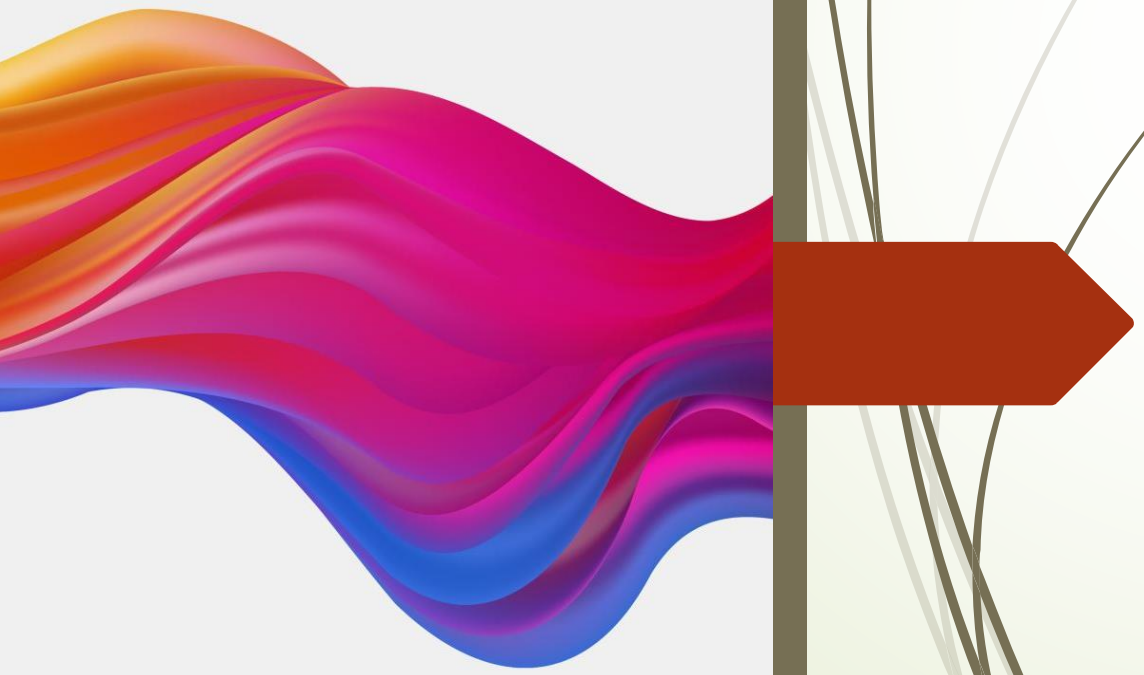

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Data-Driven allocation and optimization of EV charging stations for the reduction of Range Anxiety

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Agenda

- Introduction
- State of the Art
- Thesis focus
- Challenges
- Questions and Discussions

But first…

- Does anyone own an electric vehicle?
- Would you travel to a different country with your partner and kids in an EV right now?
- If not, why not?

- Quick stats, VW has delivered 170 000 EVs in 2022 and plans to deliver up to 3 million by 2025
- About 1000 000 new EVs registered in Europe in 2021 (statista.com)
- About 375,900 public EV charging stations in Europe (statista.com)
- February 2023: The European Parliament voted to approve a new law banning the sale of petrol and diesel cars from 2035
- A German EU parliamentarian, in an interview stated that they would not travel from Germany to Italy in an EV with his family. Reason? Range Anxiety
- So, what is Range Anxiety?

- Def: The fear/worry on the part of a person driving an electric car that the battery will run out of power before the destination, or a suitable charging point is reached.

- How can range anxiety be reduced?

1. Making cars with large batteries capacities
2. Supplying sufficient charging infrastructure for the EVs

- For this thesis, the focus is placed on (2)

- Why is this range anxiety important and how is it presented in the existing literature?

