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Autonomous Car: The Next Revolution

Chinmay Kumar[1], Sukhwinder Singh[2]
[1]Student, Department of Electronics & Communication Engineering, PEC University of Technology, Chandigarh, India
[2]Asst. Prof., Dept. of Electronics & Communication Engineering, PEC University of Technology, Chandigarh, India

Abstract: In this paper we review and discuss about the future of cars, where they are retrofitted with self-driving functionality using sensor-based solutions. These systems, known as Advanced Driver Assist Systems (ADAS), use a combination of advanced sensors, such as stereo cameras and long- and short-range RADAR, combined with actuators, control units, and integrating software, to enable cars to monitor and respond to their surroundings. Some ADAS solutions, such as lane-keeping and warning systems, adaptive cruise control, back-up alerts, and parking assistance, are available now. Many others are in the pipeline.

Keywords: RADAR, Actuators.

Introduction

We've all had those days: rushing around, trying to get errands done. You finally picked up the dry cleaning, and now you've got to get to the post office before it closes. So you go, pedal to the metal, thinking about what you need to get at the grocery store for dinner, when it hits you -- or, you hit it. While your mind was someplace else, the car in front of you stopped, and you rear-ended it. What could have prevented the accident? The obvious answer is that you could have -- by paying attention. But that answer isn't so simple. Driver error is the most common cause of traffic accidents, and with cell phones, in-car entertainment systems, more traffic and more complicated road systems, it isn't likely to go away. But if drivers aren't going to concentrate on the road, who is? If technology continues on its current course, your car will do the concentrating for you. Automakers are developing complex systems that allow cars to drive themselves. They're also furthering existing technologies such as self-parking and pre- down the road, eliminating the driver from vehicles could change the way land space is developed. One, because people may be more willing to commute further to work, pushing out suburban sprawl; two, because the considerable space currently tied up for parking in cities could be freed up and used for development if cars could drop off their passenger and go park themselves further away. One of the most obvious advantages of these technologies will be to reduce accidents, injuries, and fatalities on the road. Human driver error is a contributing factor in almost 90 percent of crashes.

Reducing this figure could therefore not only make our roads safer, but also reduce traffic congestion, improve fuel efficiency, and extend vehicle life. According to the Eno Center for Transportation, a 50 percent penetration of the market with self-driving vehicles would save almost 10,000 lives per year, highway lane capacity would increase by 21 percent, and fuel consumption would be cut by 224 million gallons per year. These benefits are not limited to personal driving. The same consequences-and the same questions - are also applicable in the commercial trucking industry. The drill here is the ability to not only cruise at a fixed speed, but also to detect surrounding traffic using laser- or radar-based sensors and adjust speed, including brake application. Several manufacturers have driverless cars in the works, but since Google of all places has the jump on this project, they're also more forthcoming (sort of) about how their cars work. The Chauffeur system, as they call it, uses lidar, which stands for light detection and ranging and is not related to the liger, which is a lion and a tiger. Lidar works like radar and sonar, but it's far more accurate. It maps points in space using 64 rotating laser beams taking more than a million measurements per second to form a 3D model in its computer brain that's accurate to the centimeter. Preloaded maps tell the system where the stationary stuff is -- traffic lights, crosswalks, telephone poles -- and the lidar fills in the landscape with moving objects like people. It also has regular ol' radar, a camera and GPS to help out. Google is not the only game in town when it comes to semi-autonomous cars. There are several in the pipeline for the next decade or so:

The 2014 BMW X5 with the Traffic Jam system can already mostly drive itself up to 25 miles per hour (40.2 kilometers per hour), though the driver still needs to keep a guiding hand on the wheel. Tesla says it will have a car that operates on autopilot 90 percent of the time, which is similar to Google's Chauffeur, by 2016 -- if these two systems are legal by then, that is.

Mercedes-Benz brought its self-driving S500 Intelligent Drive car to the Frankfurt Auto Show in 2013, promising to have a version on the market in 2020.

An Audi A6 Avant at the 2013 International Consumer Electronics Show used the Mobileye system to drive itself at speeds up to 37 miles per hour (59.6 kilometers per hour). It should reach showrooms by 2020.

Nissan has outfitted an all-electric LEAF with an array of lasers and sensors so it can drive itself. The head of Nissan, Carlos Ghosn, predicts it will be the first semiautonomous car to market -- in 2020

Fig 1. Google first revealed driverless car in 2010

With demand for advanced in-car navigation and entertainment systems growing, vehicles are becoming ever better connected. From next year cars sold by GM in the United States and Canada will come with fast 4G mobile broadband. Improved connections will also make it possible for cars to send hazard warnings to each other, to receive a constant stream of information on the traffic and weather ahead and even to interact with signals as they approach junctions.

