ON THE DESIGN OF PUBLIC TRANSPORT FOR EQUALITY OF ACCESSIBILITY

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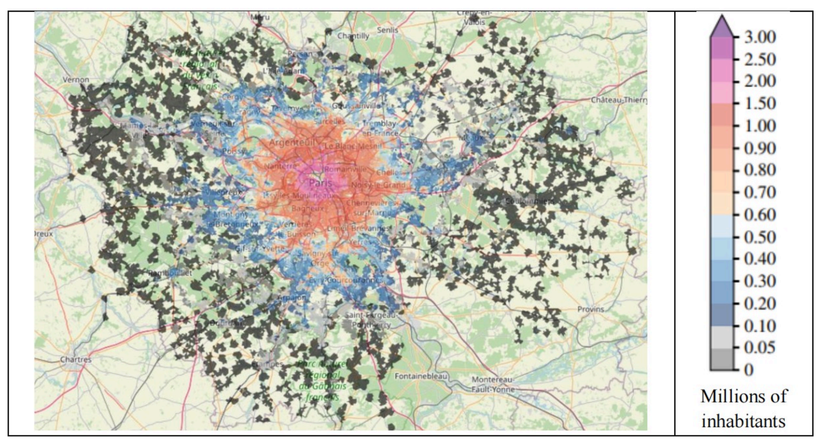
INTRODUCTION

MOTIVATION

1. Accessibility: ease of reaching surrounding opportunities.
2. Inequality: suburbs suffer from poor accessibility from public transit.



3. Consequence: car-dependency → pollution
4. Need for designing more equitable public transit

OBJECTIVE

Improve equality while preserving PT efficiency by serving or skipping PT stops

STATE OF THE ART

Our work is on what-to methods. But most what-to methods optimize efficiency, e.g., minimize cost, e.g., Farahani et al. (2013) and Calabrò et al. (2023), without considering accessibility and equality. We propose and compare two random search algorithms: efficiency- and equality-based. Our numerical results show that it is possible to reduce inequality of accessibility, with no excessive loss in efficiency.

METHODOLOGY

PUBLIC TRANSPORT (PT) AND ACCESSIBILITY

1. G: PT network
2. V: set of centroids
3. S: set of bus stops
4. The accessibility of centroid $v \in V$,

$$acc(v) = \sum_{u \in V} \frac{X(u)}{T(v,u)}$$

$T(v,u)$: shortest time to go from v to u,
$X(u)$: amount of the opportunities of the u.

5. $V^{\%}$: sset of centroids with the worst accessibility. The accessibility of graph G as:

$$Acc(G;m) = \frac{1}{|V^{\%}|} \sum_{v \in V^{\%}} acc(v)$$

6. The Atkison inequality index is

$$Atk(G) = 1 - \frac{1}{\overline{acc(G)}} \cdot \left(\frac{1}{K} \sum_{i=1}^{k} y_i^{-1} \right)^{-1}$$

RANDOM SEARCH OPTIMIZATION ALGORITHM

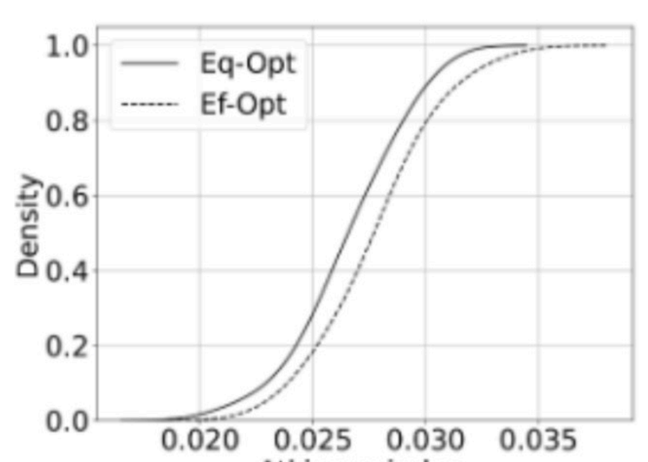
1. Ef-Opt: maximize the average accessibility (utilitarian principle)
2. Eq-Opt: maximize the accessibility of the worst centroids (egalitarian principle)

