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Investigation of Automated Vehicle Effects on Driver's Behavior and Traffic Performance

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Abstract

Advanced Driver Assistance Systems (ADAS) offer the possibility of helping drivers to fulfill their driving tasks. Automated vehicles (AV) are capable of communicating with surrounding vehicles (V2V) and infrastructure (V2I) in order to collect and provide essential information about the driving environment. Studies have proved that automated driving have the potential to decrease traffic congestion by reducing the time headway (THW), enhancing the traffic capacity and improving the safety margins in car following. Despite different encouraging factors, automated driving raise some concerns such as possible loss of situation awareness, overreliance on automation and system failure.

This paper aims to investigate the effects of AV on driver's behavior and traffic performance. A literature review was conducted to examine the AV effects on driver's behavior. Findings from the literature survey reveal that conventional vehicles (CV), i.e. human driven, which are driving close to a platoon of AV with short THW, tend to reduce their THW and spend more time under their critical THW. Additionally, driving highly AV reduce situation awareness and can intensify driver drowsiness, exclusively in light traffic. In order to investigate the influences of AV on traffic performance, a simulation case study consisting of a 100% AV scenario and a 100% CV scenario was performed using microscopic traffic simulation.

Outputs of this simulation study reveal that the positive effects of AV on roads are especially highlighted when the network is crowded (e.g. peak hours). This can definitely count as a constructive point for the future of road networks with higher demands. In details, average density of autobahn segment remarkably improved by 8.09% during p.m. peak hours in the AV scenario, while the average travel speed enhanced relatively by 8.48%. As a consequent, the average travel time improved by 9.00% in the AV scenario. The outcome of this study jointly with the previous driving simulator studies illustrates a successful practice of microscopic traffic simulation to investigate the effects of AV. However, further development of the microscopic traffic simulation models are required and further investigations of mixed traffic situation with AV and CV need to be conducted.

Keywords: Automated driving, Automated vehicles, Microscopic traffic simulation, Driver behavior, Traffic performance, Capacity

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1 Introduction

Automated vehicles (AV) have passed miles of test runs on multiple road types under various traffic conditions. In near feature, a mixed traffic situation is likely to emerge where vehicles with different degree of automation will interact with non-automated vehicles (Gouy, 2013). Advanced Driver Assistance Systems (ADAS) such as adaptive cruise control, lane keeping assistance or emergency brake assist have already significantly affected the traffic performance. Soon, more assistance systems will be implemented in new vehicles and will affect the traffic performance.

In recent decades, the growing population has implied higher transportation demand which caused a bottleneck for traffic networks and further city development (Wei, 2013). Studies have proved that automated driving illustrates the potential to decrease traffic congestion by enhancing the traffic capacity, improving the safety margins in car following and reducing THWs (Jamson, 2013).

Despite these encouraging factors, autonomous transportation raises some concerns such as possible loss of situation awareness, overreliance on automation and loss of required driving skills for resuming to manual control. These issues look more critical in case of system failure (Gouy, 2013). Besides, complex traffic situations like merging at ramps, lane closures, overtakings and crossing intersections need further investigation. Bearing in mind that most knowledge related to driving behavior in AV are based on driving simulator studies, real traffic condition needs to be examined (Amditis, 2015).

The aim of this paper is

- to examine the effects of AV on driver's behavior through a literature survey;
- to investigate the possibility to evaluate the performance measures of a typical automated scenario using microscopic traffic simulation models.
- to investigate how well can a state-of-the-art microscopic traffic simulation model simulate the presence of AV?
- to investigate how do AV affect the traffic performance?

In order to achieve the aims, a broad literature review in the area of driving simulators and psychological studies was conducted. Then, a specific road network were modelled using the microscopic traffic simulation model VISSIM. Automated vehicle's behavior was modelled based on the findings from the literature survey. Only one degree of automation was considered and in this case, all automated vehicles assumed to be highly automated.

2 Literature Review

Within the last thirty years of study and experiment on vehicle technology, vehicles that are capable of communicating with surrounding vehicles (V2V) and infrastructure (V2I) have been developed. These vehicles can collect useful information about the driving environment in order to assist the driver to fulfil the driving tasks and experience a convenient movement (Gouy, 2013).

Jamson (2013) revealed that drivers using high vehicle automation preferred less lane changing in order to overtake slower moving traffic. In other words, the tendency towards automated-mode disengagement is less, especially in heavy traffic conditions although it may increase the journey time. Evidences show that driving automated vehicle is tedious in a long run, which reduce situation awareness and intensify driver drowsiness exclusively when the road is quiet and the traffic is light. Due to the fact of more driver inclination to involve in secondary tasks, it is worthy to mention that vehicle infotainment systems potentially distract drivers from their supervisory role (Jamson, 2013).

Gouy (2013, 2014) conducted series of driving simulator studies to investigate the effects of short THW on non-equipped vehicle drivers. Output of these studies revealed that the preferred THW of non-equipped vehicle drivers remains constant, while the adopted THW differentiates significantly