Modelling the performance of delivery vehicles across urban micro-regions to accelerate the transition to cargo-bike logistics

Green Last Mile

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urbiKe

pedal me

Motivation

- The amount of **CO2 emissions** and **traffic congestion** caused by urban last-mile deliveries is estimated to increase **30% by 2030**[1]
- In urban settings, there is a **zero-emission** solution: **cargo bikes!**
  - A study found that **67% of daily van operations** of a large logistics operator in Paris could be **substituted by cargo-bikes at no extra cost**[2]
  - In the Netherlands, DHL already makes 60% of inner-city deliveries by cargo bikes.

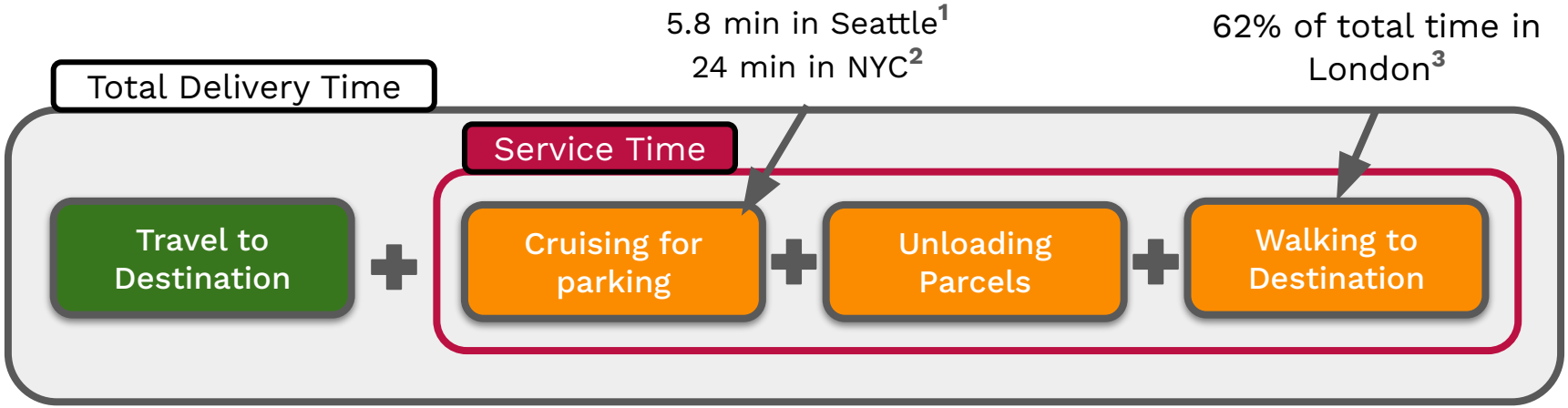
PedalMe cargo-bike in London (project partner)

1. The future of the last-mile ecosystem. In World Econ. Forum, volume 1, pages 1–28, 202
2. First and last miles by cargo bikes: Ecological commitment or economically feasible? the case of a parcel service company in paris. *Transportation Research Record*

Transitioning to Cargo Bikes

We need a Model

- Legacy companies in LML operate on **tight margins / high pressure**
- They need **a model** that captures the complexity of driver (and rider) behaviour **to convince them of the performance of cargo-bikes**



1. Do commercial vehicles cruise for parking? Empirical evidence from seattle. *Transport Policy*, 97:26–36, 2020.
2. Impacts of freight parking policies in urban areas: The case of new york city. 2016
3. Understanding the impact of e-commerce on last-mile light goods vehicle activity in urban areas: The case of london. *Transportation Research Part D: Transport and Environment*, 61:325–338, 2018.

