

## Driverless Vehicles: Future Outlook on Intelligent Transportation

Akshay Ahuja\*, Ashu Gautam\*\*, Nidhi Sharma\*\*\*

\*(Department of Electronics and communication, ITM University, Gurgaon-Sector 23A, India)

\*\* (Department of Electronics and communication, ITM University, Gurgaon-Sector 23A, India)

\*\*\* (Department of Electronics and communication, ITM University, Gurgaon-Sector 23A, India)

### ABSTRACT

Numerous technologies have been deployed to assist and manage transportation. But recent concerted efforts in academia and industry point to a paradigm shift in intelligent transportation systems. Vehicles will carry computing and communication platforms, and will have enhanced sensing capabilities. They will enable new versatile systems that enhance transportation efficiency. This article surveys the state-of-art approaches towards the future outlook on intelligent transportation. Current capabilities as well as limitations and opportunities of key enabling technologies are reviewed along with details of numerous notable projects that have been done around the world. Finally report also reviews the legal and regulatory uncertainties.

### I. INTRODUCTION

A computer-controlled car that drives itself. Also called a "robot car" or "driverless car," or "Autonomous car" "in 2011, As an autonomous vehicle, it is capable of sensing its environment and navigating without human input. Robotic cars exist mainly as prototypes and demonstration systems. It sense their surrounding with such a technique as radar, GPS and computer vision. Advanced control system interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage. Some Autonomous vehicles update their maps based on sensory input, allowing the vehicles to keep track of their position even when conditions change or when they enter uncharted environments.

The Defense Advanced Research Projects Agency jump-started the driverless industry in the U.S. In 2004, DARPA offered monetary rewards for the winners of a 150-mile driverless vehicle race in the Mojave Desert in California. No vehicle completed the course, but 22 out of 23 vehicles finished the next race in 2005 with more curves and narrower roads. In 2007, six teams completed a 60-mile run through urban streets.

Driverless cars use lasers that scan the environment more than a million times per second (see [lidar](#)). Combined with digital GPS maps of the area, driverless cars detect white and yellow lines on the road as well as every stationary and moving object in their perimeter. Autonomous vehicles can drive themselves as long as a human driver can respond quickly to a "Take Control Now" message when necessary. The current cost of the technology is entirely prohibitive for everyday use; however, in time, the \$100,000 of specialized electronics is expected to decrease to the \$5,000 range.

Although most automobile companies are in some stage of R&D for driverless cars, Google has undertaken its own project that is considered by many to be state-of-the-art. By 2013, Google employees racked up more than 500,000 driverless miles without any major incident. It might seem odd for a search engine company to be pioneering a major change in automobiles; however, the effectiveness and success of this technology lies mostly with the software algorithms. Along with the enormous technology challenge, state laws have to be changed to allow such vehicles on the road. Whether fully autonomous vehicles are years away or decades away remains to be seen.

### II. OVERVIEW:

When this open ended question is asked with most of the people around us that: "If there was one futuristic invention that you could own, what would be?"<sup>[1]</sup>. The most popular answers: time machines, flying cars and flying bikes, personal space craft, self-driving cars, and teleporters. In short, people are looking for fantastical solutions to the otherwise mundane problem of getting around. When we try to envision how technology might significantly improve our lives, a lot of us are thinking about transportation. Of all of those inventions, autonomous cars are the closest to reality. Google is already piloting prototypes on California highways. And the federal government is already planning regulation for "vehicle to vehicle" communication technology, a feature that will be essential to autonomous cars as they ping signals back and forth to each other and to the infrastructure around them (in the absence of human command). There are a lot of logistics and technical details that will still take years to work out, but the ubiquitous autonomous car is a lot closer than the time machine.

