
The impact of connectivity on road safety

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Abstract

This article explores the impact of connectivity on safety in automotive transportation, considering connectivity as a means to enhance safety, improve traffic efficiency, enable early issue detection, and facilitate traffic coordination. With the rapid advancement of information technologies, the automotive industry is moving towards intelligent vehicles capable of communicating with each other and their surroundings.

The first aspect examined is the influence of connectivity as a tool for increasing safety in automotive transportation. This connectivity allows vehicles to obtain real-time information about traffic conditions, road incidents, and accidents. Such information can be utilized to prevent collisions, warn drivers about hazardous situations, and provide assistance systems for safe driving.

The second aspect is the utilization of connectivity as a means to enhance traffic efficiency. Through connectivity, intelligent traffic systems can be created to optimize traffic flow, minimize congestion, and improve overall traffic fluidity. These systems can offer alternative routes, inform about optimal travel times, and enhance coordination between traffic signs and signals.

The third aspect is connectivity as a tool for early issue detection in vehicles. By connecting vehicles to the internet, their technical status can be monitored, and potential malfunctions or system failures can be diagnosed in advance. This information can be utilized for accident prevention, maintenance planning, and ensuring safe and reliable vehicle operation. In conclusion, connectivity plays a significant role in enhancing safety and efficiency in automotive transportation. Leveraging its potential can improve vehicle safety, optimize traffic flow, enable early issue detection, and facilitate traffic coordination. However, it is crucial to implement adequate security measures and privacy protection to minimize risks associated with cyber-attacks and unauthorized access to vehicle systems.

Key words: safety, connectivity, risk.

Introduction

The arrival of connectivity has ushered in a revolutionary era in the automotive industry, where vehicles are increasingly connected to the Internet and can communicate with each other and their surroundings. This connectivity opens up many opportunities to improve the safety and efficiency of motoring. By using connectivity as a powerful tool, we can increase vehicle safety, optimise traffic, ensure early detection of problems and improve traffic coordination. The article focuses on examining the impact of connectivity on automotive safety and explores the various aspects that connectivity brings as a means to improve traffic safety and efficiency. It provides a thorough analysis of the advantages, dangers, and steps that need to be taken to reduce security issues related to in-car connection. The article will give a general review of the present situation and prospects for connection utilisation in automotive transportation in terms of efficiency and safety.

Results and Discussion

1. Using connectivity to improve security

In order to limit the amount of traffic accidents and injuries, connection becomes a crucial instrument. Safety is always the first priority in road transportation. There are now more opportunities than ever to use connectivity to improve road traffic safety because to the development of information technology and the Internet-connected automobiles.

The ability for cars to exchange data and information is one of connectivity's key advantages. Vehicles are capable of communicating with one another and exchanging data on their state, speed, direction of travel, and other nearby vehicles. The utilisation of this data can help prevent crashes and alert drivers to possible dangers. For instance, if the car notices a sudden braking or direction change, it may immediately warn other cars, allowing them to react quickly to the traffic situation and avoiding accidents.

Software that enables users to manage, monitor, and operate items through multiple interfaces is gradually replacing hardware components. The product joins a larger network of things by providing connection and becoming one of its nodes. This product connectivity, also known as telematics, combines wireless communication, location technology, and car electronics. The major objective of this company strategy is product innovation. Numerous sensors and about 40 microprocessors gather telemetry and driving data in connected automobiles, which include on-board computers and integrated mobile broadband. A connected car may generate up to 25 terabytes of data each hour of driving and transfer it to the cloud (Balcells, 2016). The continuous Internet connection of automobiles enables a number of applications, including in-vehicle Internet access, location services, smart and environmentally friendly transportation, and road safety. With the ability to get software updates via the cloud, modern vehicles may be continuously improved and optimised without going to the dealer.

