Self-Driven

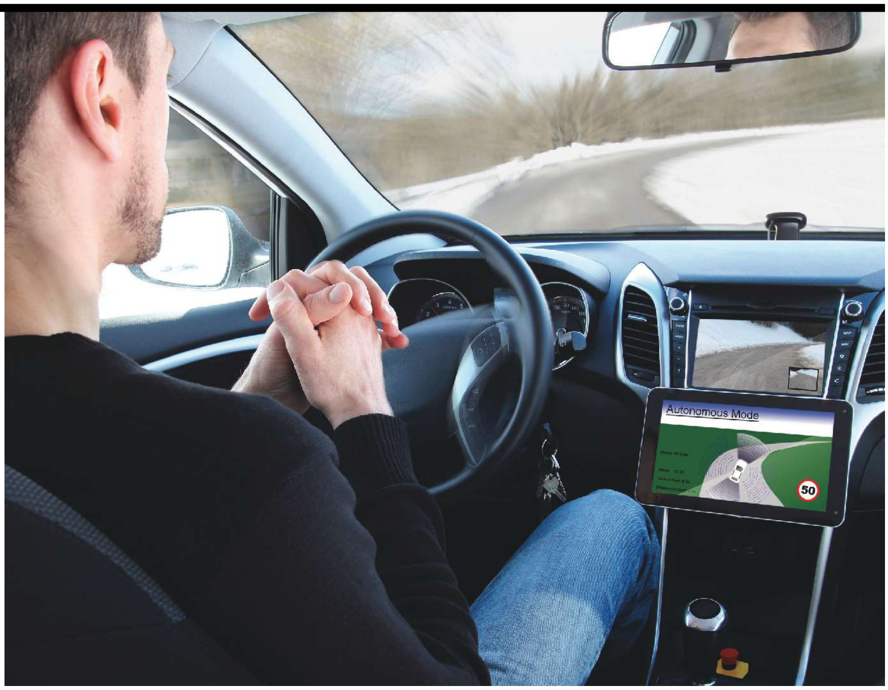
The Path Towards Autonomous Vehicles

By Steven M. Schorr and Joseph R. Fowler

It's hard to avoid car company advertising touting the latest innovations developed to reduce driver workload and increase safety. Equally common are news stories predicting the day when drivers will have little else to do behind the steering wheel than check their smart phones. Indeed, no longer the material of science fiction, auto manufacturers and technology companies are hard at work to ensure that the autonomous vehicle (AV) becomes a reality. However, the genesis of this trend actually began many years ago and has been steadily gaining momentum. Consider the automotive electrical system. Early systems had barely enough electrical capacity to blink a spark plug. Soon batteries and electronics were commonplace and with them came the foundation for virtually all future technological advances.

Autonomous Path

The tide towards autonomous vehicles actually began when vehicles went from the crank start to the automatic start, from manual brakes and steering to hydraulic braking and automatic steering. The path toward autonomous vehicles began whenever the vehicle assisted the operator in a task to help control the vehicle. A strong argument can be made that cruise control, a system common to many vehicle operators and now an industry standard, while not the first vehicle-assisted task, may have been the first major step towards vehicle autonomy. Although the system requires operator engagement, adjustment, and cancellation, once set, early cruise control systems became one of the first systems to relieve the operator of a significant portion of driving input. Several vehicle generations later, cruise control was followed by the anti-lock braking (ABS) system. While perhaps not immediately recognized as a system of vehicle autonomy, ABS operates under the basic premise that ideal braking performance cannot be achieved within the limitations of human perception and reaction. This is because ideal braking occurs when braking tires are allowed to "slip" rather than having 100 percent braking when an operator applies maximum braking. The "slip" only occurs when the tires are locked and released very rapidly, several times a second, which is much faster than human response time would allow. Factor in the very real benefit of maintaining steering control during maximum braking, and ABS soon also became an industry standard.



