

A Survey on Autonomous Vehicles Interactions with Human and other Vehicles

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Autonomous Vehicles

- **Commercial cars are categorized into 5 levels :**
 - **Level 1: Entirely manual;**
 - **Level 2: Only single operations such as anti-lock braking, brake assist, and electronic stability are automated;**
 - **Level 3: Combined function automation, two or more functions are automated;**
 - **Level 4: Those which do not require attention of the driver at any time because they use automation to control all aspects of the driving task for extended periods;**
 - **Level 5: Completely driverless and completely automatic.**
- **AVs are X-ware systems: consist of software, hardware, humans, and their interactions.**



Motivation

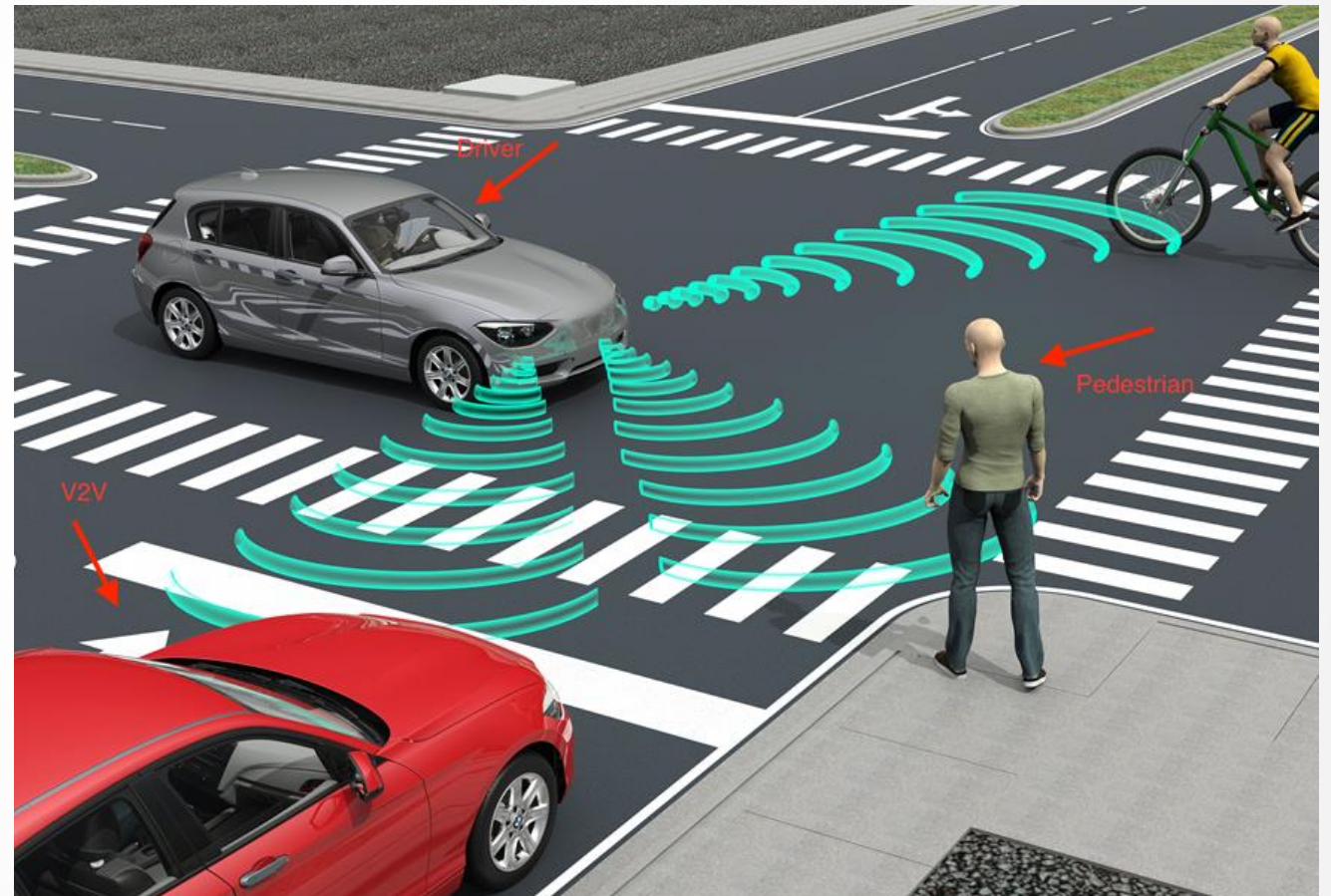
- **Autonomous vehicles (AVs) or self-driving cars have potential to replace human-operated cars.**
- **This may quickly lead to people's overreliance on AVs and overconfidence that no failures will occur.**
- **AVs can impact society positively and negatively**