Data harvesting is used in the data generation industry and mostly targets data pertaining to autos. Data may be gathered from several sources in smart, connected automobiles. The CAN bus (ECU, batteries, brakes, gearbox, etc.), sensors, and GPS are common sources. Advanced driver assistance systems (ADAS), the building blocks of self-driving cars, are important in the field of connected automobiles. In order to analyse the environment, several sensors are employed concurrently, including, for instance:

- Long-Range Radar (Adaptive Cruise Control)
- LIDAR (Emergency Breaking, Pedestrian Detection, Collision Avoidance)
- Camera (Lane Departure Warning, Traffic Sign Recognition, Surround View, Park Assistance)
- Short-/Medium Range Radar (Cross Traffic Alert, Rear Collision Warning)
- Ultrasound (Park Assistant)

Connectivity can improve safety by keeping an eye on the technical status of cars. Internet-connected automobiles may give ongoing health data, including the state of their brakes, tyres, lights, and other vital systems. This data may be analysed, and if possible issues are found, the driver may be instructed to visit a service centre right away or obtain the required repairs. In this manner, the technical component failure risk is reduced and driving safety is increased.

Naturally, it is essential to take the proper precautions to safeguard privacy and data security when using connection. Strict guidelines and procedures must be followed while transferring and processing data to reduce the chance of data misuse. To stop unauthorised access and potential cyberattacks, communication networks and systems in automobiles must be secure.

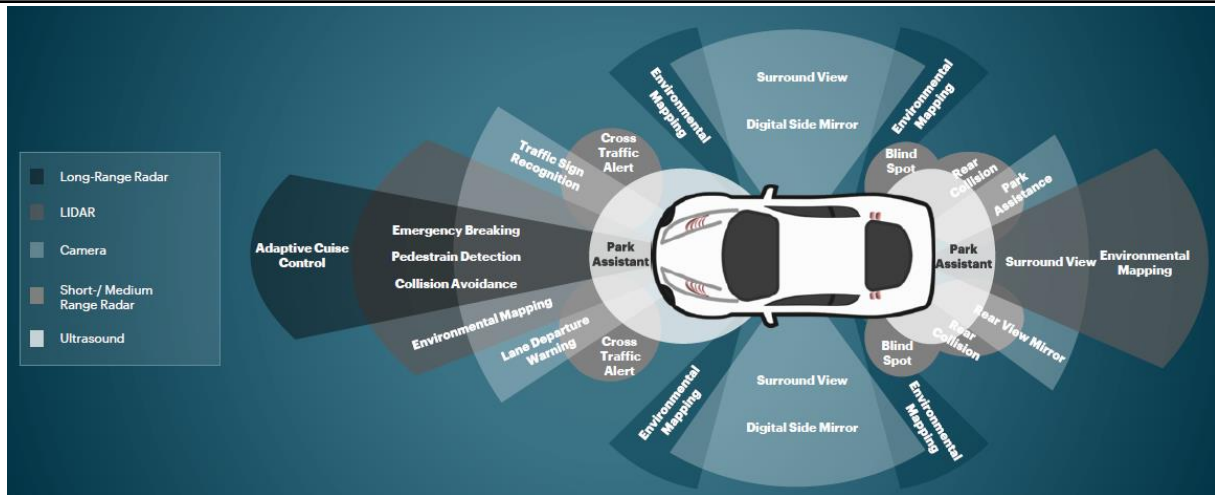


Figure 1 – Public illustration of personal data ¹

2. Using connectivity to improve transportation efficiency

Even travel is now a part of the digital world as information technology has permeated every aspect of our life. The door has opened for considerable advancements in the effectiveness and optimisation of transportation with the quick growth of connectivity. Connectivity, which involves linking cars to the Internet and enabling two-way communication between infrastructure and vehicles, is proving to be a highly useful tool in the transportation industry.

The development of intelligent transportation systems is one way that connectivity promotes more effective use of transportation. These systems rely on connection to collect data on traffic, state of the roads, accidents, and other pertinent information. Drivers can be provided with other routes that reduce traffic congestion and enhance traffic flow with the use of this information. Additionally, real-time information regarding traffic conditions, congestion, and the ideal travel time may be sent to drivers through intelligent traffic systems. By doing this, the time spent in traffic congestion is decreased and the available transportation routes are used more effectively.

Building sophisticated control systems for traffic lights and road signs is also made possible by connectivity. These systems have the capacity to adapt dynamically to the existing traffic flow and enhance it. For instance, the system can change the length of the green and red lights at traffic signals to guarantee that cars can move through without making unneeded stops when it detects a larger flow of vehicles on a particular road. Intelligent traffic control like this promotes improved traffic flow while reducing congestion.