The Google driverless car is a project by Google that involves developing technology for autonomous cars. The software powering Google's cars is called Google Chauffeur.<sup>[2]</sup> Lettering on the side of each car identifies it as a "self-driving car". The project is currently being led by Google engineer Sebastian Thrun, former director of the Stanford Artificial Intelligence Laboratory and co-inventor of Google Street View. Thrun's team at Stanford created the robotic vehicle Stanley which won the 2005 DARPA Grand Challenge and its US\$2 million prize from the United States Department of Defense.<sup>[3]</sup> The team developing the system consisted of 15 engineers working for Google, including Chris Urmson, Mike Montemerlo, and Anthony Levandowski who had worked on the DARPA Grand and Urban Challenges.<sup>[4]</sup> The U.S. state of Nevada passed a law on June 29, 2011, permitting the operation of autonomous cars in Nevada. Google had been lobbying for robotic car laws.<sup>[5][6][7]</sup> The Nevada law went into effect on March 1, 2012, and the Nevada Department of Motor Vehicles issued the first license for an autonomous car in May 2012. The license was issued to a Toyota Prius modified with Google's experimental driverless technology.<sup>[8]</sup> In April 2012, Florida became the second state to allow the testing of autonomous cars on public roads.<sup>[9]</sup> California became the third state to legalize the use of self-driven cars for testing purposes as of September 2012 when Governor Jerry Brown signed the bill into law at Google HQ in Mountain View.<sup>[10]</sup> Governor Rick Snyder signed legislation allowing the testing of automated or self-driving vehicles on Michigan's roads in December 2013, but requires a human in the driver seat at all times while the vehicle is in use. Google's robotic cars have about \$150,000 in equipment including a \$70,000 LIDAR (laser radar) system. The range finder mounted on the top is a Velodyne 64-beam laser. This laser allows the vehicle to generate a detailed 3D map of its environment. The car then takes these generated maps and combines them with high-resolution maps of the world, producing different types of data models that allow it to drive itself.

### III. HOW TO DO AUTONOMOUS CAR WORK:

Autonomous cars need to do basically two things to find their way and drive. The complete map of its surrounding area including the objects and the travel path defined in that area, and its relative position and what is doing with respect to that defined map – here defined means that the car "knows" the meaning of the objects in that map. Of course the map we are talking about here, and the

relative position of the car versus that map is dynamic and being continuously updated. In order to come up with this map an autonomous car uses equipment such as:

**1.1. Radar Sensors:** It is mainly used to detect various obstacles

**1.2. Cameras:** Currently used for distinguishing the lanes and backup assistance but as the image processing software gets more developed, the importance of cameras on board will increase, Image – processing software currently can detect traffic signs and lights, lane stripes, and other objects.

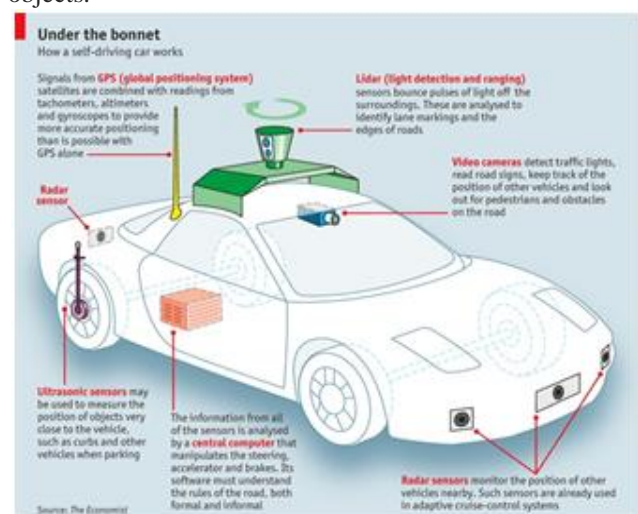


FIGURE- 1 DESCRIPTION OF THE AUTONOMOUS CAR

**1.3. GPS Units:** Global positioning system is used for determining a car's location by getting input from satellite.

**1.4. Accelerometer:** Help with navigation of the car when signal received from GPS devices are poor.

**1.5. Ultrasound Sensor:** Currently ultrasound sensors are mainly used for detecting obstacles in front and back of the car while automatically parking of the car.

**1.6. Wheel Sensor:** Also used in stability and anti- lock braking system, another use of the wheel sensor is to keep track of the vehicle's location when the GPS system is temporarily unavailable due to poor signals.

**1.7. Light Detection and Ranging (LIDAR):** Lasers that spin in order to constantly take horizontal distance measurements. Google's LIDAR system includes 64 infrared sensors units placed on the top of the car, which costs about US

\$70,000. The information taken from these measurements are combined with the information coming from cameras and the radar in order to create a detailed map of surrounding. With this sensor taking so many measurements of the immediate surroundings of the car, a detailed 3D map can be produced.

#### IV. Inertial Measurement Unit(IMU)

Its used for sensing the vehicles movement and maneuvering. It contains high accuracy 3-axis accelerometer and angle rate sensors to measure roll, pitch and angle rates. the IMU is part of position and orientation system and works with GPS to provide high accuracy position and orientation data.

