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Autonomous Vehicles: Transition and Technology - the Future is Now

1) Current Vehicle Technologies and Evidence Preservation Techniques

Classifications of vehicle technologies

Researchers, manufacturers, and suppliers to manufacturers use different taxonomies to describe vehicle technologies. For the purposes of vehicle safety systems, these are typically discussed in terms of passive and active safety systems. Passive and active safety systems are distinguished from one another based on whether they work to prevent or mitigate a collision. Passive safety systems in automobiles enhance survivability during or after a collision. Examples of passive safety systems include seat belts, air bags, crumple zones, and fuel pump cutoff switches.

In contrast, active safety systems act in the pre-crash period and serve to either completely avoid, or to mitigate the severity of, a collision. Examples of active safety systems include stability control (a system that detects loss of steering control and compensates at the wheels; required under a phased-implementation starting in 2009 US-market vehicles; 49 Code of Federal Regulations (CFR) Parts 571 & 585), brake assist (a technology that increases braking pressure under emergency braking), and collision avoidance/mitigation braking (a technology that detects objects ahead of the vehicle and, in the case of mitigation braking, attempts to brake to avoid contact).

Similarly, automated vehicle technologies may be classified in different manners. The two most prevalent taxonomies of vehicle automation are those from the National Highway Traffic Safety Administration (NHTSA) and from SAE International (SAE). NHTSA’s taxonomy has four levels, ranging from Level 0 (no automation) to Level 4 (driver-optional). SAE’s taxonomy is published as standard J3016[1] and has five levels, and ranges from Level 0 (no automation) to Level 5 (optional human management). The primary difference between the NHTSA and SAE classifications is in the definitions of intermediate levels where the human is either required to monitor or be ready to assume control from the automation. Recent NHTSA publications have followed overall industry trends and migrated to the use of the SAE taxonomy.[2]

Current state-of-the-art in evidence preservation

Current best-practices in evidence preservation include obtaining data from the vehicle (via the airbag control module and infotainment system), the use of 3-dimensional (3D) laser scanners, and precisely mapping and preserving the road using drone aerial photography and videography.

The types of data available on vehicles have increased over the past decades. Initially, data from the airbag control module on a vehicle was limited to information on the vehicle's crash pulse. While the types of data on these systems still vary widely, the types of data when information is made available to researchers include information on driver inputs, crash sensing, and even (on some newer model vehicles) deployment of supplemental restraints (e.g., seatbelt pretensioners and active headrests) and pedestrian protection modules (e.g., raised hoods and external airbags).

Telematics systems that are built into the vehicle, such as the OnStar system found on General Motors brand vehicles, can provide important information for understanding vehicle collisions. These data can include timestamped information as to the location of the vehicle, as well as route information, that may be useful in accident reconstruction. Interestingly, there are no current limitations as to how long OnStar retains data collected by the system.[3] While OnStar's data retention allows for the potential to retrieve accident data after the destruction or disposition of a vehicle involved in an accident, it also serves as a common example of retention policies for automotive third-party data.

Infotainment system downloads have also become available. The data available from these systems vary widely – both across and within manufacturers – and can include information about paired vehicles, active and prior telephone calls, texting history, vehicle location and speed, and even the status of vehicle equipment such as headlamps (on/off) and doors (open/closed). This is a rapidly evolving field in which greater data availability may be expected over the coming years.

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[1] SAE (2016). J3016: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. Warrandale, PA: SAE International.

[2] National Highway Traffic Safety Administration (NHTSA). (2017). Automated Driving Systems 2.0: A Vision for Safety. Available from https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf.

[3] https://www.onstar.com/us/en/footer-links/privacy-policy.html

The current state of the art in measurement of vehicle damage as well as site measurement is 3D laser scanning. A single scan can include both laser measurement and photography. A highly-accurate laser measures the distance to millions of points in a sphere around the device. In addition to the measurements, photographs are taken of the environment. Using specialized computer software, data from multiple scans are combined. Ultimately, this provides a 3D measurement-accurate model of the environment or vehicle that can be used for additional measurements, understanding how vehicles came together, creating high-quality animations, or printing scaled models of vehicles or sites.