1. Range anxiety can be used to determine the locations of EV charging stations.

2. Particularly important for encouraging users to switch from cars that use fossil fuels to EVs

How is the Range Anxiety presented in the literature

As a fixed value

E.g. 75 % (0.7)

- Advantage – Easy to use
- Disadvantage - Perhaps not a representation of medium to long-distance EV drivers (based on a field trial that was done 10 years ago in a Berlin metropolitan area)
- They assume that all drivers have the same/similar range anxiety, and this might not be the case, particularly for medium to long-distance drivers

As scenarios

E.g.

1. Scenario : 90% (6 days)
2. Scenario : 75% (5 days)
3. Scenario : 60% (4 days)
4. Scenario : 45% (3 days)
5. Scenario : 30% (2 days)

- Advantage – Relatively easy to use

- Disadvantage - - Perhaps not a representation of medium to long-distance EV drivers (Not widely used and based on metropolitan areas)

- As complex functions
- E.g. $\bar{R}(r) = \begin{cases} 0, if\ E_{comf} \leq r \leq E \\ \frac{R_{max}}{3a\,E_{comf}^2}\left(E_{comf} - r\right)3\,, if\ 0 \leq r \leq E_{comf} \end{cases}$

- Where.: $\bar{R}(r)$ is the accumulated range anxiety, E_{comf} is a pre-specified threshold, E is the milage of the EV, Rmax is the maximum range anxiety

- Advantage – studies that presented the range anxiety as complex functions particularly focused on the analytical relationship specification between the driver's range anxiety and EV charging stations deployment

- Disadvantage - Difficult to evaluate if the range anxiety value obtained from this complex function is actually "correct". The range anxiety values obtained from the functions are corrected to a certain degree/tolerance value

Allocation and optimization of EV Charging stations techniques in the SOA

Data-driven techniques

- Techniques that are based on data analysis and interpretation.
- Techniques organize and examine data with the goal of allocating and/or optimizing EV charging stations' locations (taking into consideration the range anxiety).
- E.g. clustering charging stations based on a certain distance

Advantage:

- Efficient with the use of large data

Disadvantage

- Do not necessarily find the best optimal solution

Optimization-based techniques

- Optimization techniques are used to find an optimal solution or to minimize or maximize study parameters.

- E.g. Minimizing the accumulated range anxiety or finding the most optimal route to a charging station

Advantage

- Finding the most optimal value

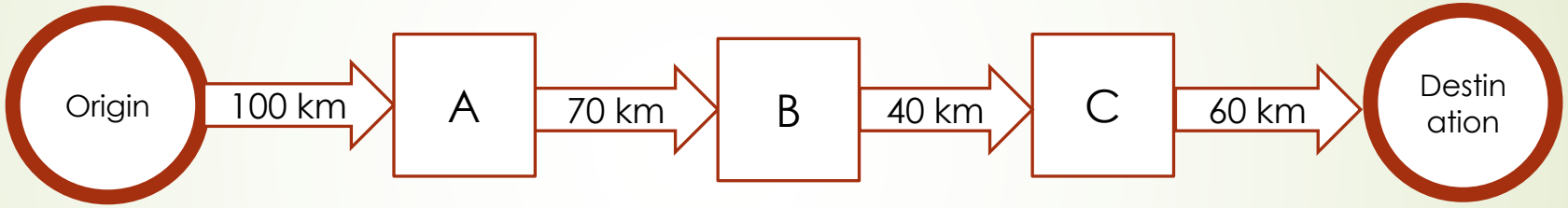
Disadvantage

- Not very efficient with large amounts of data

Thesis focus

- A two-part Data-driven allocation and optimization of EV charging stations for medium and long-distance drivers, for the reduction of range anxiety considering the cost of supplying the EV charging stations.
- First part – Inferring the range anxiety value from the data
- Second part – applying optimization-based techniques to reduce the range anxiety considering the costs of supplying the EV charging stations.

How to infer the Range Anxiety from data?



Info:
Vehicle range = 250 KM
Distance between O-D = 270 KM

Challenge

- Getting the gold (data)

1. Searching for public datasets
2. Writing to authors of papers that used this type of data (very few papers)
3. Writing to companies to try and get the data
4. Synthesize the data (perhaps from GPS data of conventional vehicles)

Questions and Discussions

Thank You