Survey on Human Interaction

Motivation

- One major challenge for AVs: communication with:
 - Driver and passenger of the AV
 - Pedestrians
 - Other users of the transportation network





Interaction Between AVs and Pedestrians

AVs & Pedestrian

- AVs are more cautious around pedestrians
- AVs are programmed to respect the right-of-way of pedestrians:
 - Yielding at crosswalks can be analyzed by using game theory, conditional on AVs “playing nice.”
- Google’s autonomous vehicles collision reports indicate that in most accidents the vehicles are hit from behind because Google’s cars stop to give the right-of-way to the pedestrians



Potential Positive Impacts:

- **Benefits**
 - **Pedestrian activity: walking could be safer and more attractive**
 - **Parking: on-street parking is anticipated to disappear, parking can be moved to the suburbs.**
 - **No driving under influence of alcohol**
 - **Less air pollution: electrical cars**

Potential Negative Impacts

- **Potential abuse of AVs by pedestrians who could make them stop at every location, which would increase congestion**
- **Learning new rules by pedestrians**
- **If AVs are more convenient, their use for short trips may be preferred instead of walking, which will increase congestion**
- **Driver's license may no longer be needed and even children could have their own private car. So, the number of autonomous cars may increase rapidly**



Acceptance

- **Acceptance:**
 - **Pedestrian might consider AVs are less risky compared to human-operated cars.**
 - **Gender, age, and risk-taking plays an important role in AV acceptance**

Potential Concerns

- Ability of AVs to distinguish between different types of objects might threaten the life of pedestrians and lead to incidents with serious consequences.
- It might be required to rebuild the physical design of an urban area, which may increase the complexity of street design and create subsequent problems.
 - required to learn new traffic signs and rules that takes time and might impact transportation safety.





AVs and other users of the transportation network

AVs & other users of the transportation network

Overview and Analysis

- It is critical that AVs are able to communicate not only with the other AVs but also with the human-driving cars.
- Compatibility between AVs from different manufacturer
- Reliability of the information being transferred
 - information received by AVs, can be lost or inaccurate or misunderstood

