THE FUTURE OF AUTONOMOUS VEHICLES: RISK WITH PRIVACY AND TRACKING

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The emergence of autonomous vehicles and the use of semi-autonomous technologies have been making news headlines in recent years. With the ever-increasing discussions regarding the use of autonomous vehicles in the commercial and private sectors, a number of questions may come to mind, aside from the common: how do they work, and how do they avoid collisions?

The ability these technologically advanced vehicles have to connect is tremendous. Autonomous vehicles (AVs) today can connect to satellites, to other vehicles, to systems, to devices, and to our own personal data. So what does that mean for data security? Can driver data be collected and used after an accident?

Before we dig in, it's important to understand the evolution, and how autonomous vehicles have become a part of the Internet of Things.

Highlights

- Privacy and security in a new era of autonomous vehicle innovation.
- What the levels of automation mean for these vehicles.
- How autonomous vehicles work.
- Collision avoidance systems and accident prevention.
- Manufacturing liability and legal concerns.

PRIVACY AND SECURITY IN A NEW ERA OF AUTONOMOUS VEHICLE INNOVATION

The vehicle industry is more than 100 years old, and in the beginning, technology advances primarily came in the form of better manufacturing, resulting in more affordable vehicles. The last 10 years have been a watershed of technology innovation with an almost manic obsession with driverless vehicles as the "next big thing." As with so many disruptive advances in technology, driverless vehicles will not only create new industries and opportunities, but this new technology will also result in a shift in privacy for the average person and an entirely new area of forensic and litigation expertise.

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We are already in the age of a permanently connected car with features such as hot spots and cellular access. But this is primitive compared to the level of connectivity that will be needed to fully realize the vision of driverless vehicles navigating in congested urban environments. AVs will eventually become part of the ever-growing Internet of Things (IoT) where all kinds of devices are communicating with each other and with the AVs.

The Internet of Things (IoT)

As more "things" are connected, via the internet, to other devices and networks, like cars, trucks, GPS devices, personal fitness watches, home automation devices, nanny cams, industrial plant controls and even refrigerators, privacy becomes an even greater concern. There are currently more than 8.4 billion "things" connected to the Internet. Every device, whether it is a computer or a vehicle, is susceptible to hackers either compromising the software and taking over or using the device for their own nefarious purposes.

The Upside to Connectivity

Communication within this new electronic environment can enable cars and trucks to share their location and speed with other vehicles to avoid collisions. The on-board sensor suites react, with superhuman speed, to inputs from the vehicle and the environment immediately around the vehicle.

> The Mirani Botnet is a well-known event where, in an effort to make more money, some Minecraft server operators decided to compromise IoT devices and attack servers and knock their competitors offline.

AVs will also communicate with other parts of the environment (e.g. traffic management systems), to help avoid traffic jams and gridlock.

It's an interesting preview into this new communication environment, with examples such as Apple's CarPlay and Google's Android Auto. Both of these systems communicate with the electronic environment from the vehicle while linked to the driver's cell phone. Other communication systems such as On-Star have features such as live sensor data, GPS tracking, and can offer control of vehicle systems remotely. Systems such as OnStar have been in existence for more than 20 years, and in 2001, began being offered as an accessory for non-GM vehicles.

Drivers can even make purchases, ask for directions, or control their linked smart home devices with Echo Auto, when Ford announced it was bringing Alexa into vehicles in 2017.

However, this is only the beginning as the true implementation of autonomous vehicles will need high speed, high availability, communications. The ability for a vehicle to communicate with other vehicles, and with land-based traffic monitoring systems, will be key to the widespread adoption of autonomous vehicles.

The Downside to Connectivity

What makes all of this both exciting and a little frightening is the fact that this style of communication, and our devices (which are now integrated into our vehicles), are all hackable. Imagine getting into your car, pressing the start button and having a ransomware message appear, "If you want to start your car, send $500."

*Mirai is a malware that turns networked devices running Linux into remotely controlled "bots" that can be used as part of a botnet in large-scale network attacks. It primarily targets online consumer devices such as IP cameras and home routers.

The more ways we are able to sync our communication systems together, and find those links, the more likely some enterprising hacker will find a way to exploit one of those links in some way.