Due to connection, opportunities for ride sharing and using public transportation also arise. Connectivity is used by ride-sharing companies and applications to link people with related travel requirements. By doing this, it is feasible to employ vehicles' capabilities more effectively and cut down on the number of empty journeys. Additionally, shared transit and trips help to lessen traffic and pollution.

It is crucial to stress that collaboration amongst many stakeholders is necessary for the successful use of connectivity for more effective use of transportation. To develop standards and procedures for communication between automobiles and infrastructure, the automotive industry, transportation organisations, and governments must collaborate.

¹ https://scholar.google.cz/scholar?q=DATA-DRIVEN+BUSINESS+MODELS+IN+CONNECTED+CARS,+MOBILITY+SERVICES+%26+BEYOND&hl=cs&as_sdt=0&as_vis=1&oi=scholart

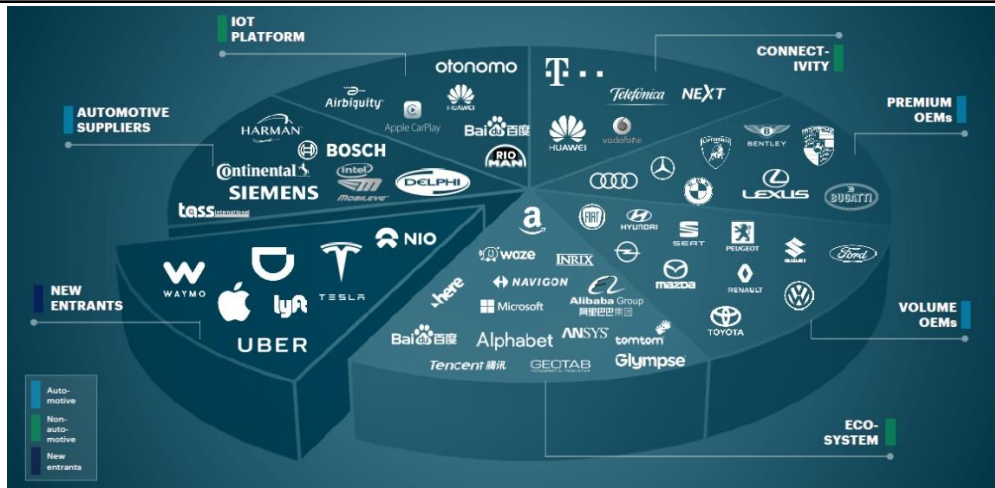


Figure 2 – Automotive connectivity ecosystem²

2.1 Traffic light and sign control mechanisms

The following devices need to be connected to the system: light signalling, signs with operating information, and signal portions of traffic control devices, such as variable traffic signs. Infrastructure, with the exception of infrastructure used for traffic systems, must also be monitored by the system.

The following systems are listed:

1. Infrastructure for power supply
2. The telecommunications system
3. the operator’s workspace’s equipment

The following classifications are used to categorise the RSD system in order to establish common requirements:

Way of managing traffic	Reliability	Algorithmic difficulty
containing direct control system	A	G1
a traffic management system that uses only manual and direct sign	A	G3
system with simply monitoring and no traffic switching	B	G3

Application in practise the system has to be installed on:

1. two redundant servers
2. two or more operator stations that may communicate requests for servers and operator stations as well as specifications for assuring server redundancy.

Transport technology and intelligent transportation systems:

Modularity: The entire system must be created with modularity in mind, and its capability must be able to be increased by plug-in modules placed into the system through a universal open interface, without requiring system-wide modifications. This interface's documentation must be provided with the system.

Dynamic traffic flow navigation.

Individual traffic management is necessary due to fluctuating traffic conditions on highways and in cities. Therefore, a crucial element for ensuring safe traffic flow is dynamic traffic signs that are centrally managed. LED-based variable traffic signals Modern traffic management systems that provide road users with clear and concise information are necessary due to the constantly changing

² https://scholar.google.cz/scholar?q=DATA-DRIVEN+BUSINESS+MODELS+IN+CONNECTED+CARS,+MOBILITY+SERVICES+%26+BEYOND&hl=cs&as_sdt=0&as_vis=1&oi=scholart

continuously tracking different sensors and characteristics, issues can be found before they become serious. For instance, if the sensors pick up on strange engine vibrations or noises, a notification may be sent right away to the vehicle's owner or a servicing facility.