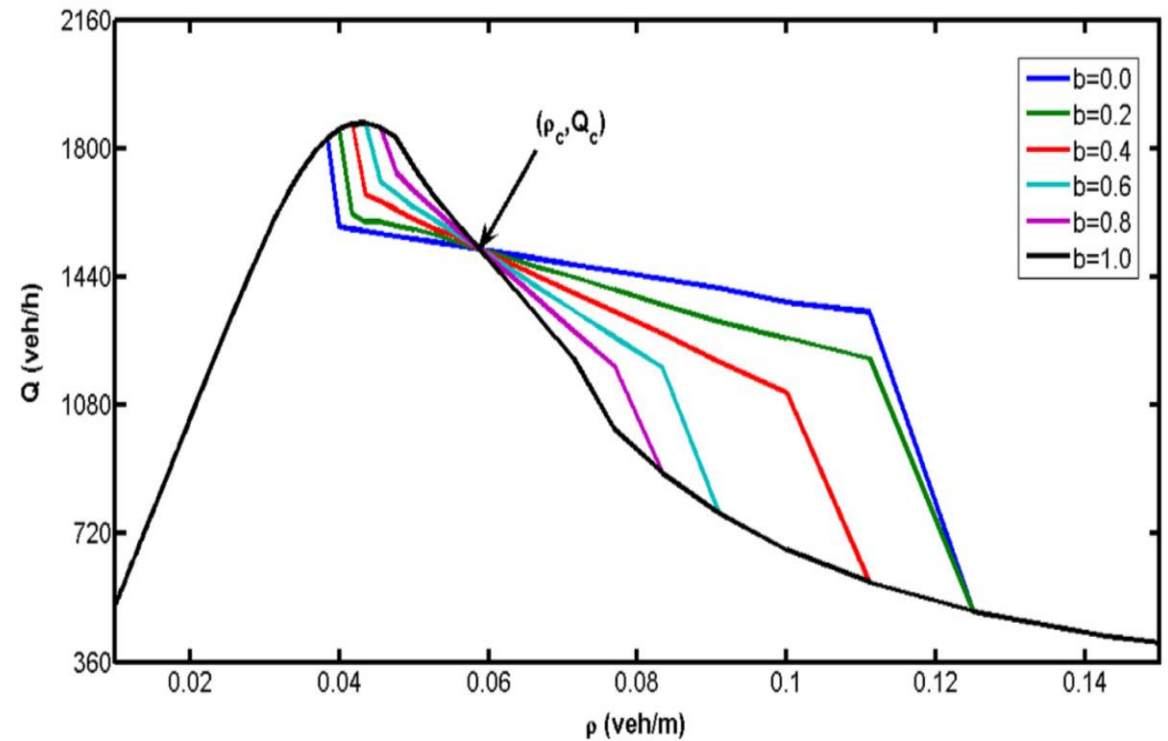


Overview and Analysis

- **Simulation studies:**
 - **Impact of AVs on driver's behavior of manual cars and traffic performance**
- **Different scenarios consisting of a 100% Automated vehicles (AV) and 100% conventional vehicles (CV)**
 - **positive effect of AVs reduce congestion**
- **Frequency of message passing has direct impact on communication performance.**

Overview and Analysis (2)

- Mixed traffic flow of human-driving and AVs in six different scenarios.
 - There is a critical point on the density-flux curve that distinguishes two opposite behaviors for mixed traffic flow.





AVs and Driver

Transition from automated to manual driving

- Analysis of impact of distraction level with respect to the age of drivers when predicting performance of taking control of a highly automated vehicle
- Analysis of behavior of distracted driver and response time to resume manual control
 - Being involved in other activities, e.g., taking nap, reading, distractions from other passengers
- Investigating the ability of drivers to handle conditions where automation reverts to manual control with respect to
 - length of the time the driver was not looking at the road ahead.
 - considered eye movement patterns

Transition from automated to manual driving (2)

- **Ignorance of driver of AVs' malfunction**
- **Driver in AVs analogous to Pilots in Auto-pilot aircraft:**
 - **Short time window for decision-making and proper action to avoid undesirable consequences**
 - **More frequent unexpected situations on the roads rather than in sky**

Transition from automated to manual driving (3)

- **Alert system**
 - Clear language to unambiguously communicate
 - Level of urgency
 - Audio, tactile, visual, vibro-tactile warnings
- **Impact of driving skills**

Conclusion and Future Work

- It is still a long way to go to make Autonomous Vehicles a reality
- It is critical to identify and quantify the potential risk factors that exist in the interaction of AVs with:
 - Pedestrian
 - Other vehicles
 - Driver
- Future work:
 - Discuss the possible failures in greater detail and will offer potential solution and methods to objectively measure efforts to make improvements that enhance safety and convenience.