How Can V2X Technology Increase Safety and Security for the Autonomous Car?
Introduction

The increasing number of road accidents is leading to loss of life and property. It is estimated that globally nearly 1.2 million people die in motor vehicle accidents every year; an additional 20-50 million are injured. With more than half of all road traffic deaths occurring among people between the ages of 15 and 44, road accidents rank as the 9th leading cause of death and account for 2.2% of all deaths globally. According to studies, an average of nearly 400,000 people, under the age of 25, die due to road accidents with 90% of all road fatalities occurring in low and middle-income countries. Apart from the massive loss of life every year, accidents also leave a trail of financial losses behind. It is estimated that every year road accidents cost USD 518 billion globally with low and middle-income countries accounting for nearly USD 65 billion annually.

Unless specific measures are taken, road traffic injuries are predicted to become the fifth leading cause of death by 2030.

While attempts have been made to reduce road accidents through legislation, technology, better infrastructure, and driver education, various innovations have been made in the automotive industry to make vehicles safer and reduce accidents.

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These systems range from warning the driver about an impending hazard to automatically taking control of the vehicle and maneuvering them to safety. Based on the technologies used, these systems can be classified as Active Safety and Passive safety systems.

**Active safety systems:** These systems take complete control of the vehicle in case of an emergency. Actions can include steering the vehicle, applying brakes, etc.

**Passive safety systems:** Passive safety systems provide a warning to drivers in case of emergency situations such as a vehicle in blind spot or obstacle in front when driving under low visibility conditions. The signals can be an audible beep, vibration in steering column, or message on the dashboard screen.
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These systems are being progressively integrated into various categories of Autonomous vehicles. The automotive industry has come up with various levels of autonomy based on the level of engagement concerning the active and passive safety systems:

1. **Level 0 (No Autonomy)** – Many cars on the road today fall into this category. They mainly depend on the person to drive the car. These vehicles may include passive safety systems that warn a person in case of a hazard like an ultrasonic sensor for rear-ending, rearview camera, etc.

2. **Level 1 (Driver assistance)** – Some of the features like Adaptive Cruise Control, Automatic Lane Control, etc. are done by the car. Such systems rely on sensors and basic vision-based systems.

3. **Level 2 (Partial Automation)** – Level 2 includes enhanced driver assistance, but still, the driver needs to be in control. This level includes driver assistance for steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver performs all remaining aspects of the dynamic driving task.

4. **Level 3 (Conditional automation)** – In this level all aspects of driving are automated. Cars at this level will ask drivers to intervene when the self-driving systems fail.

5. **Level 4 (High Automation)** – These are fully autonomous cars that work well in road conditions. They can monitor the road conditions and drive safely to the destination. As per SAE, Level 4 includes all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene.

6. **Level 5 (Full Automation)** – This is the ultimate level of autonomy where the car is driven autonomously irrespective of the environment, surroundings.

The automotive industry has come up with various levels of autonomy based on the level of engagement concerning the active and passive safety systems.
Realization of each of these levels requires a combination of technologies as follows:

1. Use of sensors like Ultrasonic sensors, Lidar, Radar
2. Use of Advanced Driver Assistance Systems based on computer vision
3. Use of Vehicle-to-Vehicle (V2V, V2I, V2X) technologies

**Ultrasonic sensors**: These are used for parking and have a short range of 15 centimeters to 5 meters. They are primarily used in rear parking solutions.

**Lidar**: Light Detection and Ranging (Lidar) is based on the technology which fires millions of light beams and processes the reflections that are detected from the objects. Lidar technology provides a 360-degree view of the surroundings and is a key technology that helps create a view of the surroundings. Lidars help cars detect a pedestrian or cyclist, ranging from about 10 to 50 meters away.

**Radar**: Radars are used in use cases like adaptive cruise control, collision warning/mitigation, etc. Radars have a range of around 200 meters, and their operation is not affected by climate. Most automotive radar systems use a pulse-Doppler approach, where the transmitter transmits for a short period, and the system switches to receive mode to process the reflections for extracting range and relative motion of detected objects.
**Vision-based ADAS Systems:** These are based on computer vision technology that operates by processing the images captured by the cameras mounted at different points on the vehicle. Some of the applications of vision based ADAS systems are:
- LDW – Lane departure warning
- FCW – Forward collision warning
- BSD – Blind spot detection

Vision-based systems suffer from performance limitations under low light conditions or foggy situations.

