Autonomous Vehicles

Seminar on Digitalisation and the Rebound Effect

Danil Ivanov
28.11.2019
Current Road Usage

• One billion vehicles
• Unchanged vehicle design
• Powered by combustion engine
• Driven by one person
• Designed for a broad use
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Some Numbers

• 95% rely on fossil fuels
• 20% global GHG emissions
• 20km/h average speed
• 1.24 million annual road deaths
• 103 million years of life lost to air pollution

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Polluting
Inefficient
Dangerous toward users
Dangerous toward bystanders
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Outline

State of the Art

Remaining Work

Rebound Effects

Conclusion
State of the Art

Remaining Work

Rebound Effects

Conclusion
Autonomous Vehicles

Definition¹: An autonomous vehicle (AV) is a vehicle that is capable of sensing its environment and safely moving through it with no human input.

¹Definition based on my understanding of the domain
Levels of Autonomy

2

- Level 0: No Assistance
- Level 1: Hands On
- Level 2: Hands Off
- Level 3: Eyes Off
- Level 4: Mind Off
- Level 5: Steering Wheel Optional

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\[2\text{Automated Driving – Levels of Driving Automation defined in New SAE International Standard J3016. SAE International. 2014.}\]
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Example of Level 2 Automation

Figure 1: Tesla Autopilot
Example of Level 4 Automation

Figure 2: Autonomous mini bus in Zug
Available Technology (1)³

- **Connected Vehicles**
  - GPS + IoT
  - OnStar, Android Auto, CarPlay

- **Coordinated Vehicles**
  - IoT communication
  - Routing apps (Waze, Google Maps)
  - Parking apps (ParkingPay, EasyPark, Parknow)

- **Driverless Vehicles**
  - Waymo
  - Mobility

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\(^3\)Lawrence D. Burns. A vision of our transport future, Nature 497, pp. 181-182, 2013
Available Technology (2)

- Electric Vehicles
  - Increased control over drive system
  - Reduced emissions
  - Popular (Tesla, Jaguar, VW, etc...)
- Tailored Vehicles
  - Current vehicles are over-specified and under-utilized
  - More efficient due to being lighter
  - Longer distances on smaller batteries
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Legal Landscape

• Driver must remain in control of the vehicle at all times
• International Convention on road traffic amendment in 2006 to include automated driver assistance systems
• Presence of driver is mandatory
• Driver not exempted of their obligations and responsibilities

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- Functional requirements of automated/autonomous vehicles

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Regulations and Guidelines

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- Functional requirements of automated/autonomous vehicles
- New assessment and test method

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- New assessment and test method
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- Data storage system and event data recorder

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Case Study: Mobility Preferences in the Future

• Study on mobility preference shift upon introduction of autonomous vehicles
• Based on travel mode choice theory
• Took form of an online survey combined with paired comparison

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Figure 3: Preference migration results
Case Study: Mobility Preferences in the Future - Conclusion

- No intrinsical eco-friendly motivation
- Public Transport must improve in order to remain competitive against carsharing
Case Study: Mobility Preferences in the Future - Conclusion

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Case Study: Simulation of City-Wide Autonomous Vehicle Network Deployment\textsuperscript{7}

\textsuperscript{7}Joschka Bischoff and Michal Maciewski. Simulation of City-wide Replacement of Private Cars with Autonomous Taxis in Berlin, Procedia Computer Science, 83, pp. 237–244, 2016
Case Study: Simulation of City-Wide Autonomous Vehicle Network Deployment

• Simulation of autonomous vehicle fleet that replaces all classic vehicles in Berlin

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Case Study: Simulation of City-Wide Autonomous Vehicle Network Deployment

- Simulation of autonomous vehicle fleet that replaces all classic vehicles in Berlin
- Goal: find optimal fleet size to provide high quality service

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Case Study: Simulation of City-Wide Autonomous Vehicle Network Deployment - Results 100'000 AVs

Figure 4: Passenger wait times for each hour
Case Study: Simulation of City-Wide Autonomous Vehicle Network Deployment - Results 100’000 AVs

Figure 5: Average operation mode split for each hour
Case Study: Simulation of City-Wide Autonomous Vehicle Network Deployment - Conclusion

- High quality service achievable using 100,000 vehicles - 1:10 ratio to classic vehicles
- Fleet size determined by peak hours
- Drive time increases by 17% due to empty runs
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- Efficiency gains will compensate the increase in total distance travelled

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Positive vs. Rebound Effect

- Efficient driving and routing
- Higher occupancy per vehicle
- Sharing of costs and maintenance (cost reduction)
- Optimized vehicles
- Land use & Safety
- Travel by underserved population
- Faster travel
- More Travel
- Shift in travel mode preference
- Job market
- Public transport popularity decrease

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• Building blocks are available for AV networks
• Policy-makers and governments introducing frameworks for the development of AV networks
• Ecological, societal and economical impacts
• Total impact depends on adoption rate
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Thanks for listening! Do you have any questions?
Case Study: Estimating Potential Increase in Travel with Autonomous Vehicles\textsuperscript{10}

- Studies potential increase in total vehicle distance travelled
- Increase due to senior citizens, non-drivers, and users with prohibiting medical conditions.
- Estimated 14\% increase in total distance driven, due to increase in mobility of non-driving demographic