Service Times as a Function of Urban Context

Dividing the City into Micro-Regions

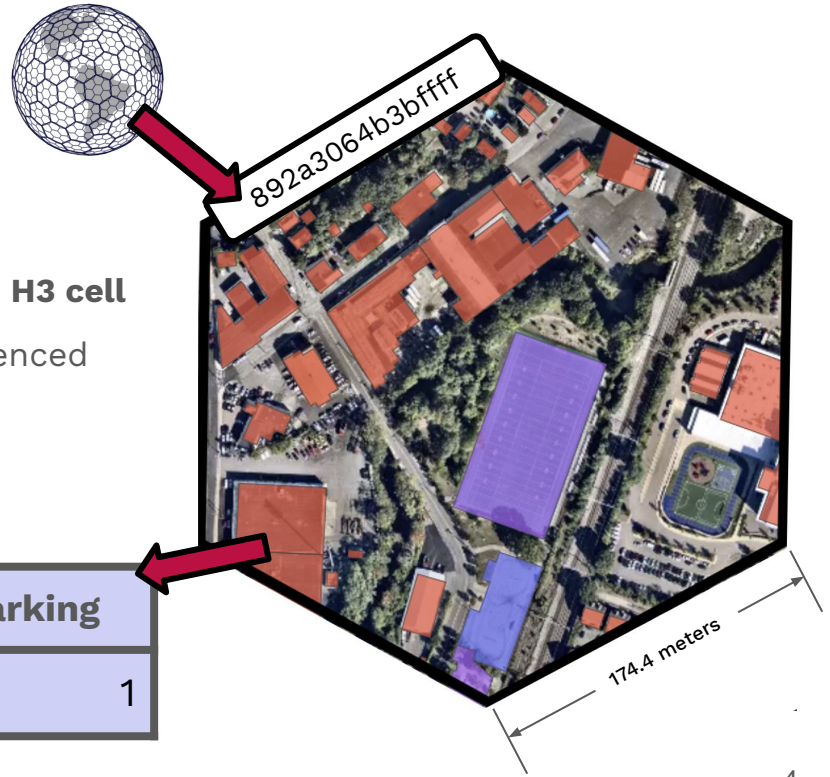
- Using **Uber H3** to tessellate space into hexagons

Using OpenStreetMap tags as descriptors

- More than 1000 *key:value* pairs

We aim to predict the distribution of service times inside an **H3 cell**

- Cell mean times **should be transferable** and less influenced **by package characteristics**
- Intra-cell variance is **high,** meaning it is important to understand not just the mean, but also the variance



