Evaluating different strategies to solve rebalancing operations in car sharing systems: A generic optimization framework

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Outline

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   - Motivation
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3. Methodology
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   - Preliminary experiments

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37.5% of the U.S. greenhouse gas emissions is due to transportation (EPA, 2021). Passenger cars contribute the most with 40.5%.

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**Car sharing systems**
- Short rentals
- Higher car and less parking utilization
- Examples: Mobility, car2go, SHARENOW

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Introduction

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  - Passenger cars contribute the most with 40.5%.

- Car sharing systems
  - Short rentals
  - Higher car and less parking utilization
  - Examples: Mobility, car2go, SHARENOW

- Introducing a car sharing system results in between 3% and 18% reduction in CO2 emissions (Amatuni et al., 2020\(^2\)).

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- Is shared mobility as sustainable as we think?
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- The added-value of bike rebalancing in bike sharing systems?
  - Shu et al. (2013)\(^4\) find that the number of substituted trips change as a function of number of bicycles and number of redistributions per day.
  - Periodic and frequent rebalancing operations are not necessary for some configurations of the system.

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Motivation

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- The added-value of rebalancing operations in car sharing systems
  - The effect of city characteristics
  - The effect of trip demand behavior
  - The effect of different rebalancing operations strategies
  - ...
Previously in the literature...

- Martinez et al. (2017)$^5$
  - Agent-based model and supply side, i.e., operations by the staff such as maintenance, rebalancing, and refueling

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- Vasconcelos et al. (2017)$^6$
  - The same agent-based model as in Martinez et al. (2017)
  - Comparison between with and without rebalancing
  - Evaluating three different policies that investigates the effect of electric vehicle adoption

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- Considers both supply and demand side of car sharing.
- Uses a transport simulation toolkit, i.e., MATSim, and its car sharing API.
- Incorporates rebalancing operations optimization.
The framework

Figure: The framework
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Diagram:

- Initial vehicle and free parking configuration
- Stations
- Plans
- Rebalancing operations strategy
- Transport simulation
- Trips
- Events
- Final vehicle and free parking configuration

Figure: The framework
Illustrative case study

- Sioux Falls, US scenario
  - 84110 agents
  - 24 stations (5 vehicles and 5 free parking spots per station)
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- Every agent has a membership.
- Parameters are set to default.
Scenarios

- "do nothing" scenario
  - The final configuration of the vehicles for one iteration is fed back to MATSim as an initial configuration for the next iteration.
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- "rebalance" scenario
  - The minimum required number of vehicles per station is computed and the free parking is determined where each station has 10 total parking spots.
Results

Figure: Score statistics (rebalance)

Figure: Mode statistics (rebalance)
Comparison of two strategies

Figure: Number of rentals for both strategies
Conclusions and future work

- A generic framework to evaluate different rebalancing operations strategies is presented.
- Preliminary experiments on Sioux Falls scenario using MATSim carsharing API show promising results.
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The next steps include
- selecting a choice model and rebalancing operations strategies from the literature and
- analyzing the effect of rebalancing operations that consider different strategies.
- applying to a bigger case study, such as Zurich, Switzerland.
Questions and discussion

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