A Survey on Autonomous Vehicles Interactions with Human and other Vehicles

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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.
Survey on Human Interaction

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
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 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
AVs & Pedestrian

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
AVs & Pedestrian

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

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
AVs & other users

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.
• 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
AVs & 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
AVs & Driver

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
AVs & Driver

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
AVs & Driver

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.