Fig 2. Preloading of route map and speeding instructions from GPS

In Ann Arbor, near Detroit, 2,800 cars, lorries and buses have been fitted with devices to send and receive such alerts. Some have just a simple beacon that informs other traffic of their location, speed and direction. Others have more elaborate kit that can detect, for example, if another wired-up car, out of sight around the next bend, has slammed on its brakes. Carmakers are keen to support such research. Ford has provided eight sedans for this experiment and is using them to try out various ways of alerting drivers: sounds, warning lights, even projections onto the windscreens using a head-up display. Jim Sayer, who is overseeing the trial, says drivers seem interested too: when his team went to local schools and a hospital looking for volunteers to have their cars wired up, they got far more than they needed.

The environmental benefits are also ambiguous. The report suggests AVs could save energy through more efficient use, say by driving closer together at lower speeds to make better travel time, much like a train. Plus, if crashes did go down, companies could build lighter cars to lower their carbon footprint. On the other hand, if driverless cars became super popular, that could mean more people are on the road in general because it's easier and more fun to travel, which would make congestion worse and make energy emissions—and fuel prices—shoot up.

More often than not news of "autonomous" cars that operate without a driver has been positive but last week in Tokyo their future was being predicted as having far more hurdles than is commonly reported. Hurdles include massive projected costs, connectivity barriers, liability questions, regulatory unknowns, lack of universal industry standards, and other technological limitations. These were all mentioned last week by engineers, IT specialists and others contemplating mass autonomous vehicle adoption.

Recent advances in computing power and networking technologies are improving the viability of both the technology and economics on a daily basis. Today's technology uses GPS to recognize where the cars are on the road. Cameras, lasers, and radar help them keep their distance from other cars and recognize objects like pedestrians. Superfast processors weave all the inputs together, allowing cars to react quickly.

Over time, data spidering systems, like those used by search engines, will be used to log details of every road in the country in real time, report potholes, cracks, or other dangerous conditions immediately when they occur, and build an information highway to serve as the backbone for our real highways.

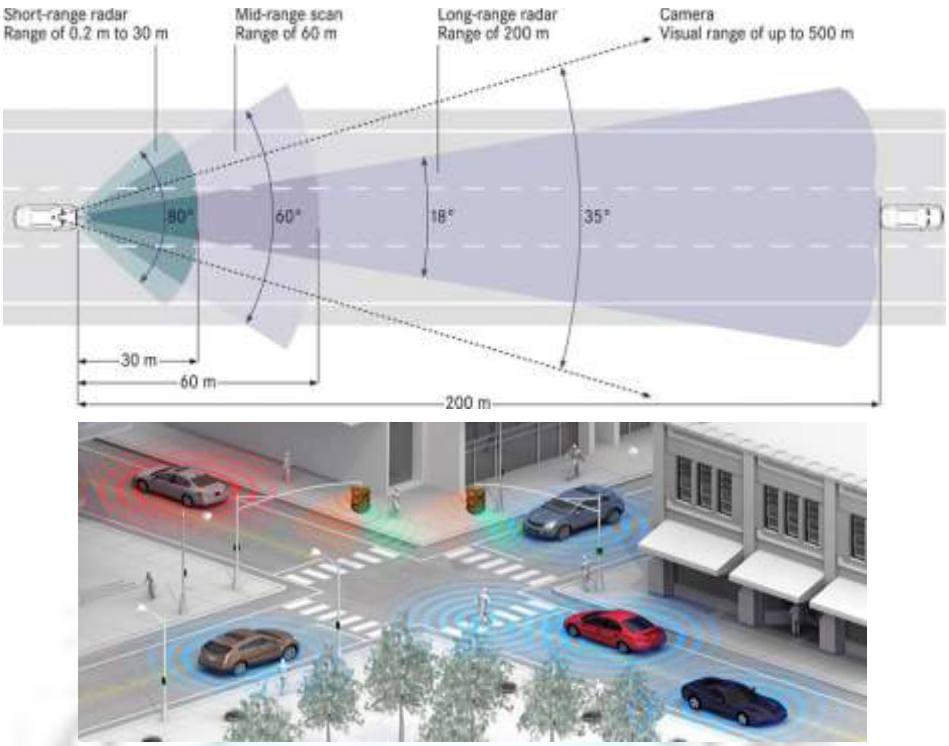

Fig 3 Connected-vehicle systems use wireless technologies to communicate in real time from vehicle to vehicle (V2V) and from vehicle to infrastructure (V2I), and vice versa

This is ironic according to a report by Automotive News that observed in previous years the people who are now throwing a wet blanket on autonomous vehicles are the same ones who hyped them up at previous meetings of the ITS World Congress. Autonomous technologies rely on Wi-Fi networks to control a vehicle careening down the road. These involve massive data streams of 1 gigabyte per minute monitoring all aspects of the vehicle, keeping it at speed, in place on the road, with myriad variables to contemplate like staying tuned to roadside sensors, mindful of stray pedestrians, objects in the road, curbsides, street signs and signals, and more.