Apart from these sensors some of the sensors system are also deployed which we might be using in our cars such as cruise control, antilock braking system, traffic assist etc. along with these and the above sensors combine in an automated way which are controlled by the controlling unit present inside the vehicle. In the figure – 3 is the illustration of the sensing action is shown along with the block diagram in

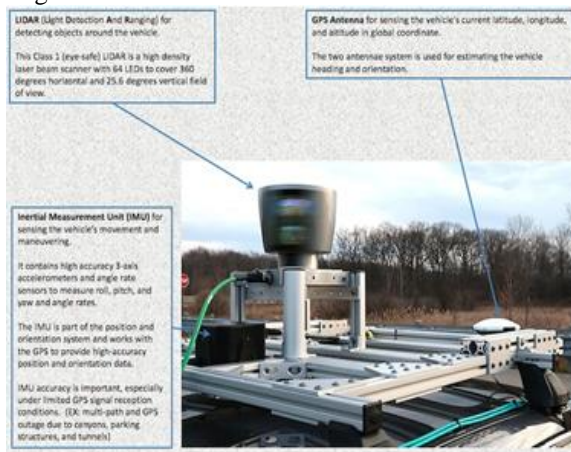


FIGURE- 2 SYSTEM USED ON THE TOP OF THE AUTONOMOUS CAR

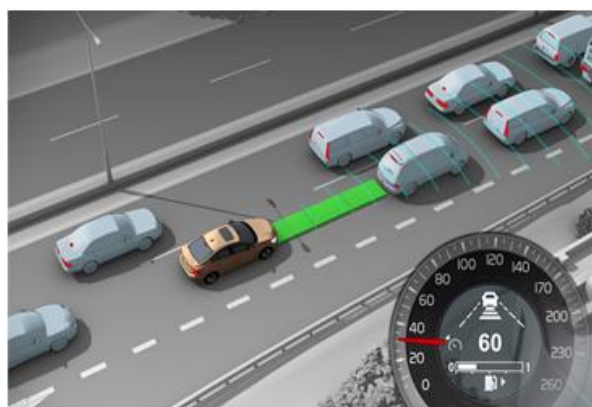


FIGURE- 3 ILLUSTRATION OF SENSING ACTION

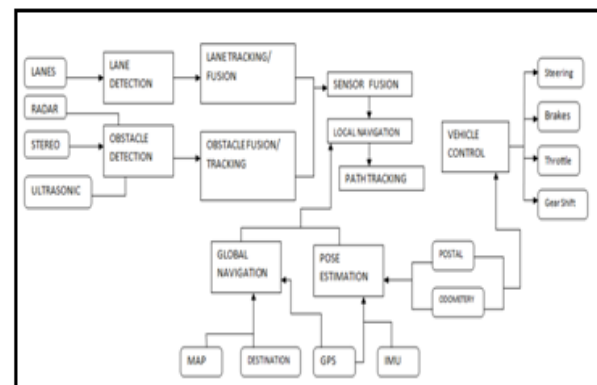


FIGURE- 4 BLOCK DIAGRAM DEPICTING OF WHOLE AUTONOMOUS CAR SETUP

#### NOTABLE PROJECTS:

- The DARPA Grand Challenge has been held in 2004, 2005 and 2007 as an autonomous driving competition with millions of dollars in prize money.
- In November 2010, Hyundai Kia Automotive Group held the Korean Autonomous Vehicle Competition (AVC), with a top prize of \$100,000.<sup>[citation needed]</sup> The Hanyang University A1 team won the prize.<sup>[citation needed]</sup>
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- In October 2013, KSAE and KATECH held the Korean Autonomous Vehicle Competition (AVC), with a top prize of \$100,000.<sup>[citation needed]</sup> The Hanyang University A1 team won the prize.<sup>[citation needed]</sup>
- The Google driverless car project maintains a test fleet of autonomous vehicles that has driven 300,000 miles (480,000 km) with no machine-caused accidents as of August 2012.
- The €800 million EC EUREKA Prometheus Project conducted research on autonomous vehicles from 1987 to 1995. Among its culmination points were the twin robot vehicles VITA-2 and VaMP of Daimler-Benz and Ernst Dickmanns, driving long distances in heavy traffic.
- The \$90 million Automated Highway System program demonstrated vehicle automation to thousands at Demo '97 in San Diego, California.<sup>[citation needed]</sup>
- The 2010 VIAC Challenge saw four autonomous vehicles drive from Italy to China on a 100-day 9,900-mile (15,900 km) trip with only limited human intervention, such as in traffic jams and when passing toll stations. At the time, this was the

longest-ever journey conducted by an unmanned vehicle.