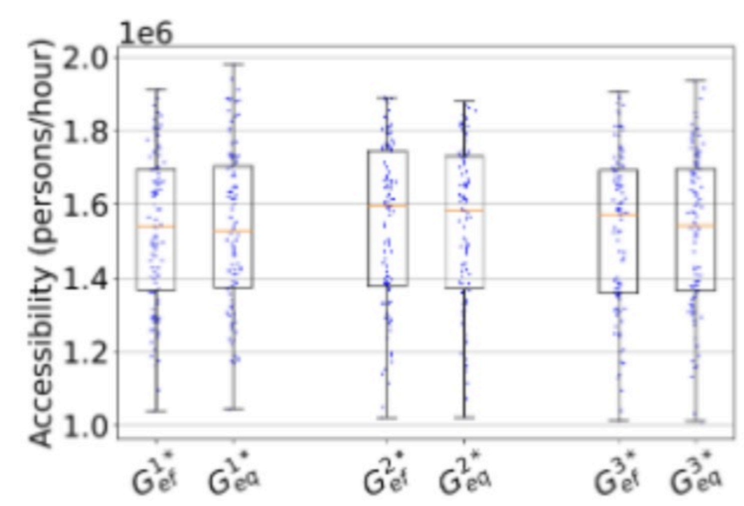
Algorithm 1: Random search optimization algorithm

Input Public transport graph $\mathcal{G}$ with stops $\mathcal{S}$.
    Parameter m of the accessibility formula (2).
For search instance $i \leftarrow 1$ to n :
    Initialize $\mathcal{G}_0 \leftarrow \mathcal{G}$ and $\mathcal{S}_0 \leftarrow \mathcal{S}$.
    For step $t \leftarrow 0$ to ∞ until **termination condition**:
        Select a random stop $s_t \in \mathcal{S}_t$ and deactivate it.
        Set $\mathcal{S}_{t+1} \leftarrow \mathcal{S}_t \setminus \{s_t\}$ and let $\mathcal{G}_{t+1}$ the resulting PT graph.
        Compute the new accessibility: $Acc(\mathcal{G}_{t+1};m)$
    EndFor
    Record $\mathcal{G}^i = \arg\min_{\tau=0}^{t+1} Acc(\mathcal{G}_\tau, m)$.
EndFor
Return PT graph $\mathcal{G}^* = \arg\min_{i=1}^{n} \mathcal{G}^i$.

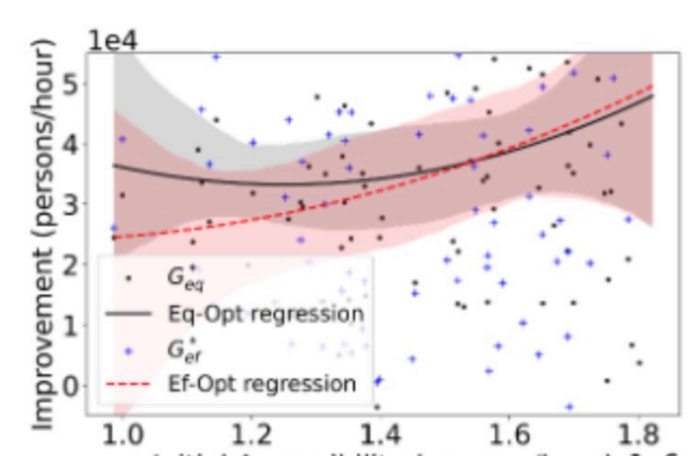
RESULTS

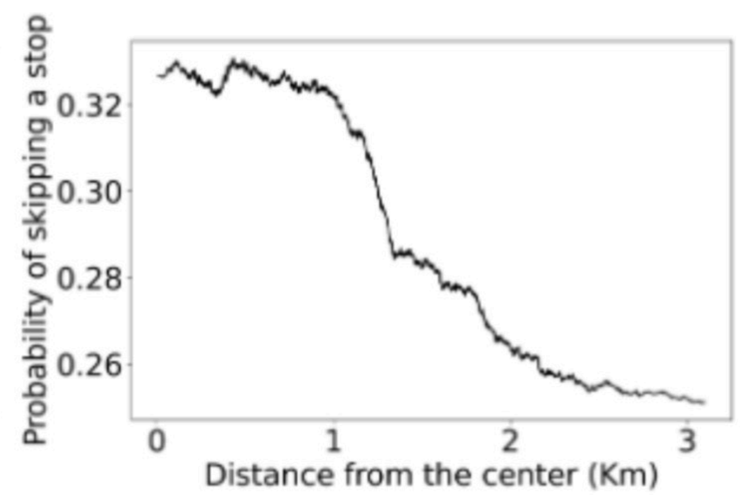
1. By optimizing the accessibility of the underserved location, inequality can be reduced, with no excessive loss in efficiency.





2. Lesson learned: Stops in the center and connected to few PT lines should be preferentially skipped, so as to increase the line frequencies.





FUTURE WORK

- Apply optimization to real PT network data (GTFS)
- Consider the deployment of shared mobility

References

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Samovar PhD day

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