Additionally, networking makes it possible to solve problems more quickly and effectively. The issue may be identified and fixed considerably more quickly now that cars are connected to the corporate office and servicing facilities. Additionally, if there are any issues with the roads, a signal may be sent to dispatch right away, guaranteeing quicker obstruction removal and damaged section restoration.



Figure 4 – Car connectivity

4. Using connectivity to coordinate transportation

There is a chance to utilise connection as a way to better coordinate traffic and optimise the flow of cars given the rise in the number of vehicles on the road and the increasing traffic load.

Through the exchange of information, connectivity in road transportation facilitates communication between cars, infrastructure, and transportation systems. Intelligent systems can analyse the current traffic condition, foresee possible issues, and take actions that will enhance traffic flow and reduce congestion thanks to this information sharing.

The development of intelligent traffic systems that can gather and interpret data on current traffic is one example of how connectivity is used for traffic coordination. The systems keep track of a number of variables, including the volume of traffic, vehicle speed, the condition of the traffic lights, and more, and they use this information to optimise the timing of light signals and traffic management. As a consequence, there is better traffic flow, shorter wait times, and less congestion.

Road barriers and dynamic lane management are two other ways connection aids in traffic coordination. Internet-connected cars may advise traffic management systems of their intended path and manoeuvre through communication. Based on this data, the system may modify lane assignment and barrier opening/closing to improve traffic flow and reduce crashes and other conflicts between cars.

Additionally, connection permits information sharing between cars, which improves traffic coordination. Vehicles are capable of communicating with one another and exchanging data regarding

their current location, intended course, and upcoming manoeuvres. This enhances traffic safety, boosts travel efficiency, and makes it easier to forecast and avert collisions.

4.1 Autonomy-related dangers

Road safety may be negatively impacted by a variety of additional threats brought on by the switch to fully autonomous cars. The biggest concern is that autonomous cars would act inappropriately in difficult circumstances. A terrible catastrophe may occur, for instance, if a bicycle suddenly emerged on the road and was hard for an autonomous car to perceive. Therefore, it is crucial that autonomous cars have enough sensors and algorithmic capabilities to react to hazardous circumstances. Additionally, the possibility of hacking into driverless vehicles exists. Someone who gained access to the autonomous vehicle's system may take control of it and cause a collision. To avoid unauthorised access to the vehicle's system, it is crucial that autonomous cars be outfitted with adequate security measures. Autonomous cars must also be able to recognise and respond to any hacking attempts.

5. Vehicle connectivity with a focus on driver safe

In the rapidly evolving world of transportation, vehicle connectivity has emerged as a game-changing technology with the potential to revolutionize the way we drive. By seamlessly integrating vehicles with advanced communication systems, driver safety can be significantly enhanced, leading to a safer and more efficient road environment.

This article section delves into the realm of vehicle connectivity, placing a particular emphasis on its impact on driver safety. We explore the various aspects of this technology, ranging from smart features that aid in accident prevention to intelligent systems that assist in emergency situations.

With the rise of connected vehicles, drivers now have access to a wealth of real-time information, enabling them to make informed decisions on the road. We examine the role of sensors, cameras, and data analytics in creating a comprehensive network that enhances situational awareness and provides early warning systems for potential hazards.

Moreover, we delve into the realm of connected infrastructure, investigating how vehicles can communicate with traffic management systems, traffic lights, and other smart city components. By establishing a seamless connection between vehicles and their surroundings, we explore how driver safety can be improved through optimized traffic flow, reduced congestion, and timely response to road conditions.

Is necessary deeper understanding of vehicle connectivity's impact on driver safety. By examining its potential, limitations, and future prospects, we aim to equip readers with the knowledge necessary to navigate the rapidly evolving landscape of connected vehicles, enabling us to embrace a safer and more connected future on the roads.

Through the exploration of innovative technologies such as vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, we delve into the advancements that are reshaping the driving experience. We analyze the potential of connected vehicles to exchange crucial information in real-time, such as traffic conditions, weather updates, and road hazards, creating a networked ecosystem that enhances driver safety.