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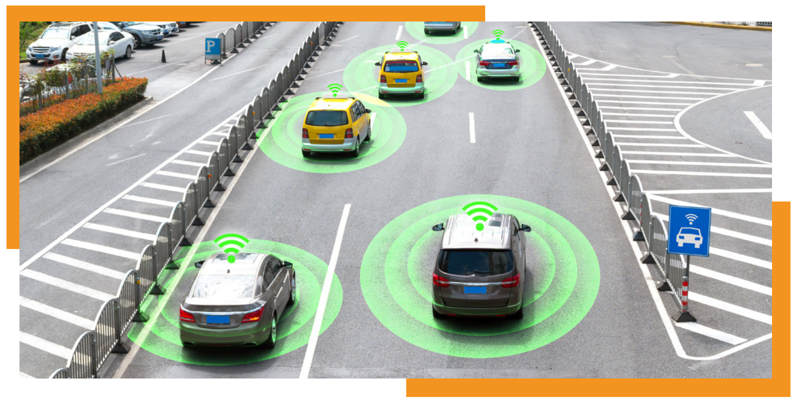
Data and More Data

Big data and crowdsourcing has become one of the biggest economic booms in recent memory. Consider just how much data has been collected on shopping habits, purchasing patterns, personal preferences and social media preferences. With the advent of the connected vehicle, which will be a critical precursor to wide scale adoption and deployment of AVs (big trucks, cars, taxis, and so on), even more data will be collected about what is going on with any vehicle, at any time.

HOW DO VEHICLES DRIVE AUTONOMOUSLY?



A multitude of sensors and actuators help vehicles to operate autonomously. These sensors and actuators are needed for navigation, driving, and managing the performance of the vehicle's internal systems.

Existing, high-resolution maps of known roads help vehicles navigate. High-resolution GPS sensors in vehicles can pinpoint the vehicle's location on a map—down to the appropriate lane in which the car is driving. Cadillac paired up with Ushr to drive and survey every interstate in the U.S. and Canada in order to develop its SuperCruise autopilot system. SuperCruise's high-resolution maps are accurate down to 5 cm. (1.97 in.), documenting every curve, turn, and tollbooth. With built-in custom maps, automakers can geofence specific areas where drivers are able to use autopilot features.

Levels of Automation

There are different levels of vehicle autonomy that range from 0 (no automation) to 5 (full automation).

Level 0 – No automation. Vehicles with cruise control in which the driver sets the desired speed is considered to be Level 0.

Level 1 – Driver assistance. Adaptive cruise control that modifies a vehicle's speed or steering assistance in certain scenarios is considered to be Level 1 autonomy. Level 1 also includes electronic stability control (ESC) and anti-lock braking systems (ABS). The driver must monitor the system and assume control if needed.

Level 2 – Partial automation. The system controls speed and steering in certain scenarios. The driver must constantly monitor the system and assume control if needed.

Level 3 - Conditional automation. The system can perform the driving functions in certain scenarios. The system notifies the driver when its limits are reached. The driver does not need to monitor the system but must assume control within a certain time frame upon the system's request.

Level 4 – High automation. The system can perform all driving functions and the human driver does not need to monitor the system. The vehicle can stop safely and transfer control to the driver if needed.

Level 5 – Full automation. The system performs all driving functions without driver assistance.

Most semi-autonomous vehicles currently available to consumers have Level 2 autonomy. Drivers must keep their hands on the steering wheel, otherwise the vehicle will issue a warning. However, it's important to note that prior to the warning, that level of autonomy could potentially afford enough time to tempt drivers into taking their eyes off the road for a few seconds and send a text message or look in a purse or bag, increasing the possibility of a vehicle accident.

Semi-Autonomous Systems and Radars

Current semi-autonomous systems use multiple forward, side, and rear-facing cameras to detect the roadway, lane markings, other vehicles, cyclists, pedestrians, and other obstacles. Stereo vision systems allow for distance estimation. However, variations in lighting conditions and the effects of shadows pose a challenge to current vision-based systems for steering control of autonomous vehicles. Additionally, while vision systems can capture a lot of detail, they require a lot of computer processing power to interpret the data.

Ultrasonic sensors emit sound waves and capture the reflected signal in order to determine the distance of obstacles in the immediate vicinity of a vehicle. In automated parking technologies, when the vehicle is moving slowly, ultrasonic sensors detect obstacles and calculate the optimum steering angle needed to park the vehicle.

Radar uses radio waves for short and long-range detection of other vehicles, seeing through heavy rain, fog, and dust. Short-range radar applications such as blind-spot detection and lane-change assist operate at 24 GHz. Current automatic emergency braking systems (AEBS) and adaptive cruise control (ACC) technologies use long-range radar at 77GHz, with ranges of up to 250 m. A radar system transmits radio waves to the target object, and this signal is reflected back to the receiver.