2) Emerging Technologies and Accident Reconstruction

Active Safety Technologies

Active safety systems such as collision mitigation braking and collision warning systems are becoming more common on new United States-market vehicles. These systems hold the potential to reduce the severity of, or even completely avoid, a substantial number of collisions. For example, research has indicated that a forward collision warning system can reduce the rates of rear-end impacts by 20%, with reductions of up to 56% possible for systems that warn the driver and then provide collision mitigation braking.[4]

Level 2 Automation

While most individuals assume that automated vehicles will only be available in the far-future, vehicles with some limited abilities to control steering, acceleration, and braking are currently available. These include systems that are designed to control the vehicle in stop-and-go traffic, commonly known as Traffic Jam Assist (TJA), and systems that provide highway speed hands-off/feet-off cruise control (i.e., Mercedes-Benz Distronic Plus Lake Keeping Assist, Tesla AutoPilot, and Cadillac SuperCruise). Vehicles with TJA or highway speed automation allow the driver to remove their hands and feet from the controls of the vehicle. However, the driver is required to monitor the roadway as the vehicle could require driver intervention with little or no warning.

Evidence preservation and collision reconstruction

Capturing the evidence for, and performing a scientifically-valid reconstruction of, a collision involving a modern vehicle requires an approach utilizing all current best practices of forensic data collection. That includes obtaining data from the vehicle airbag control system, infotainment system, and vehicle manufacturer, as well as undertaking a comprehensive evaluation of the accident site to understand the confluence of driver, vehicle, and environmental factors that could have contributed to the collision event.

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[4] Cicchino, J.B. (2017). Effectiveness of forward collision warning and autonomous emergency braking systems in reducing front-to-rear crash rates. Accident Analysis & Prevention, 99, 142-152. doi: 10.1016/j.aap.2016.11.009.

In the case of vehicles offering some form of automation, this process is complicated. Information regarding the automation state of the vehicle may not be provided via the airbag control module or infotainment system. Therefore, obtaining data from the vehicle manufacturer may be required. For example, the National Transportation Safety Board (NTSB) examined a crash involving a 2015 Tesla Model S being operated in AutoPilot (an automated vehicle control system) and a 2014 Freightliner Cascadia tractor with a 53-foot refrigerated semitrailer. While extensive data was collected by the Tesla vehicle (including radar, machine vision, ultrasonic, and camera data), the vehicle did not and was not required to have an event data recorder (49 CFR 563). Therefore, the NTSB was required to work with Tesla to obtain data relevant to the collision investigation.[5] As regulation has not addressed highly automated and self-driving vehicle technologies, scenarios such as this may become increasingly common.

Data from an accident site should also include aerial photography. While as little as a decade ago this was an expensive proposition, the availability of commercial-quality drones has greatly reduced the cost of obtaining aerial photography and video from crash scenes and recent crash sites. However, drone aerial work requires understanding the rules and regulations present from the Federal Aviation Administration (such as the licenses required to legally operate a drone for commercial purposes, and limitations on the flight area for drones), as well as how to capture evidence of interest such as tire marks and roadway geometry in a manner that can be integrated with scaled diagrams and forensic animations.

3) Near-Future Technologies and Accident Reconstruction

Level 3+ automation

While there is generally little public awareness of the automated driving capabilities of current vehicles, there is also little awareness of the state of development of Level 3 and higher automated vehicles. Numerous automakers, industry suppliers, and technology companies are actively developing and performing limited public-road testing of Level 3-5 automated driving systems. One of the better-known companies performing public-road testing is Waymo (formerly known as Google X's Self-Driving Car project). Waymo has reported a fleet-total of over 3 million miles.[6]

The operational concepts for these highly-automated vehicles has varied, but are largely centered on removing the need for a driver for certain types of operations or removing the need for a driver altogether. This can include vehicles that retain steering wheels, but offer the ability to have the vehicle control all aspects of the drive (including emergency responses). It can also include vehicles that do not offer the ability for the driver to have any control over the vehicle except for specifying a destination.

