TUM TSE research on Shared Autonomous Vehicles

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The Future of Shared Mobility and Public Transport
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Contents

• Review on Shared Autonomous Vehicles (SAV)

• Modelling reservation based SAV services

• Optimization model for SAV chain formation
Review on Shared Autonomous Vehicles (SAV)
About the review

• SCOPUS database query using 13 keywords

• Top 3 keywords: shared autonomous, autonomous taxi, autonomous mobility on demand

• Screening based on relevance and additional papers from the references of the screened papers

• Type of documents: journal papers, conference papers and technical reports

• Number of documents: ~160 (Collection completion: Jan, 2019)
Basic definitions

- **Shared mobility** - shared use of a vehicle for performing a trip. E.g., Car–sharing, ride-sharing, bike–sharing & scooter–sharing

- **Automated vehicles** - vehicles with some level of automation to assist or replace human control

- **Autonomous/self-driving vehicles** - Level 5 automation

- **Shared Autonomous Vehicle (SAV) services** - diffusion of growing shared mobility services and emerging autonomous vehicle technology
SAV typology

Zhang et al. (2015); Cyganski et al. (2018); Lekhandwala & Cai (2018)

Alazzawi et al. (2018); Alonso-Mora et al. (2017); Gurumurthy & Kockelman (2018); Heilig et al. (2017); Jäger et al. (2018); Liu et al. (2018); Martinez & Viegas (2017); Massoud & Jayakrishnan (2017); Sherif et al. (2017)

Alam & Habb (2018); Allahviranloo & Chow (2019); Bischoff & Maciejewski (2016); Chen et al. (2016); Childress et al. (2015); Dias & Javanshour (2017); Fagnant & Kockelman (2014, 2018); Fournier et al. (2017); Hadian et al. (2017); Jager et al. (2017); Moreno et al. (2018); Zhao & Kockelman (2018)

Kim et al. (2017); Miller & How (2017); Pimenta et al. (2017)

Moorthy et al. (2017); Salazar et al. (2018); Shen et al. (2018)

Allahviranloo & Chow (2019); Baur et al. (2018); Bischoff & Maciejewski (2016); Bischoff et al. (2017); Böscher et al. (2016); Böscher et al. (2018a); Browne & Kornhauser (2014); Chen et al. (2016); Childress et al. (2015); Dias & Javanshour (2017); Fagnant & Kockelman (2014, 2018); Gelauff et al. (2017); Hörl (2017); Jager et al. (2017); Kondor et al. (2018); Liu et al. (2017); Loeb et al. (2018); Lekhandwala & Cai (2018); Ma et al. (2017); Martinez & Viegas (2017); Massoud & Jayakrishnan (2017); Mendes et al. (2017); Moreno et al. (2018); Zhang et al. (2015); Zhang & Gahathakura (2018); Zhao & Kockelman (2018)

Components of SAV modelling

Tools Used

Objectives incorporated in SAV modelling

Minimise travel cost
Minimise waiting time
Minimise travel time
Maximise comfort
Minimise emissions
Minimize congestion
Maximise spatial coverage
Maximise social welfare (equity)
Maximise traffic safety

Maximise revenue
Maximise requests served
Minimise fleet size
Minimise service operational cost
Minimise maintenance cost
Minimise fuel/charging cost
Minimise parking cost

Categories of Impacts of SAV services


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Impacts of SAV services ctd.

Most studies predict **moderate increase of VKT**, independent of the vehicle replacement rate


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Expected penetration of SAV services


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Policy requirements

• **Laissez-faire governance** approach: less sustainable outcomes

• Need for **regulation** and interventionist approach

• **Dynamic adaptive policy** framework (set up basic policies, monitor the system and prepare trigger Responses)

• Reinforce public transport system and support walking & cycling

• Requirement of close cooperation between operational control centre, traffic control centre and the transport network operator
Modelling reservation based SAV services

SAV network assignment modelling

• Formulation as Nash-Cournot game between two players

• Players: Road users and SAV operator
SAV chains

Model flow chart

Iterative optimization and assignment (IOA) method


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Model features

• Private and shared-autonomous vehicles

• Car sharing & ride sharing (trips with same OD pair)

• Scenario analysis (different penetration rates and vehicle occupancies)

• Usable for different networks with little effort (input files & parameters)
Test network

Planning data
Time horizon in hour: (0, 5)
Demand per OD: 100
SAV penetration rate: 100% CS
Number of SAV vehicles: 200
Expected arrival times in hour: (1, 4)

Network data
Link capacity: 1800veh/hr
Link length: 8km
Link free flow travel time: 12min
Depot node: 1

DUE model time step: 2min

Output
Number of vehicles used: 100 (2 trips/veh)
Departure time in min:
OD1 - 38 to 60
OD2 - 218 to 240
Arrival time in min:
OD1 - 50 to 72
OD2 - 230 to 252
Elapsed time: 1 min

CS – car sharing
Test network – relative outflow
Optimization model for SAV chain formation (Vehicle assignment)

Optimization model

- Metaheuristics: tabu search (random assignment, request switching, tabu list)
  Based on the methodology of Cordeau and Laporte (2007)
- Clustering method: K-means & K-medoids
- Numerical test 1: SiouxFalls (100 requests, 40 vehicles & 4 clusters)
Optimization model for SAV chain formation

- Numerical test 2: NY taxi dataset (3986 requests, 800 vehicles & 100 clusters)
Optimization model for SAV chain formation

- Numerical test 2: NY taxi dataset (3986 requests, 800 vehicles & 100 clusters)
Thank you for your attention!

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