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Connected and Autonomous Vehicles (CAVs) Challenges with Non-motorized Amenities Environments

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ARTICLE INFO	ABSTRACT
	With the deployment of Connected and Automated Vehicles in the coming decades, road transportation will experience a significant upheaval. CAVs (Connected and Autonomous Vehicles) have been a main emphasis of Transportation and the automotive sector, and the future of transportation system analysis is widely anticipated. The examination and future development of CAVs technology has been the subject of numerous researches. However, as three essential kinds of road users, pedestrians, bicyclists, and motorcyclists have experienced little to no handling. We explored the influence of CAVs on non-motorized mobility in this article and seven various issues that CAVs face in the environment.

1. Introduction

For more than a century, the automotive industry has existed. The intelligent process in the automotive area has accompanied in an era of fast growth in recent centuries, with the fast growth of science and technology. At this point, active safety technology has progressed, and while not all intelligent aided driving technologies have been implemented on a big scale in existing passenger cars, they will empower innovative adaptable systems that improve transportation protection and competence [1,2]. A few alternatives for assisted driving include electronic stability, aggressive braking, and lane departure and retention systems. Despite technological advancements, road accidents continue to occur. More than 93 percent of all traffic accidents are still caused by driver error [3]. At the moment, drivers have complete control of vehicles: they receive information, make verdicts, and lastly take accomplishment through a multifaceted process of insight and response to react to various road risks, and people must learn a lot more about autonomous vehicles [4,5]. Vehicle safety systems, both passive and active, can still not fulfill the present aim of zero fatalities and accidents [6-9].

2. Literature Review

Due to advancements in sensor technologies, information technologies, and vehicle control technologies,

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the automation of vehicle control has garnered a lot of attention recently. Intelligent traffic forms with self-driving technology have become an important aspect of addressing severe traffic safety, efficiency, and convenience challenges. Major automakers, Internet corporations, universities, and research organizations have all launched prototype or concept versions of CAVs. Recent statistics indicate that [6], Audi, BMW, Mercedes-Benz, Volvo, and other automobile manufacturers, as well as internet businesses like Baidu and WAYMO and public transit companies like Uber, have already put autonomous prototypes to the test and deployed the intelligent automotive market [7-9]. Simultaneously, the driverless test area for CAVs is improving; examples include the Detroit M-city in the United States, Shanghai Nice-city in China, and Chongqing's I-Vista. Governments are also pushing autonomous technologies, with California allowing CAVs on public roads [10]. Beijing, China, has just made several roads available for testing self-driving cars. Shanghai also enables autonomous vehicles to operate on certain of the city's partially open roadways, advancing linked and autonomous vehicles [11].

The introduction of CAVs sparked debate about coexistence with other road users, such as traditional automobiles and non-motorized traffic. Pedestrians and bikers are excellent indicators of a community's social, economic, and physical well-being. In society, high levels of pedestrian and bicycle activity are frequently connected to stronger economies and healthier, more socially cohesive communities. A lack of pedestrian and bicycle activity on roadways, on the other hand, may indicate that personal security and safety needs aren't being addressed, or that destinations aren't accessible by foot or bicycle. On the other hands, the high number of automobiles on the road has risen year after year, eroding the space available for walking and bicycling and worsening the travel environment. Encourage and promote a high level of service for pedestrians and bicycles to improve fitness, clean air, and sustainability, and Automobiles emit plenty of pollutants into the atmosphere.

3. The Meaning of Connected and Autonomous Vehicles (CAVs)

Before getting into CAVs, it is important to understand the terms Automated Driving System (ADS) and Advanced Driver Assistant System (ADAS) [12]. More than a warning function is available in the ADS system. It also has a property for planning and controlling autonomous driving assistance systems. ADAS collects data, identifies static or dynamic objects, detects and tracks static cars,

and combines that data with navigation map data using a range of sensors fitted in the vehicle. Drivers can receive alerts in advance while in an emergency, thanks to ADAS calculations and analysis. As a result, ADAS efficiently improves the vehicle's driving comfort and safety. The system could actively intervene, such as activating the automated braking system, with the newest ADAS technology. CAVs are graded on 0 to 5, with 0 being the least automated and five being the most automated. The definitions for these six levels can be found in Table 1 [13]. The ADAS system refers to Level 0 to Level 2, and the ADS system refers to Level 3 to Level 5. Table 1describes the driving levels.