The next step on the evolutionary path to vehicle autonomy was external sensors. Reverse proximity sensors alerting drivers of objects within their path were followed by cameras, then forward and side-looking devices, all with alert capabilities. Recently, automobile manufacturers have begun an important shift in how these sensors are utilized. Specifically, rather than providing a simple alert to the driver, the sensors now can provide a direct input into the already-automated speed and brake control systems. For example, rather than simply sounding a warning device to alert the driver, these proximity sensors can actually remove the driver accelerator input and apply the brake. In fact, the most recent systems employ electronic, self-actuating steering systems allowing the vehicle itself to control essentially all of the basic driving demands such as parking and lane-change assistance. The takeover of these functions makes the vehicle partially automated.

Even the development of electronically-control comfort features such as power windows, seats, and door locks; climate control; entertainment systems; and especially navigational systems, though not actually automating the actual driving task, still provide valuable informational and interactive technological foundation for the communication of autonomous vehicles.

Not only do autonomous vehicles need to adapt to the roadway environment, but they also need to adapt to the presence of other vehicles, thus making vehicle to infrastructure and vehicle-to-vehicle communications a critical component of the autonomous vehicle process. Adding all these systems together into one vehicle results in a sophisticated product that is aware of its surroundings and that can adjust to them automatically, taking one more step on the path towards a fully automated vehicle.

Independent Freedom

However, the definition of autonomous is "having freedom to act independently." To that end, an autonomous vehicle (AV), a fully self-driving vehicle, must not only be able to operate the vehicle, but it must be designed to think on its own and make decisions on its own, without the operator's involvement. A true fully automated vehicle would require the vehicle to make all the driving decisions. To do that, the AV must decide what data to collect and then must collect the data, must process the data, and then must make decisions utilizing that processed data. The ability of an AV to make a split-second decision in an attempt to avoid a collision is based on Crash Optimizing Alorithms created by…humans.

So what would happen if an AV is confronted with a situation where a collision is not avoidable? For example, if an AV is traveling down a mountainous roadway approaching a narrow tunnel and just before entering the tunnel, a child attempts to run across the roadway, but trips near the center of the lane, blocking the path of the AV. The AV has two options — hit and fatally injure the child, or swerve into the wall on either side of the tunnel and fatally injury the AV occupant. The tunnel problem sets forth the issue of whether the AV should choose to kill the AV occupant or a third party. Who should decide how the AV should react (i.e., be programmed)? Options include: The AV manufacturer? One would think that the manufacturer would opt to protect their consumer over a third party. The government? What specific moral/ethical foundations would the governmental authority rely upon, and who ultimately would be in charge of making that decision? The AV owner? It is probable that the owner would choose self-preservation above other options.

The Tunnel Problem reflects just one tiny scratch on the surface of the incredibly complex issues relative to how an AV should be programmed to think. There are a multitude of moral, ethical, and legal dilemmas that will arise as the government and manufacturers travel down the path towards a time when people cede control of their driving experience over to their autonomous vehicle. From a litigation perspective, the function of the interacting vehicle components along with their potential communication with infrastructure that combine to move the AV will be a focus should there be a failure in the AV system. Additionally, one would expect that whatever algorithm is developed to define the actions of the AV would also be scrutinized as potential litigation targets.

While it may have taken 100 years or so to achieve the advancements witnessed during nearly every current car commercial, and while we have made considerable technical progress toward the autonomous vehicle, it may take a while longer to achieve the full vision of a world comprised of primarily autonomous vehicles. As the world moves toward a potentially fully autonomous future, it is clear that whether recognized or not, the automotive industry has been traveling the path to vehicle autonomy since its inception, and it continue to do so for the foreseeable future. LM

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Four Laws of Robotic Car

A beginning thought process for AV algorithms can be traced back to the Isaac Asimov short story "Runaround" where he sets forth three rules of robotics, which provide the framework of the four laws of robotic cars as set forth by Dr. Raul Rojas [Professor at University of Nevada, Reno].

Rule 1 – An AV may not injure a human being or, through inaction, allow a human being to come to harm.

Rule 2 – An AV must obey the traffic rules, except when they would conflict with Rule 1.

Rule 3 – an AV must obey the orders given to it by human beings, except where such orders would conflict with the First or Second Laws.

Rule 4 – an AV must protect its own existence as long as such protection does not conflict with the First, Second or Third Laws.