"In busy environments, the reflected signal from a motorcyclist or pedestrian beside a large truck may be obscured by the stronger signal from the truck, making the smaller object almost 'invisible' to the radar system."

The difference in frequency between the transmitted and reflected signals can be used to measure the distance of the target object as well as distinguish between different targets. However, smaller targets such as motorcyclists and pedestrians have relatively smaller areas of hard and metallic surfaces to reflect a radar signal. In busy environments, the reflected signal from a motorcyclist or pedestrian beside a large truck may be obscured by the stronger signal from the truck, making the smaller object almost "invisible" to the radar system.

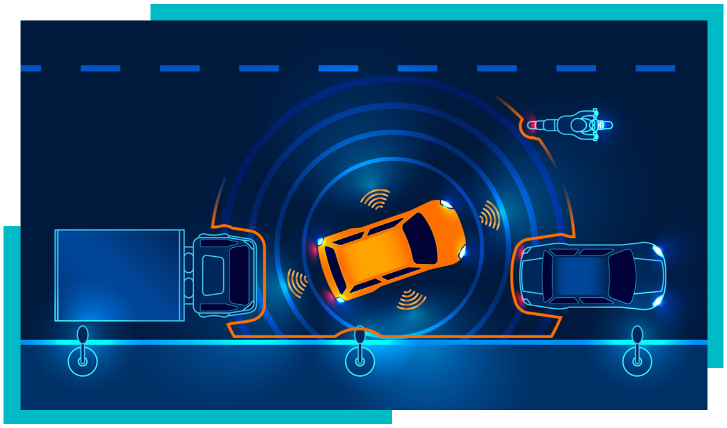
High-level Autonomous Systems and LIDAR

Most of today's automakers assume that LIDAR (light detection and ranging) sensors are an integral part of Level 4 and Level 5 autonomous systems. Although its range is not as great as that of radar, LIDAR technology is much more precise. LIDAR detects the position and shape of objects by computing the time it takes to send out an infrared beam and for it to be reflected back. It can create a detailed, 3D point cloud of objects, with sufficient resolution that the object can be identified. However, LIDAR sensors are currently very expensive and therefore are currently not suitable for large-scale production.

Control Systems

At the heart of the autonomous system is a control system that can interpret all the large amounts of data collected by the sensors. The control system must filter out irrelevant data points, analyze the relevant data, and determine an operational plan. Instead of relying on explicit programming, companies are using machine learning to develop self-driving vehicles. In a machine learning algorithm, a vehicle must continually observe the surrounding environment, detect objects, classify those objects, and predict their movement. The control algorithm is trained by first exposing it to one set of data and then testing it on a different set. For example, the algorithm could be fed images of different objects, annotated by the type of object contained in the image, such as a vehicle, a pedestrian, or an animal. During this process, the algorithm modifies its parameters to adjust its internal definition of each object type. When presented with a new set of images, the algorithm will be able to classify objects with high accuracy. Researchers are working on ways to use machine learning, along with GPS data and LIDAR sensors, to allow a self-driving vehicle to navigate unmapped roads. Vehicles are trained on data from one set of roads and then tested on another set.

As a result of machine learning, the operational decision of a self-driving vehicle results from the numerous traffic situations to which the control algorithm has been previously exposed. This means that in order to understand a vehicle's behavior, examination of its source code is not sufficient, and simulation and testing are also required.



COLLISION WARNING AND AVOIDANCE SYSTEMS

The National Transportation Safety Board (NTSB) prepared an investigation report in May 2015, following a review of vehicle crashes that occurred between 2012 and 2015. These crashes reportedly resulted in 28 fatalities and 90 injured people. In the report, the NTSB explored technologies used by manufacturers that were found to reduce front-end and/or rear-end crashes through the use of collision warning systems and/or active braking. The NTSB concluded that the use of Collision Warning Systems (CWS) and Collision Avoidance Systems (CAS) would be effective in preventing vehicle crashes and saving lives.

Collision Warning Systems (CWS)

Collision Warning Systems (CWS) help drivers to avoid crashes by providing visual, audible and/or tactile warnings of approaching hazards. CWS systems use many of the sensing systems described above to alert a driver if the distance between the vehicle and an object becomes too short that a crash is imminent. However, the driver is in full control of the vehicle and is responsible for taking evasive action, such as performing a steering maneuver to prevent an accident.

Collision Avoidance Systems (CAS)

On the other hand, Collision Avoidance Systems (CAS) help drivers avoid crashes by providing assistance through active braking, passive braking, and steering inputs, in addition to audible, visual, or tactile warnings. One method designed to aid a driver in avoiding a collision is a Dynamic Braking Support (DBS) system.