Table 1. Driving level of CAVs [14]

No	Description
Level 0	No automation
Level 1	Automated systems can sometimes support the human in some parts of the driving activities.
Level 2	Partially automated systems can conduct some driving activities while human monitors and accomplishes other driving activities.
Level 3	Conditionally automated systems can demeanor some driving tasks in different situations, but the human driver must be ready to take back control
Level 4	Highly automated can conduct all driving activities in different circumstances without human control.
Level 5	Fully automated systems can perform all driving activities under all conditions in which humans could drive.

3.1 Connected Vehicles

The goal of linked vehicles is for the vehicle to deliver relevant information to the driver to aid in decision-making, such as weather, a driver with a mobile phone that provides information to the urban traffic network or an in-car satellite navigation system that can provide real-time route information. As a result, the distinction between vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication is frequently noted [15]. It is worth noting that the car does not make decisions for it; instead, it communicates with the outside world to gather useful data. This technology used to be associated with automobile communication. It is becoming common for it to include the Internet of Vehicles. The Internet of Cars offers real-time networking between vehicles and roads, vehicles and other vehicles, vehicles and people, and vehicles and

the environment, as shown in Figure 1. It's a network system that keeps track of, schedules, and controls the system's various components. The Internet of Vehicles collects data from the vehicle's sensing device (sensing layer). It uses network sharing (network layer) to connect drivers, pedestrians, the car networking platform, and the urban network, allowing for intelligent, safe driving and enjoyment of technologies and living services (application layer).
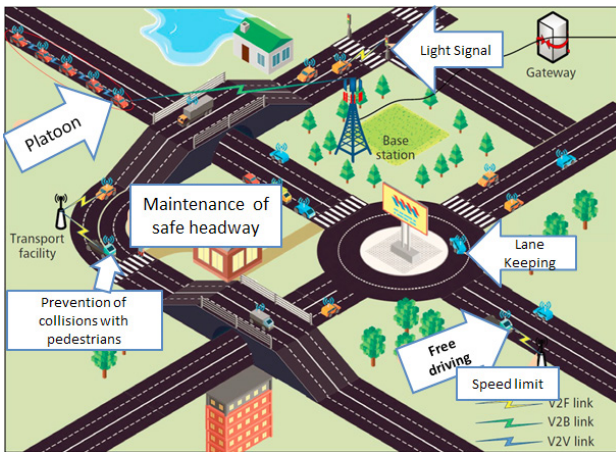

Figure 1. A representation of connected vehicles and infrastructure [16]

3.2 Autonomous Vehicles

Autonomous cars employ an inbuilt sensor to monitor their status and surroundings, then control their speed and direction using an actuator. To make decisions, the per-ception devices employ the path, vehicle location, and obstacle data they have collected. It's a comprehensive intelligent system that incorporates navigation, environmental awareness, control, decision-making, and interaction into one package. Human-computer interaction models, sensor equipment, and algorithms are all part of the autonomous vehicle development process. A unified interactive platform does not exist now. Self-driving cars work in a fairly closed manner today, with no connection to the Internet of Things.

4. CAVs Control Optimization at Intersections in Urban Areas

What will happen to the city if people no longer have to drive when they pass through? As a result of this trend, communities must think about how autonomous vehicles can fit into their plans. According to traffic managers, highways may get narrower in the future. Furthermore, because people do not need to park vehicles, there will be more space on the main road for walking and cycling where parking meters used to be. It is possible that CAVs will not even have their specific area. CAVs can switch to different services at different times of the day thanks to share mobility with the Internet of Vehicles. A centralized intersection controller accepts vehicle requests. Calculate and verify vehicle conflict points by establishing the passing sequence of all vehicles, which must adhere to the principle of first-come, first-served [17], as shown in Figure 2.