Furthermore, we investigate the role of advanced driver assistance systems (ADAS) in promoting safe driving practices. From adaptive cruise control to lane departure warning systems, we delve into the capabilities of these technologies and their ability to prevent accidents, mitigate risks, and assist drivers in making split-second decisions on the road.

However, as with any transformative technology, there are challenges and considerations to address. We examine the potential cybersecurity vulnerabilities that arise with vehicle connectivity, emphasizing the importance of robust security measures to protect against unauthorized access and potential hacking risks.

<p>Internal</p>	<p>Strengths:</p> <ul style="list-style-type: none"> Advanced Driver Assistance Systems (ADAS): Car connectivity enables the integration of advanced driver assistance systems, such as adaptive cruise control, lane-keeping assist, and automatic emergency braking. These features can actively monitor the road and surroundings, provide warnings, and even intervene to prevent potential accidents, enhancing driver safety. Real-Time Vehicle Monitoring: Car connectivity allows for real-time monitoring of various vehicle parameters, such as tire pressure, engine health, and brake conditions. This information can help drivers identify potential safety issues promptly, enabling them to take necessary action and prevent accidents due to mechanical failures. Emergency Services Integration: Connected cars can be equipped with emergency services integration, enabling automatic emergency notifications in case of an accident. The vehicle can transmit critical information, such as location and severity of the crash, to emergency response teams, facilitating faster assistance and potentially saving lives. Driver Behavior Monitoring: Car connectivity can include driver behavior monitoring systems that assess driver actions, such as aggressive acceleration, harsh braking, or erratic steering. These systems provide feedback to drivers, helping them develop safer driving habits and reduce the risk of accidents. Geo-Fencing and Parental Controls: Car connectivity features can include geo-fencing and parental control functionalities, allowing parents or fleet managers to set boundaries and receive notifications when the vehicle deviates from predefined routes or exceeds speed limits. This helps promote safe driving behavior, especially for new or inexperienced drivers. 	<p>Weaknesses:</p> <ul style="list-style-type: none"> Cybersecurity Risks: Car connectivity introduces the risk of cybersecurity breaches, including unauthorized access, data theft, or remote control of vehicle systems. If security measures are inadequate, hackers can exploit vulnerabilities, compromising driver safety. Software Malfunctions and Bugs: The integration of complex software systems in connected vehicles increases the risk of software malfunctions and bugs. If critical systems or safety features experience errors or crashes due to software issues, it can jeopardize driver safety. Driver Distraction: Car connectivity features, such as infotainment systems and smartphone integration, can be potential sources of distraction for drivers. Interacting with these features while driving diverts attention from the road, increasing the risk of accidents. Dependence on Network Coverage: Car connectivity relies on a stable and reliable network connection. However, in areas with poor network coverage or signal interruptions, the functionality of connected safety features may be compromised, leaving drivers without access to critical assistance systems. Lack of Standardization and Compatibility: The lack of standardization and compatibility between different car connectivity systems can pose challenges. Incompatibilities may limit the effectiveness of safety features or hinder interoperability with external services or emergency response systems.
<p>External</p>	<p>Opportunities:</p> <ul style="list-style-type: none"> Advanced Driver Assistance Systems (ADAS): Car connectivity provides an opportunity to enhance driver safety through advanced driver assistance systems. Features like collision warning, blind-spot detection, and lane-keeping assist can help drivers avoid potential accidents and improve overall road safety. Emergency Assistance and Crash Notification: Connectivity enables vehicles to automatically alert emergency services in the event of an accident or breakdown. Integrated sensors can detect crashes and send out distress signals, enabling faster response times and potentially saving lives. Real-Time Traffic Information and Routing: Car connectivity allows for access to real-time traffic data and navigation services. Drivers can receive up-to-date information about road conditions, traffic congestion, and alternative routes, enabling them to make informed decisions and avoid potential hazards. Driver Monitoring Systems: Connectivity offers the opportunity for driver monitoring systems that can detect signs of drowsiness, distraction, or impairment. These systems can provide timely warnings or intervene to ensure driver alertness and reduce the risk of accidents. Remote Vehicle Monitoring and Maintenance: Connectivity enables remote monitoring of vehicle health and maintenance needs. Automakers can provide proactive alerts and reminders for regular maintenance, tire pressure checks, and other critical vehicle safety aspects, ensuring that the vehicle is in optimal condition for safe driving. 	<p>Threats:</p> <ul style="list-style-type: none"> Driver Distraction: Car connectivity features, such as infotainment systems and smartphone integration, can distract drivers from focusing on the road. Interacting with these features while driving can lead to inattention, delayed reactions, and an increased risk of accidents. Malfunctioning Safety Systems: Car connectivity relies on various safety systems, such as collision avoidance or lane departure warning systems. If these systems experience malfunctions or errors due to connectivity issues or software vulnerabilities, it can compromise their effectiveness and potentially lead to accidents. Overreliance on Assistance Systems: Connected cars often come equipped with advanced driver assistance systems (ADAS), such as adaptive cruise control or automated parking. However, drivers may become overly reliant on these systems, assuming they will always function flawlessly, which can lead to complacency and reduced driver attentiveness. Data Privacy Breaches: Car connectivity involves the collection and transmission of driver-related data, such as driving habits, location, or biometric information. If this data is compromised or accessed by unauthorized parties, it can lead to privacy breaches, identity theft, or misuse of personal information. Hacking and Remote Control: Connected vehicles are vulnerable to hacking attempts, where malicious actors can gain unauthorized access to the car's systems. If successful, hackers could remotely control critical vehicle functions, compromising driver safety and potentially causing accidents.
<p>AUXILIARY</p>		<p>HARMFUL</p>