**V2X:** This enables real-time communication between the vehicle and its surroundings. V2X includes vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-pedestrian. Vehicle-to-vehicle and vehicle-to-infrastructure help in increasing road safety through some of the services as described below. The key communication technologies used in V2X are:

1. **Dedicated Short Range Communication (DSRC) based on 802.11p:** This technology has been there for a decade and has been under trial in various parts of North America. 802.11p is based on existing Wi-Fi technology 802.11. Compared to 802.11b, the range has been increased by reducing the bit rate.
2. **Cellular Vehicle to Vehicle (C-V2X):** This technology is driven by 3GPP, the body behind standardization of cellular technologies. C-V2X claims to provide better performance due to the multiplexing scheme and turbo coding resulting in better error resilience, MIMO antenna, no packet loss at high density, etc. It also proposes a roadmap for connecting to the wide area network that would facilitate other services like real-time information exchange with smart city infrastructure, broadband provisioning in the car, Internet of things, etc. C-V2X is driven by players who have their origins in the mobile industry as the architecture has many elements that are common with cellular infrastructure. While these technologies differ in the access layer, the C-V2X industry leverages the work done over a decade by standard bodies like IEEE, ETSI, SAE in standardizing the interfaces at higher layers like network and transport layer, facilities layer, application layer, etc.
The key use cases enabled by these technologies are as follows:

- Driving assistance from roadside units – Road hazard warning where warning is sent from roadside infrastructure to the vehicle
  - Emergency electronic brake lights
  - Wrong way driving warning
  - Stationary vehicle – accident, vehicle problem
  - Traffic condition warning
  - Signal violation warning
  - Roadwork warning
  - Collision risk warning

- Driving assistance from surrounding vehicles – These are real-time messages sent from one vehicle to another in its vicinity. These include speed, direction of heading, location, etc.
  - Emergency vehicle warning
  - Slow vehicle indication
  - Intersection collision warning

- Urban mobility through integration with the broader ecosystem of traffic planning systems
Each of these technologies has their advantages and disadvantages. As we move from lower levels of autonomy to higher levels, one technology is not sufficient and vehicle manufacturers use a combination of technologies.
Autonomous cars will need a combination of the technologies described above to achieve various levels of autonomy. The following table gives an overview of technologies required for various levels of automation:

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<th>Level</th>
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<td>Radar</td>
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<td>Radar, Vision-based ADAS, Lidar</td>
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Also, technologies like V2V can be deployed in standalone manner or combination of other technologies to provide better warning of the hazards during driving thereby preventing accidents.

Given the focus of potential of the various technologies including V2V, various trials have been going around to assess these technologies. The UK Connected and Intelligent Transport Environment (UK CITE) creates a real-world-lab for companies to test how connected and autonomous vehicles (CAV) can interact with communications infrastructure. The University of Michigan’s Transportation Research Institute has undertaken several projects on automated driving and smart city initiatives using V2X.
What has been the progress so far?

**Regulatory:** Considering the potential of V2X technology in making roads safer steps have been taken by several countries towards the regulatory framework.

USA has issued a notice for proposed rulemaking in December 2016 for new light vehicles and to standardize the message and format of V2V transmissions. This is based on DSRC technology. This will create an information environment in which vehicle and device manufacturers can create and implement applications to improve safety, mobility, and the environment. The proposed schedule would require 50% of new cars to have DSRC by 2021, 75% by 2022, and 100% by 2023.
In Europe, Germany is the first country to have passed legislation on automated driving which includes V2V communications. Germany is currently cooperating with France regarding a combined digital testing facility for real-time cross-border traffic including Cross-border V2V and V2X communication. Other countries have started to recognize the benefit of V2V and have initiated steps towards regulation.

**Technology:** On the technology front, the key challenges are:

1. Interoperability between different devices that form part of the V2X system
2. Cost competitiveness of the solution to drive mass market adoption
3. Validation of the solution and ensuring reliability under various environmental and driving conditions
4. Ensuring privacy and security – For example, hacking into messages sent may have a potentially disastrous effect regarding accidents/tracking of persons

There have been innovations from the semiconductor industry regarding coming up with cost-effective chipsets for V2X. New players like NXP, Autotalk, Qualcomm have been introducing new chipsets for V2X which is expected to provide a further boost to cost reduction.
Various technologies for autonomous vehicles have the potential to improve safety and comfort of the automobile. For a solution to be successful, it is essential that it generates economic value to various constituents of the value chain. The key players include automotive Tier-1s and their suppliers, automotive OEMs, road operators, telecommunication network operators, and municipal corporations running smart city projects.

Technologies like V2X require the evolution of an ecosystem where adaption by other players will generate the network effect resulting in higher benefits to all participants. V2X technology requires investment in roadside units (RSU), backhaul communication between RSU and core network, analytics systems to monitor and regulate traffic, etc.

Telecom operators through their extensive presence with cellphone towers can leverage their existing infrastructure to provision RSUs; using C-V2X technology. Other monetization methods are possible in terms of providing real-time updates. V2X and other autonomous driving technologies could increase vehicle safety resulting in benefits to users as well as insurance providers.
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