Many low-level CAVs could handle driving on freeways and suburban roads, but urban road technology is
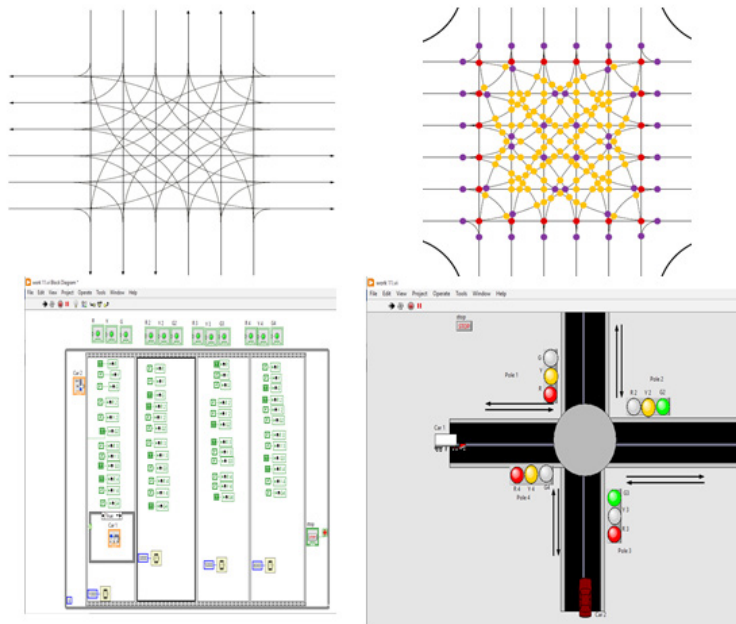

Figure 2. LabView Vi CAVs optimization at the intersection

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still inadequate, particularly in areas with congested traffic. Urban roads are more complicated than other roads, with many cars and various vehicle types. Various parts, non-motorized traffic flows, and road intersections all have vastly different speeds. As a result, the main challenge for self-driving automobiles in urban contexts is a technical one.

5. Connected and Autonomous Vehicles (CAVs) Issues

CAVs have made significant advances in all areas over the last few decades. New challenges and problems have surfaced at the same time. Multiple mishaps using CAVs, in particular, have prompted more critical and objective conversations concerning the impact of CAVs [18]. CAVs have experienced hurdles and obstacles in the following six areas: technology, safety concerns, legislation and policy, economy, privacy and cyber-security, and public acceptance.

5.1 Technology

Sensors, sensor fusion, localization, motion planning, and decision making are the three primary components of CAV-related technology [19]. CAVs use sensor equipment to recognize their surroundings, including pedestrians, traffic signals, and road signs. Vehicles should be able to decide whether to proceed or stop after receiving the data. Computer vision and machine learning are linked technologies. The perception process using sensor devices has made tremendous progress in recent years due to the popularity of deep learning technology, so the accuracy of identifying other road users and facilities has improved subversively [20]. This technology lays the groundwork for self-driving vehicles to be as safe as possible. Sensors, on the other hand, are now unable to recognize small-scale road signs or pedestrian movement. Identifying pedestrian behavior and predicting their intents, particularly for gestures, are the challenges [21]. Whether using laser, sonar, or radar sensors, the signals conveyed have a lot of noise and uncertainties in the second portion of sensor fusion and localization. The primary issues are how to filter out useless data and restore the objective environment in 3D. Particle Filter and Kalman Filter are two extensively used algorithms for localization. Radar and sonar were the primary sensors utilized by autonomous vehicles in the beginning. LIDAR, a revolutionary method that uses light for detection and ranging, has become popular in recent years (equipped with laser beams to illuminate at different times and spaces to get information), great penetration rates, quick perceptions, and high accuracy are all advantages

of this technology [12,22]. LIDAR technologies, on the other hand, respond to a high price. Cost is a stumbling block for the mass manufacture of CAVs with LIDAR systems.

Furthermore, the concept of the Internet of Vehicles as it relates to CAVs faces technological challenges. Vehicle to Vehicle (V2V) communication is a flexible and convenient communication on the Internet of Vehicles that does not require coordination or control of basic communication infrastructure. As a result, V2V has good scalability. However, the distance of the work zone varies dramatically with time due to the vehicle's greater traveling speed. As a result, vehicle-to-vehicle network communication has drastically decreased. Vehicles will be segregated when coping with low traffic density. A high traffic density, on the other hand, will reduce network data transmission efficiency and accuracy. The Vehicle to Roadside (V2R) communication mode necessitates using a stationary communication device at the roadside. The network's scalability suffers as a result. As a result, this communication mode is suited for use in urban traffic scenarios that require many hotspots and base station signals.

