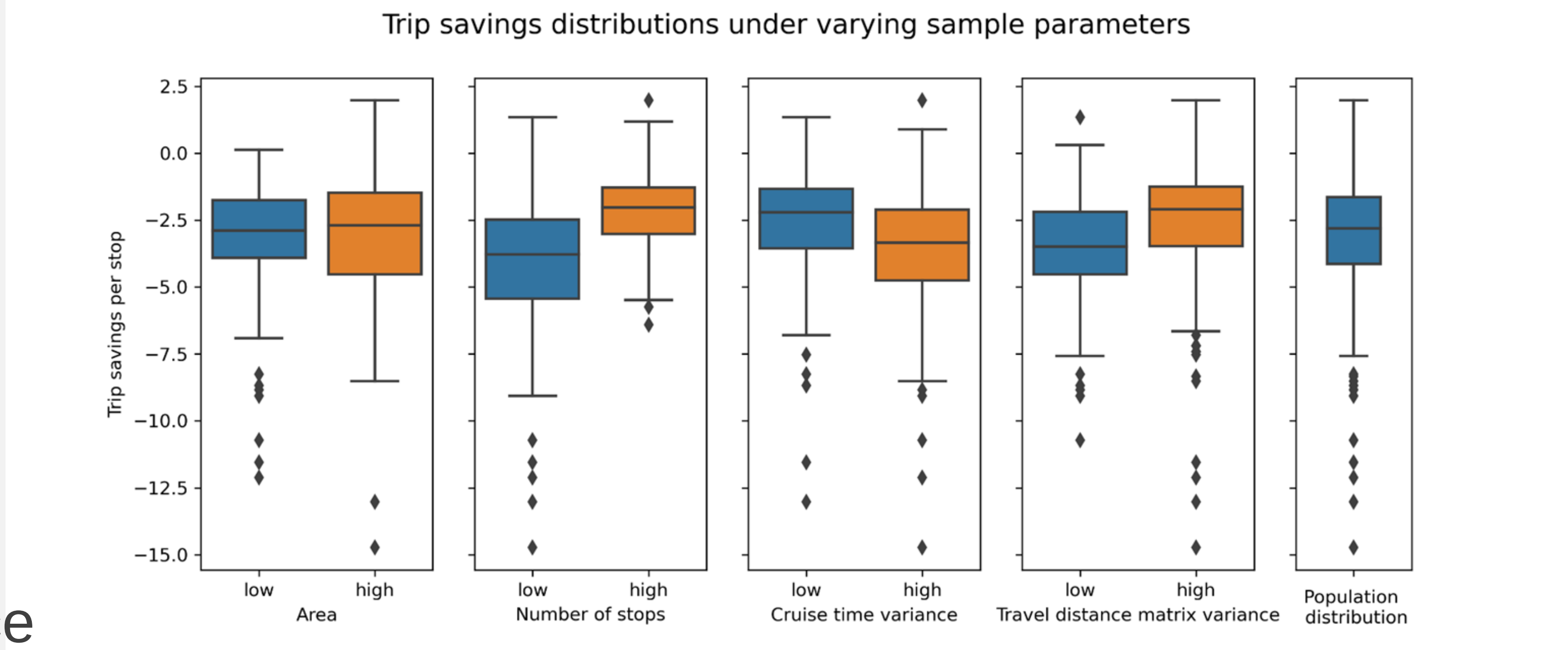
20 min - 15 min

= 5 minutes drivetime savings

Synthetic Study - Parameters of Interest

Variable	Low	High	Variable	Low	High
Size of Area (a)	**1 km²** 	**4 km²** 	Variance of Cruise Time Delays (σ_{cd})	**σ = 0.5** 	**σ = 2** 
Number of Stops (n)	**5 Stops** 	**15 Stops** 	Variance of Travel Time Matrix (σ_{tt})	**$\sigma = 0.35 * \sqrt{a}$** 	**$\sigma = 1.5 * \sqrt{a}$** 

Synthetic Study - ANOVA



Significant variables:

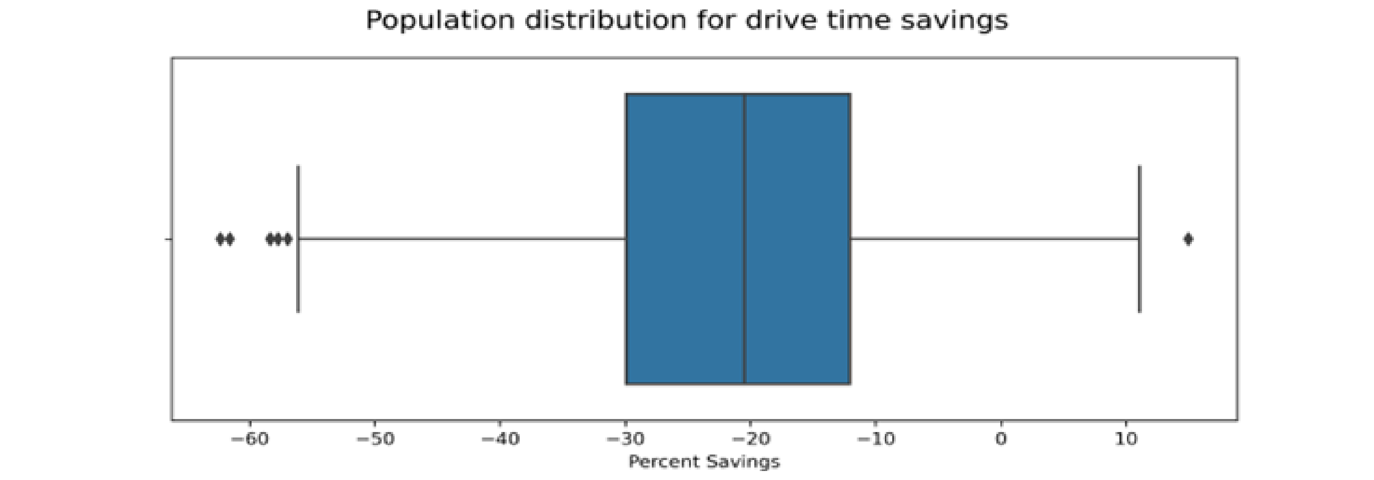
- Number of stops
- Cruising time variance
- Travel distance variance
- Cruise time Variance * Number of Stops

Best configuration: Few Stops, Homogeneous Shape, High Cruising delay variance

Mean saving per stop: -5.18 minutes per stop

Findings

- Variance of cruise time delays, the number of stops, and shape of the route all play a significant role in determining savings
- **Few** Stops, **Homogeneous** Shape, **High** Cruising delay variance have largest mean drive time savings of 39% and an average of -5.18 minutes per stop
- Highly variable: average drive time savings of 21.6% with savings up to 60% for some routes.



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Questions?

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