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[5] Gregor, J.A. (2017, May 7). Driver Assistance System Specialist's Factual Report (NTSB Report No. HWY16FH018). Washington, DC: National Transportation Safety Board.

[6] https://waymo.com/ontheroad/

The lack of a requirement for a driver creates the potential for a number of new operational concepts. Populations who would previously not be able to have automotive transport, such as disabled individuals, children, and the elderly) would be able to travel upon demand. Different ownership models, including ride sharing, become feasible. Transportation as a service may become more prevalent, replacing our traditional single-owner/single-operator model. This has the potential to greatly change the way most Americans approach vehicle ownership, driving, and commuting.

Several challenges to implementing these highly-automated vehicles are present. At a most basic level is their ability to safely operate on public roads. Determining the real-world performance of automated vehicles requires extensive on-road testing. Research conducted by the RAND Corporation has identified that approximately 275 million miles of automated vehicle driving would be required to demonstrate performance equivalent to human operated vehicles.[7] Beyond this, automated vehicles are currently operating in limited ranges within urban areas, in non-inclement weather conditions. Operating across all weather conditions, in areas outside of major cities, will be necessary.

In addition, there are legal and policy issues that must be resolved before any nationwide implementation of highly automated vehicles can proceed. Multiple states have enacted legislation addressing the operation of automated vehicles. The U.S. Department of Transportation has released a model policy for state and local agencies regarding automated vehicles.[8] Harmonization across these different entities will likely be necessary to allow for a unified nationwide implementation.

But one of the most important unanswered questions in this space is liability and insurance. The technology to allow for self-driving vehicles is continuing to evolve at a much more rapid pace than the framework for insuring such vehicles. This will continue to be a major barrier to a nationwide implementation of self-driving vehicles.

Challenges to data accessibility

Self driving vehicles continue to be a major development push for manufacturers, Tier-1 suppliers, and technology companies. However, data ownership is also becoming an important topic as the potential for additional revenue streams and different ownership models becomes likely.

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[7] Kalra, N., & Paddock, S.M. (2016). Driving to safety: How many miles of driving would it take to demonstrate autonomous vehicle reliability? Report No. 1478-RC. Santa Monica, CA: RAND Corporation.

[8] National Highway Traffic Safety Administration (NHTSA). (2016). Federal automated vehicles policy. Available at https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf

Data is increasingly not stored on the vehicle, or only stored on the vehicle in a very limited fashion. As illustrated in the NSTB investigation of the Tesla Model S crash, a very limited segment of data was present on the vehicle and a much fuller dataset present with the manufacturer.[9] This is unlikely to be a unique approach due to the potential for developing profiles of individual operators. In addition to data from automakers, data from third-party telematics providers such as OnStar and other firms will be critical for gaining information that can be vital in reconstructing a collision involving an automated vehicle.

4) Summary

Vehicles offering some degree of automation are currently for sale in the United States. Vehicles offering higher levels of automation are coming onto the market, and vehicles that offer driver-optional automation are being developed. Vehicle technology and automation has the potential to reduce the number and severity of collisions. However, it also presents new challenges to accident investigation and reconstruction in terms of the types of data and evidence collision requirements. These are factors that entities involved in the management of vehicle claims will need to be aware of and prepared for in the coming years.

A comprehensive approach to evidence preservation is required for the reconstruction of crashes involving modern vehicles with advanced technologies. As automated vehicles become increasingly common, understanding what data are available, how to obtain them, and how to apply them to the reconstruction becomes critical.

[9] Gregor, J.A. (2017, May 7). Driver Assistance System Specialist's Factual Report (NTSB Report No. HWY16FH018). Washington, DC: National Transportation Safety Board.