5.2 Safety and Crashes

The numbers for traffic accidents in the United States in 2010 are shocking: 32,999 people were killed, 3.9 million people were injured, and 24 million vehicles were damaged, costing $277 billion in both real and intangible damages [23] and Nearly 80% of carbon monoxide emissions and 55% of nitrogen oxide emissions are attributed to transportation, according to the US Environmental Protection Agency. Bicyclists who commute to work save 2,000 miles of driving and around 2,000 pounds of CO_2 per year in the United States. Furthermore, it equates to a nearly 5% reduction in the average American carbon footprint. Furthermore, it corresponds to a nearly 5% reduction in the average American carbon footprint [24]. Pedestrians and bicyclists, on the other hand, are in a weak position in the urban transportation system when it comes to traffic safety issues and is more prone to traffic accidents [25]; as Figure 3 demonstrates, the burden cost on the market has a ripple effect and affects productivity [26].

5.3 Economy

According to the estimate, it will take at least 2045 for half of the new vehicles to be autonomous and 2060 for half of the vehicle fleet to be autonomous, implying that CAVs will disrupt the current economic sector [28]. Traditional automakers' business models have shifted as a result of driverless car technology. It improves communication between manufacturers and governments by determining

if governments should provide automobile manufacturers sufficient authority to produce CAV peripheral products (infrastructures). Governments will also confront fiscal concerns, such as whether substantial sums of money are required to establish roads entirely for driverless automobiles to develop autonomous cars. Furthermore, the majority of current CAVs researches use sustainable energy, which has impacted fuel markets. According to estimates from Intel Corporation and Strategy Analytics, the economic effects of self-driving cars will total $7 trillion by 2050 (Figure 4). This outcome is based on the assumption that by 2025, all cars will be CAVs with a level 5 of automation [29].
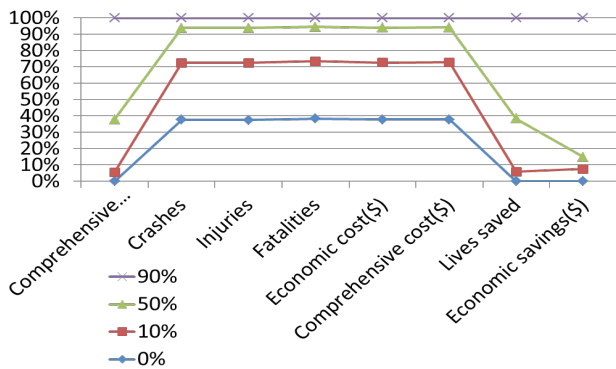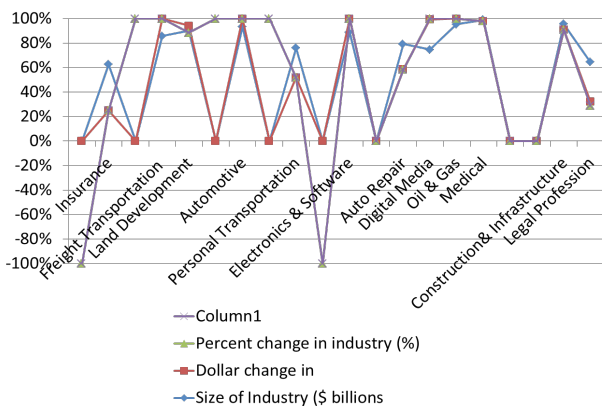

Figure 3. CAVs Market Infiltration [27]

Figure 4. Instantaneous economics changes [30]

5.4 Privacy and Cyber-Security

Hackers and third-party car control are the most major information security risks for CAVs. In the absence of self-driving cars, hackers can endanger passengers' lives by hacking steering, braking, and other driving-related systems. They can also deceive CAVs by targeting sensing systems such as radars and cameras, causing them to make incorrect conclusions [31]. Cloud computing, cloud decision-making, and V2X (vehicle to everything) expose more vulnerable sections of automobiles to the Internet

in preparation for the Internet of Vehicles arrival [32,33]. In the state legislature, there is no legislation regarding CAV security and privacy. In July 2015, however, similar federal legislation was introduced (Autonomous Vehicles and Cybersecurity Concerns, 2019). This law allows for an inter-departmental study into the problem of vehicle network security.