building:yes	sport:american_football	amenity:parking
39	1	1

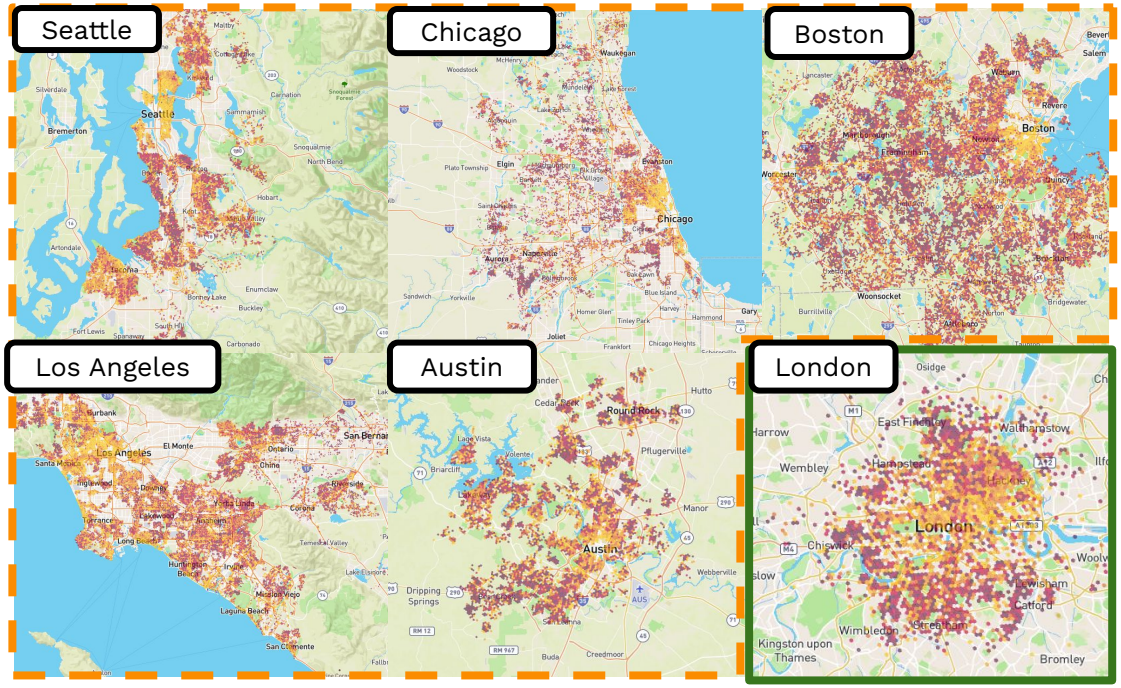
Datasets

Van

- Amazon Delivery Dataset[1]
  - **5 US Cities**
  - 6,112 Driver Routes
    - **56% of time spent is service time**
  - 896,242 Deliveries
    - **1.8 minutes of service time per stop**

Cargo-bike

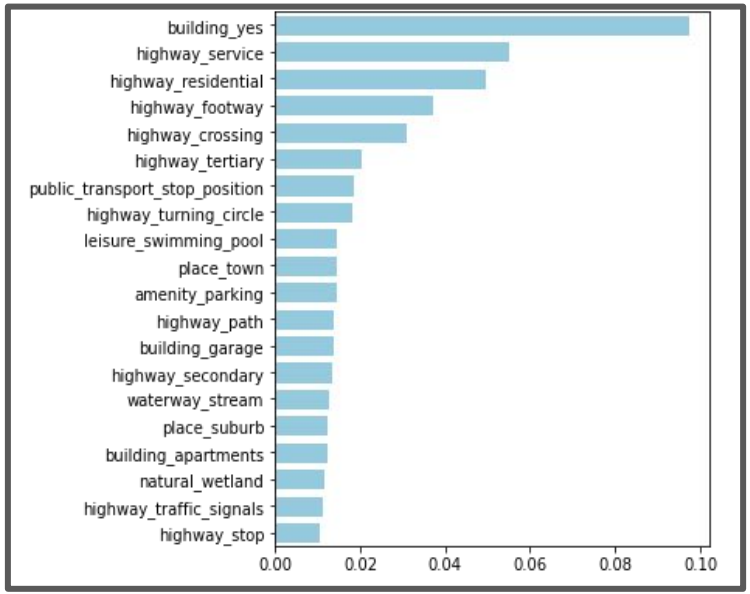
- pedal me (London, UK)
  - 100 Bikes
  - ~30,000 Deliveries
    - **Ongoing Analysis**
- urbiKe (Brussels, BE)
  - **Ongoing Analysis**



1 https://github.com/MIT-CAVE/rc-cli/blob/main/templates/data_structures.md

Preliminary Results

- Using **NGBoost**[1], we perform **variational regression** for service times
  - The containing **H3 cell tag counts are the feature vector for a delivery**
- Testing on Boston (5-FOLD CV), w/ **35, 442 deliveries** in **1197 hexagons** w/ **674 OSM Tags**.
  - mean NLL of 3.51 (SD = 1.23) and
  - **mean R2 value of 0.55 (SD = 0.08).**
- **Most important features** are **coherent with characteristics of urban space**. For e.g.,
  - **presence of parking**, the type and **density of buildings**, or the **type of roads**.



1. https://dl.acm.org/doi/abs/10.5555/3524938.3525190
2. Standard Deviation

Future Roadmap

- Build a ML model that is **generalizable across multiple cities**
  - Should **use the same tag features across multiple cities** & **not incorporate domain knowledge**
- Compare different H3 resolutions between the variability in service and navigation time predictions for cargo bikes vs vans
  - We hypothesize that cargo bikes have less variability between urban regions than vans!
- We plan on **releasing datasets with the OSM tag features added**, to prompt future modelling efforts.