> "Another form of CAS involves lane departure technology, which assists drivers of semi-autonomous vehicles by gently turning the steering toward the center of the lane when a driver begins to drift outside of the lane lines or onto the shoulder."

DBS systems utilize data from feedback devices located around the vehicle to initiate collision avoidance measures. By pre-charging the braking system fluid pressure, the system is able to facilitate faster engagement of the brakes once the driver begins to depress the brake pedal. More advanced systems are capable of fully applying the brakes to decrease stopping distance in the event of an emergency once the driver begins to apply the brakes. Autonomous Emergency Braking Systems often utilize technology that will alert the driver of a potential hazard and then apply brakes if the driver fails to respond to the audible and visual warnings.

Another form of CAS involves lane departure technology, which assists drivers of semi-autonomous vehicles by gently turning the steering toward the center of the lane when a driver begins to drift outside of the lane lines or onto the shoulder. Additionally, a feedback mechanism will alert the driver of their departure through visual and audible alerts. More advanced vehicle systems incorporate an additional feedback device in the seat that will vibrate when the driver begins to drift outside of the lane lines.

Think of the impact this could have on the trucking industry...

Many industry leaders and analysts predict that the trucking industry will, in fact, lead the way in the adoption of autonomous vehicle technology. It is simple economics when you think about the fact that the commercial freight vehicle population is half that of consumer vehicles, yet turns over twice as fast. This means that generations of trucks will be adding new driver assistance and autonomous vehicle technology at a much faster rate. Autonomous vehicles will improve safety and should allow for the extension of the driver workday without making any compromises. The burden of driving a big rig would be shared by technology.

ACCIDENT PREVENTION AND SCENARIOS

Automobile manufacturers are still working to achieve a greater level of reliability and control in deploying collision avoidance measures while maintaining a competitive advantage. However, we do know that manufacturers already have the ability to provide steering control through power steering system design modifications. Many manufacturers have been using some form of brake assist algorithms in a variety of currently available vehicle systems including Electronic Stability Control (ESC) and Traction Control (TC). With the newer throttle-by-wire systems, which are replacing traditional physical connections, the accelerator pedal provides an electronic input to the vehicle's computer. Therefore, accelerator control can be accomplished by modifying control algorithms already used in the vehicle's powertrain control and engine control modules.

Inclement Weather

Bad weather often results in a loss of traction and a need for the engagement of vehicle TC systems, all-wheel drive systems, and ESC. As a vehicle starts to slide sideways on ice or on snow-covered roadways, there is often a need for steering inputs, braking inputs, all-wheel drive, and stability control algorithms to work together simultaneously. To be effective, all of this must be accomplished by the collision avoidance system as it attempts to remain aware of the vehicle's surrounding environment including other vehicles, pedestrians, roadway features, and obstructions.

> "Ideally, control systems and collision avoidance measures would share data between connected vehicles to determine the best possible action to avoid having a connected vehicle collide with another connected vehicle, person, or object."

Sensing Danger

Tesla reports that they utilize eight cameras to provide 360 degrees of visibility around the car with a range of up to 250 meters (820 ft. or 273 yds.) Tesla currently uses 12 ultrasonic sensors to complement this vision, allowing for detection of both hard and soft objects at nearly twice the distance of their prior system. A forward-facing radar with enhanced processing is reported to provide additional data about the world on a redundant wavelength that is able to see through heavy rain, fog, dust, and even the car ahead.

Connected vehicle (CV) technology is an emerging technology designed to facilitate vehicle-to-vehicle communication to avoid circumstances that cause or contribute to crashes. CV technology development is being encouraged by the Department of Transportation and the NHTSA as a means of establishing continuous communication between vehicles within range of each other. The goal of CV technology is to increase the chance of collision avoidance by creating a dialogue between vehicles that could potentially come in contact with each other because of their trajectories. Ideally, control systems and collision avoidance measures would share data between connected vehicles to determine the best possible action to avoid having a connected vehicle collide with another connected vehicle, person, or object.

Effect of Smart/Autonomous Systems on Perception-Reaction Time

While makers of autonomous vehicle technology believe they incorporate adequate feedback devices and anti-collision measures, forensic engineers and vehicle accident reconstructionists question whether or not the speed at which collision avoidance can be achieved will be sufficient in all cases.

Perception-reaction time is a term commonly used by vehicle accident reconstructionists to determine if a party involved in a serious or fatal collision had adequate time to avoid a crash. In cases where it can be demonstrated, scientifically, that a crash was avoidable, a forensic engineer can provide expert testimony to convey that data, and help explain why there was adequate time to avoid a collision.