Systems that might use cellphone networks or wireless communications are known as "Dedicated Short-Range Communication," and getting these right is considered critical to making autonomous vehicles happen. Christoph Hagedorn, CEO of Continental Japan, told Automotive News the data stream is "huge" and can be too much even for today's 4G LTE cell networks.

"It's no longer a challenge of the automotive industry. It's actually becoming an IT challenge," he said.

Another challenge to mass proliferation is limitations with sensors. A driving demonstration of an experimental autonomous Mitsubishi Outlander failed to warn the occupant sitting in the driver's seat of unaware pedestrians or motorcycles in the car's blind spot. Another time its "Caution, Oncoming Vehicle" buzzer sounded an alert to pedestrians, but it was tough to pinpoint which vehicle among several the warning was coming from. Nissans such as its experimental autonomous Leaf – shown in a positive report from another event below – could get around some issues by being equipped with multiple radar sensors, lasers and cameras to monitor surroundings and plot the car's course.

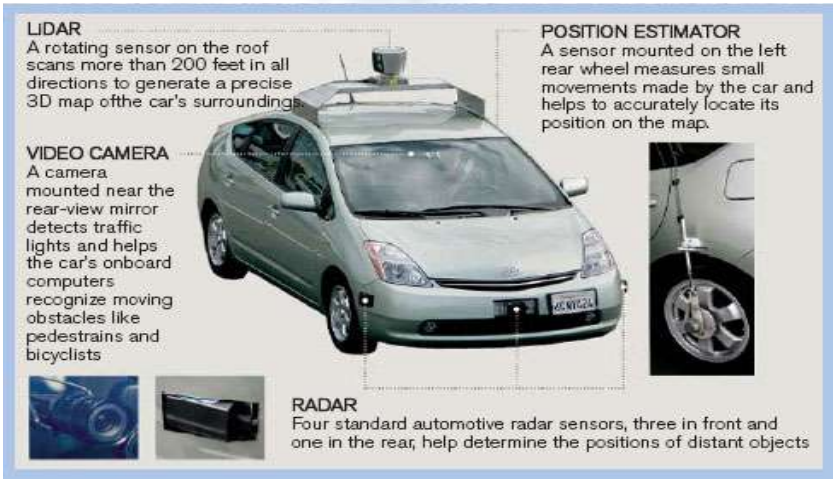

Fig 4 showing various components of driverless car

But sensors can't see well around corners or blind spots miles down the road. And cars' computers must instantaneously crunch millions of driving scenarios.

"The biggest obstacle is the millions of different driving scenarios you have to face," Hagedorn said. "There are so many driving scenarios it will probably require years of validation."

Another issue standing in the way is the cost to dot the landscape with sensors and radios needed to feed data to the cars as they roll down the road.

These would alert of construction work underway, traffic jams, oncoming cars, blind spots, emergency vehicles or hidden stop signs, and such systems are already in place in Japan and plans in South Korea and Europe also call for them.

A universal standard is seen as needed so all cars will operate across the platform and these would have to be at every intersection, say those researching the issues.

- In New York City, an estimated 13,000 intersections would need to be wired with these state-of-the art technologies and the money seems daunting to those who have been pushing autonomous technology. Problem is, in most countries, legislation does not allow for cars to operate without on-board human supervision. That will have to change before such systems can be made available. That applies even more so to cars able to ply highways and byways fully automated, but we'll get back to that subject in a moment.
- While we're in this transitional phase of semi-automated cars, there are also serious safety concerns. As more and more of the work load is taken away from the driver, keeping the driver focused on the task at hand becomes more difficult.
- That only becomes worse when you factor in both the factory fit and portable gadgets now found in most modern cars. If the car is doing most of the driving, the temptation to send that text only gets worse.
- Out of all the statistics and information utilized within the research paper, there is still much research to be done regarding the government's views on driverless cars in states other than California, Florida and Nevada. Legally speaking, liability issues as well as the legality of driving in such cars are two topics that have not been addressed much yet. This is most likely due to the recent introduction in autonomic cars in our society. One question is, if people from the three states that legalized this technology wished to purchase driverless cars, will they be able to drive these cars in states other than those in which it they are legal?
- Furthermore, security issues regarding the driverless car are another topic in which much more research is required. As paradoxical as it is to say that driverless cars may become unsafe due to viruses or malfunctioning, it is true that Google has not released any information regarding the possibility of this event. Although passengers can take control of the car at any time they want, is there another way to ensure that the system's computer stays functioning while the car is driving itself?