Figure 5 – SWOT analysis of vehicle connectivity with a focus on driver safety

Moreover, we acknowledge the ethical implications surrounding data collection and privacy in connected vehicles. Balancing the benefits of data-driven insights with the need for user consent and data protection is essential in building trust and ensuring the responsible implementation of vehicle connectivity for driver safety.

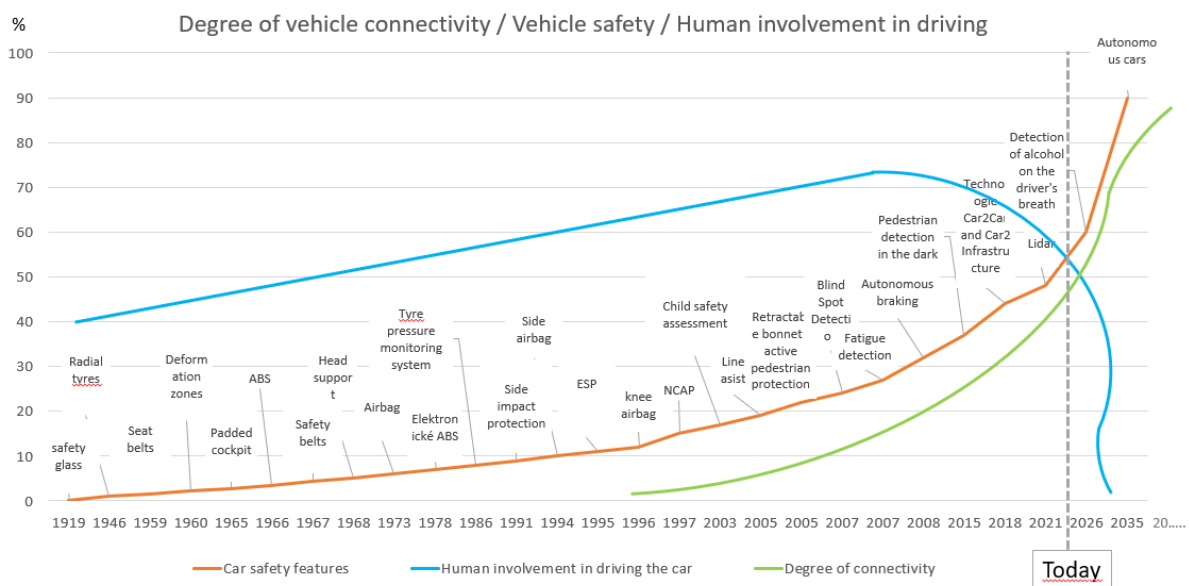


Figure 6 – Graph showing the evolution of safety features, connectivity and human involvement in driving

With increasing vehicle autonomy and technological advancements in driving, a significant concern arises regarding the decreasing involvement of humans in driving and the associated risks to driver safety. While technological innovations promise benefits such as improved efficiency, comfort, and potentially fewer accidents, we cannot overlook the negative aspects that come with these changes. One of the key issues associated with increasing vehicle autonomy is the gradual weakening of drivers' skills and experience. When we rely on technologies that take over part or even full control of the vehicle, it can lead to a reduced ability of drivers to respond to unusual situations or critical moments on the road. When their role is limited to mere supervision and occasional intervention, drivers may gradually lose their alertness and reaction speed.