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Automobile manufacturers have not yet released proprietary information or data revealing the amount of time required to initiate and complete a collision avoidance measure. We will need to stay tuned for the results of competitive vehicle test protocols designed to measure an autonomous vehicle's ability to successfully avoid collisions in real world situations.

Consider the fact that, as a general rule, reconstructionists use a perception and reaction time of 1.5 to 2.5 seconds as an industry accepted time frame for a driver to perceive a hazard and react by attempting to avoid the collision. This means that 1.5 to 2.5 seconds may pass before an attentive human driver will then begin to brake or steer to avoid a hazard and collision. During the perception-reaction time period, the driver is still covering ground and closing in on a potential target.

The question of whether or not autonomous vehicles receive enough input from their environment to make good driving decisions, and to allow other drivers adequate perception-reaction time, is being explored as we learn more about the benefits and drawbacks to this new technology. While users of the technology may claim that vehicles are able to deploy crash avoidance measures almost instantly, a better understanding of the technology and its limitations will be necessary to ensure that perception-reaction times in real world situations are acceptable in cases where, for example, a child suddenly darts out in the street in front of the vehicle, or when an object falls from either a vehicle or a building.

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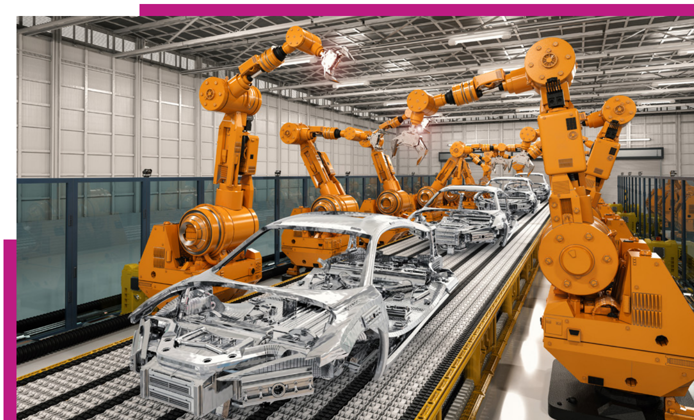
It should be no surprise that there is a point where adding too many sensors and feedback systems to the vehicle is cost prohibitive. Only time will tell if vehicle buyers will pay the additional costs related to having a vehicle equipped with the best available collision avoidance technology.

Types of Driver Override Features

Drivers interested in the possibility of purchasing a vehicle with semi-autonomous features such as the Tesla, often wonder if they will have an opportunity to quickly take control of the vehicle to avoid a collision that they believe could be imminent without a driver input. According to Tesla, "All Tesla vehicles produced in our factory, including Model 3, have the hardware needed for full self-driving capability at a safety level substantially greater than that of a human driver." While this is possible with vehicles like the Tesla Model S, manual vehicle control may not technically be possible to achieve instantly without autonomous vehicle interference. While the period of time required to override autonomous control, this could potentially be the difference between a near miss and a serious collision.



MANUFACTURING LIABILITY AND LEGAL CONCERNS RELATING TO COLLISION AVOIDANCE

While many manufacturers are embracing the new technology and opportunities autonomous and semi-autonomous vehicles present, users and makers of autonomous control systems likely have concerns surrounding a greater level of legal liability because of alleged vehicle defects. If a vehicle is advertised as having crash avoidance technology and it's involved in a crash, the ramifications could potentially be extremely costly for those who manufacture or sell those vehicles.

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CONCLUSION

There is no doubt that autonomous vehicles are the future for a number of reasons, with the primary driving force being economic (just think about the savings in fuel costs and the potential for fewer accidents).

But, when big data is collected and potentially accessible by third parties, technicians, and even intruders or hackers, it begs the question, will personal privacy become an issue in both criminal and civil litigation?

The amount of technology and innovation that has gone into the testing and design of these vehicles can absolutely afford the driver with the luxury they envision. But that doesn't mean that luxury comes without a cost. As with most technologies, it's never 100 percent reliable. There will always be idiosyncrasies. It's not fool proof or accident proof. It could pose possible concerns with manufacturing liabilities. But that is the beauty of innovation, and it doesn't mean it's not still an incredible creation.

Will driverless cars continue to be the "next big thing?" We don't know. But we do know it will likely continue to cause disruption to the taxicab and trucking industries at a minimum, for countless reasons. The progress in this new industry, over the next few years, will prove to be an exciting time.

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