Lastly, Google's issue with privacy is one that many people would naturally find to be unnecessary. Perhaps, upon purchasing a driverless car, Google should allow buyers the option to decide whether their whereabouts be known to the company or not.

Social Problems Involved

After a great deal of research regarding this topic, one may deduce that the greatest social and personal problem related to the driverless car is the fact that it takes away the essence of driving a car. One needs to weigh the benefits of the driverless car against the attachment they may feel towards controlling their vehicle at all times. Further, more economically, the success of insurance companies and their rates rely on human error and vehicular issues. The driverless car may have the potential to weaken and decrease the number of jobs in such a large market. Such a significant decrease in collisions per year may indeed have a grave effect on the U.S. economy. Lastly, utilizing the car will be the driver's decision to sacrifice some privacy. Google has refused to endorse simple privacy protection. In a letter sent from Consumer Watchdog to the California governor, "Google's entire business model is based on building digital dossiers about our personal behavior and using them to sell the most personal advertising to us. You're not Google's customer; you are its product," ("Consumer watchdog," 2012). The fact that one's movements and destinations can be recorded and sent back to the Google headquarters certainly does imply that one's privacy will be compromised in return for a driverless car.

Security Concerns

The widespread implementation of driverless cars, as safe as they are designed to be, indeed has some chance in posing as a threat to a passenger. Buyers will essentially have to make a personal decision as to which is safer: the machine's calculated decision versus a human's natural intuition and discretion. As secure as the car may seem with its cameras, maps and calculations, computers are never fully immune to the risks of crashing, malware interference and viruses. At times, airplanes and traffic control systems fail due to such technological anomalies. The buyer must then weigh the benefits with such a concern. What makes the driverless car vulnerable to this risk?

Most important of all, the driverless car will drastically reduce the carnage of road accidents and the colossal medical costs associated with them. A new study by the World Health Organization shows that such accidents kill a shocking

1.24m people a year worldwide. McKinsey's Mr Kaas says that in China and other countries where most motorists are fairly new to driving, safety features are an important selling point for cars.

Cars on autopilot will also radically change the car-insurance business. Most of the cost of this is to cover liability for accidents, which will become rare, so revenues will come down a lot. Stricter speed limits, safer cars, seat belts and the like have already brought a steady decline in casualty rates since the 1960s, when Ralph Nader wrote his anti-car diatribe, "Unsafe at Any Speed", but now there are signs that in America "distracted driving"—texting, phoning and tweeting at the wheel—is reversing the trend.

If automated driving means more people are able to use cars, and more cars can safely be fitted onto the same roads, that should be good for the motor industry. In time cars that have hardly any accidents should also become cheaper to make, because they will not need to be so robust. But in the shorter term the carmakers will have to add lots of expensive sensors, computing power and software to their models, which will make it harder to turn a profit. Larry Burns, a former GM executive who now works on driverless cars and other transport issues, says the technology looks inevitable, but it is hard to see how it will deliver value for car companies' shareholders.

Final Thoughts

The reason driverless cars will prove to be so disruptive for the automobile industry is that it will enable on-demand transportation services to replace the need for individual car ownership. Rather than having to conform to the route and timing of today's mass transit systems, people will simply be able to request a vehicle through their smartphones whenever they need it, and a driverless vehicle will show up, on-demand, and take them to wherever they desire to go.

An on-demand transportation system will not significantly reduce the overall number of vehicles on the road at peak times, but will be better at matching the size of the vehicle with the number of people traveling. Since the vehicles will be in continuous operation, there will be significantly less need for parking spaces.

To be sure, this is a very complicated topic. Many other countries will be competing with the U.S. to become global leaders in this multi-pronged emerging industry.

With Google pushing the lobbying effort in Las Vegas, look for them to become the initial showcase for the world.

The military will likely find unusual uses in for these vehicles that have few civilian applications.

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Conclusion/Results

The coming years will see the public first embracing the technology and at the same time disdaining the tumultuous effects its having. In the end, we will be driving towards a far safer and more resilient society, but we'll be travelling down some very bumpy roads along the way.

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