Another significant risk is the insufficient interoperability between autonomous vehicles and regular drivers. When vehicles with different levels of autonomy share the roads, situations may arise where underdeveloped or incompatible systems fail to effectively adapt to each other. This can result in confusion on the road and increased accident risks.

The issue of cybersecurity cannot be ignored either. With connected vehicles and an increasing reliance on electronic systems, new threats of misuse and hacking emerge. If autonomous vehicles are inadequately protected, they may be vulnerable to attacks that could have serious consequences for driver safety.

The psychological and human factor is another aspect of concern. People are accustomed to being in control and having a sense of mastery over their vehicles. With the transition to higher autonomy, a sense of loss of control and trust in the vehicle may arise, which can have a negative impact on drivers' mental state and their ability to respond appropriately in emergency situations.

The transition to higher vehicle autonomy is inevitable and can bring many benefits. However, it is important to be aware of the risks associated with the decreasing involvement of humans in driving and the increased safety hazards for drivers. Development efforts must focus not only on achieving higher autonomy but also on ensuring safety, interoperability, and protection against cyber threats. Only a balanced and thoroughly considered approach can ensure a safe and smooth transition to the era of autonomous vehicles.

Examples possible measures to address these risks:

- Strengthen driver education and training: It is crucial to focus on educating and training drivers to effectively respond to new technologies and situations associated with increasing vehicle autonomy. Including specific training programs, awareness campaigns, and safety information will help drivers maintain their vigilance and skills.
- Ensure interoperability and standardization: It is necessary to ensure that autonomous vehicles and their systems are interoperable with other vehicles on the roads. Standardizing communication protocols and security measures will help minimize the risk of confusion on the roads and accidents caused by improper communication between vehicles.
- Enhance cybersecurity: Manufacturers and service providers should prioritize high-level cybersecurity for autonomous vehicles. This includes regular software updates, strong data encryption, monitoring, and protection against potential cyberattacks.
- Emphasize the human factor: When designing and implementing autonomous systems, it is essential to consider human factors and driver psychology. Creating user-friendly interfaces that ensure clear communication between the vehicle and the driver and respecting the human need for control and engagement can help minimize negative impacts on drivers.
- Transparency and regulation: It is important for autonomous vehicles to be subject to strict regulatory norms and safety standards. Transparency in the development, testing, and approval of these technologies will provide public trust and ensure that autonomous vehicles are reliable, safe, and respect the interests of drivers and other road users.

Conclusions

In the world of car transportation, connectivity is crucial, and its effects on safety are clear. A safer and more dependable transportation environment is made possible through the use of connectivity as a way to improve safety, more effectively employ transportation resources, identify problems early, and coordinate transportation. Connectivity makes it feasible to track the health of cars in real time and spot potential issues early. This lowers the possibility of accidents and prevents component failure. Additionally, connection provides early identification of issues with the road network and infrastructure, allowing for quicker repairs and upholding a safe driving environment for all users.

Another benefit of connection is more effective utilisation of transportation. Systems with connectivity can analyse the flow of traffic and improve it, enabling quicker and more fluid vehicle movement. Not only do shorter wait times and fewer traffic congestion increase transportation efficiency, but they also reduce emissions and enhance the environment.

Another area where connectedness is important is in the coordination of transportation. Intelligent traffic management and adaptability to the environment are made possible through information interchange between cars, infrastructure, and transportation systems. Vehicles' ability to communicate and report their direction enables effective lane assignment and reduces disputes and crashes.

Overall, it is evident that connection has enormous potential to raise safety in the transportation industry for vehicles. The effectiveness, efficiency, and safety of road traffic may all be significantly increased by the proper application of connectivity and its integration into transportation systems and vehicles. To build a smart and secure transport environment for the future, it is crucial to keep funding investments and research in this field.

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