Taxi Trajectory Analysis

EDAA - G04

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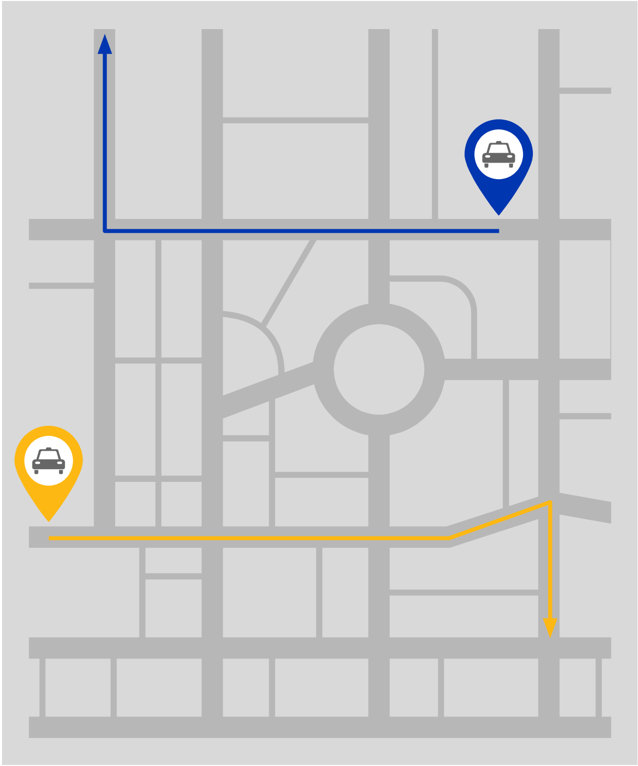
Goals

The goal of this project is to analyze **taxi trajectories**. Taking into account the **size** of the data we will be dealing with, we have to implement **efficient algorithms**.

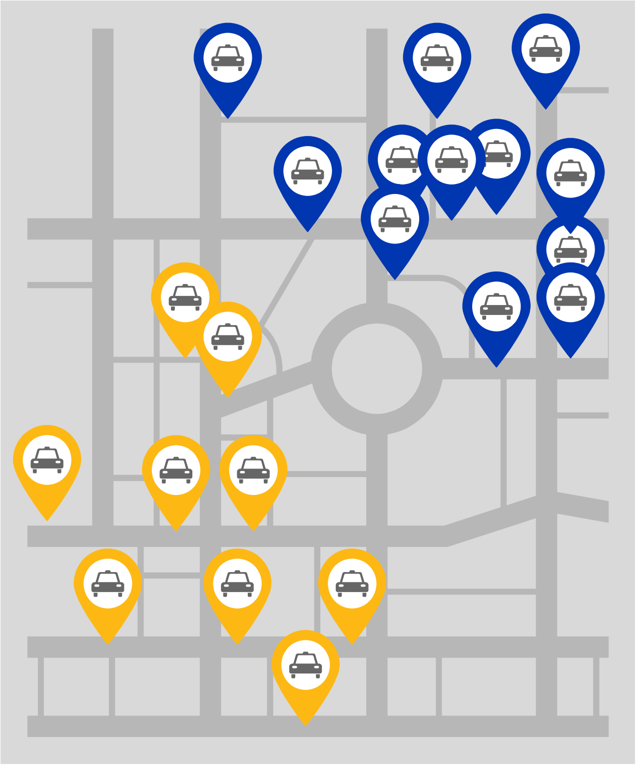


Problem definition

Clustering of the **processed data points** in the first part of the project.

Traffic assignment

Analysis of the network (taxi logs): coverage and other metrics.



Traffic assignment

Traffic assignment is the **selection of routes** between origins and destinations in a transport network.

People don't always take the shortest path in distance or time: there are **other cars** that cause **traffic issues**

Traffic assignment

Input:

- List of trips, each described by (origin, destination) pair, in a given timespan

Output:

- For each trip, the path that was followed

Objective function:

- Some function that describes people's behaviors

Traffic assignment

Typical objective:

- People use a path if it gives them an optimal balance between:
  - **Distance** – because fuel is a cost
  - **Time** – Takes into account time in congested network

Traffic assignment

Procedure:

1. Allocate each route to its shortest path (a.k.a. *all or nothing*)
2. Reassign routes until some criteria is met

What is congestion?

Congestion $S_a(v_a)$ is the travel time across edge *a*, assuming the volume of traffic traversing that edge is v_a. The most popular congestion formula is from the Bureau of Public Roads:

$$S_a(v_a) = t_a(1 + \alpha\,(v_a/c_a)^{\beta})$$

t_a is the free-flow time, c_a the capacity, and α and β are empirical constants, usually set to α=0.15 and β=4

Traffic assignment

Stopping criteria:

- **Wardrop equilibrium:** a person chooses a given path if **no other path is shorter** than that path **taking congestion into account**. This criteria is user-optimal [Boyles et al. 2021] because no unilateral path change leads to a reduction in travel time [Correa & Stier-Moses 2011], therefore being a stable equilibrium (a bit like stable marriages).
    - Assumes people **do not communicate** with each other, or otherwise that **everyone thinks their contribution is so small** that they can do as they want
        - Similar to how people litter because they are just a "small drop", although many small drops make an ocean

Traffic assignment

Stopping criteria:

- **System-optimal:** the user-optimal strategy is stable and optimal if people are greedy, but it is not globally optimal.
    - We won’t go into detail about system-optimal, but involves communication and agreements between people, so that some people may not take the most advantageous path for them, but there is some global goal being optimized (e.g., reducing CO_2 emissions, or reducing average travel time)

Traffic assignment

How to solve the problem?

This is an optimization problem → Use optimization algorithms

Nonlinear programming (because objective function is not linear)

Traffic assignment

Methods

- **Convex optimization:** Frank-Wolfe algorithm, aka conditional gradient method, used to solve constrained convex optimization. This algorithm can be adapted to work for transport networks
- **Metaheuristics** (non-convex methods), with the usual well-known methods: simulated annealing, genetic algorithms, …

Q&A