6. Non-motorized Environment and Non-motorized Transport Amenities

Nonmotorized transportation provides fundamental mobility, affordability, public transportation access, and health benefits. Improving the convenience, comfort, and safety of walking and cycling helps to address the major traffic difficulties that many communities face. Walking and cycling are important contributions to lowering damaging local pollutants and greenhouse gas emissions because they are zero-emission modes. A non-motorized transportation strategy aids in the development of a shared vision for the improvement of the walking and cycling environment. The plan can be used as a guide for specific initiatives like streetscape makeover or the adoption of an on-street parking management system. It can also aid coordination among the various authorities involved in the planning and management of non-motorized transportation systems. A non-motorized transport strategy can supplement mobility plans, which provide detailed guidance on specific mobility initiatives, by laying out the vision for an improved walking and cycling environment. The following are different city with high rate of non-motorized transport:

Communities that improve non-motorized travel conditions generally see considerable increases in non-motorized travel and corresponding automobile travel reductions [34,35]. Residents of a pedestrian-friendly community walked, bicycled, or took public transportation for 49 percent of work trips and 15 percent of non-work journeys, respectively, 18 and 11 percentage points higher than residents of a comparable automobile-oriented community [36]. Morris (2004) discovered that those who live within a half-mile of a cycling trail are three times as likely to commute by bicycle as the national average. Another study discovered that walking is three times more common in neighborhoods with pedestrian-friendly roadways than in less pedestrian-friendly streets [37]. As seen in Figure 5, non-motorized travel accounts for a significant share of travel in some cities.

If all other factors are equal, each mile of bikeway per 100,000 residents boosts bicycle commuting by 0.075 percent [38]. Although bicycles account for only around 1% of

all journeys in the United States, riding rates are five to 10 times higher in many North American localities [39] (Comsis, 1993). As shown in Figure 6, international researchers have discovered considerable disparities in non-motorized travel habits. High levels of non-motorized travel in such geographically diverse regions, compared to lower levels in similar places, suggest that transportation regulations and community attitudes are more important in influencing non-motorized travel than geography or climate [40,41].
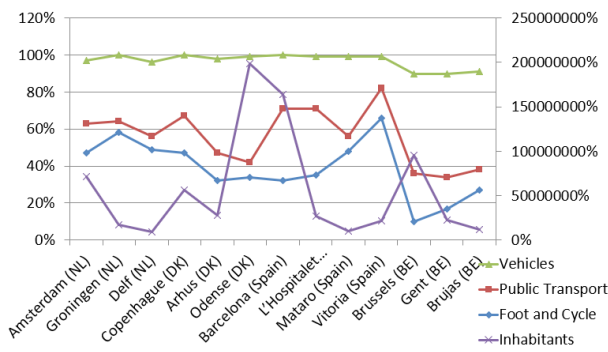

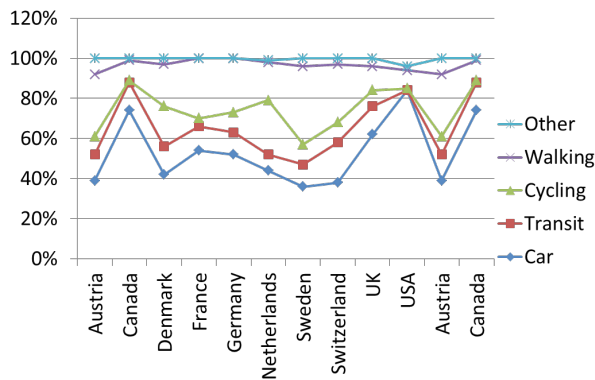**Figure 5.** European cities have high rates of non-motorized transport

Figure 6. Non-motorized travel common in some urban areas

7. Conclusions

The definition and newest developments in autonomous vehicles are discussed, and the obstacles and arguments that contemporary CAVs face, technical impediments the Internet of Vehicles' popularity, identity, and decision-making. We go over the definition of self-driving vehicles, how autonomous driving is classified, and the special equipment and technology required. The definition of connected and autonomous vehicles, as well as automotive networking, is fraught with debate. Some argue that the Internet of Automobiles does not apply to linked and autonomous vehicles. Many incidents involving self-driving vehicles have occurred worldwide due to technologi-

cal flaws, resulting in fatalities. CAVs may have a big economic influence in the future, since the traffic system will be more efficient as a result of the benefits of the CAVs' following mode, which may improve fuel efficiency to some extent. The situation similarly raises the question of whether automakers have the legal right to build and operate infrastructure.

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