- The ARGO vehicle (see History above) is the predecessor of the BRAIVE vehicle, both from the University of Parma's VisLab. Argo was developed in 1996 and demonstrated to the world in 1998; BRAIVE was developed in 2008 and demonstrated in 2009 at the IEEE IV conference in Xi'an, China.
- In 2012, Stanford's Dynamic Design Lab, in collaboration with the Volkswagen Electronics Research Lab, produced *Shelley*, an Audi TTS designed for high speed (greater than 100 miles per hour (160 km/h)) on a racetrack course.
- Oxford University's 2011 Wildcat Project created a modified Bowler Wildcat which is capable of autonomous operation using a flexible and diverse sensor suite.
- The Volkswagen Golf GTI 53+1 is a modified Volkswagen Golf GTI capable of autonomous driving. In his 2010 book, *Democracy and the Common Wealth*, Michael E. Arth claims that autonomous cars could become universally adopted if almost all private cars requiring drivers, which are not in use and parked 90% of the time, were traded for public self-driving taxis, which would be in near-constant use.
- AUTONOMOS – part of the Artificial Intelligence Group of the Freie Universität Berlin
- Toyota has developed prototype cars with autonomous capabilities for demonstration at the 2013 Consumer Electronics Show.
- In February 2013, Oxford University unveiled the Robot Car UK project, an inexpensive autonomous car capable of quickly switching from manual driving to autopilot on learned routes.
- Israel has significant research efforts to develop a fully autonomous border-patrol vehicle. This originated with its success with Unmanned Combat Air Vehicles, and following the construction of the Israeli West Bank barrier. Two projects, by Elbit Systems and Israel Aircraft Industries are both based on the locally produced Armored "Tomcar" and have the specific purpose of patrolling barrier fences against intrusions.
- The Oshkosh Corporation developed an autonomous military vehicle called TerraMax and is integrating its systems into some future vehicles.

#### ADVANTAGES :

There are several advantages of driverless cars. Accident avoidance is a major incentive, because the car is expected to respond faster than a human.

On a long highway trip, people will be able to read a book or watch a movie and arrive at their destination more relaxed. In its ultimate manifestation when driverless cars become the norm, many more vehicles can be on the road at the same time. In addition, the computer can operate the vehicle much more economically than most people.

#### LEGAL ISSUES:

As the cars will be driving themselves, the responsibility and liability picture will look a little different of course. In case of a car accident for instance, the liability will belong to whoever is responsible for not maintaining the software and the mechanical condition of the responsible car according to the laws and regulations. If you are the car owner, you will be responsible to make sure your car is maintained per the current laws. If you are the mechanic, you will be responsible for doing the maintenance per the standards. Owning a car that drives itself also means you do not have to go to the repair shop anymore. Your car will automatically go there when it needs to. I am suspecting that by the time we have widespread use of autonomous cars, auto mechanics will also be in a transition phase of losing their jobs to robots, so this whole maintenance process will look much more automated but that's another subject.

Nevada, Florida and California have already passed laws about driverless cars, as of January 2013. The laws require the motor vehicle department to establish the rules and standards for autonomous vehicle operation and serves to pave the way for mainstreaming the technology on the highways.

In Europe for instance, Volvo has teamed up with Car to Car Communication Consortium, in order to have the infrastructure of vehicle to vehicle communication, or the traffic lights and signs that communicates with vehicles to start to be in place within the next several years. If you remember the fact that chips are becoming more of a commodity like water or electricity, with ever decreasing prices and dimensions, it is inevitable in the very near future that everything around us will be intelligent. Another thing to consider when comparing the autonomous systems versus the manually driven system is the elimination of the human judgment, which is still far better than Artificial Intelligence and will be this way for a long time. It is true and we have already mentioned that the driverless cars will make less number of mistakes in comparison to the human drivers, but there will be some points in time that using an automated system will not be as good as a human making judgment with his common sense. All these different scenarios will needed to be sorted out before the driverless technology will be allowed but as we argued above,



even with occasional possible glitches, the overall benefits will far outweigh the costs.

## V. FUTURE OUTLOOK

Most of today's autonomous cars rely heavily on GPS systems and cameras to drive on the road without intervention from a driver. But Volvo claims that GPS systems and cameras have limitations in certain conditions. As a result, the automaker is currently testing road magnets as a safer and more reliable method to guide self-driving cars down the road. Volvo Claims Road Magnets are Safer than Cameras and GPS Systems for Self-Driving Cars | Inhabitant - Sustainable Design Innovation, Eco Architecture, Green Building According to Volvo, established positioning technologies such as GPS and cameras have limitations in certain conditions, but road-integrated magnets remain unaffected by physical obstacles and poor weather conditions. The auto manufacturer has announced that it has completed a research project using magnets placed in the roadway to help a self-driving car determine its position on the road.

Volvo teamed up with the Swedish Transport Administration to create a 100-meter long test track at its testing facilities in Hälleröd outside Gothenburg, Sweden. A pattern of round 40×15 mm ferrite magnets were placed 200 mm below the road surface and the car was equipped with several magnetic field sensors. The project was designed to evaluate crucial issues, such as detection range, reliability, durability, cost and the impact on road maintenance. "The magnets create an invisible 'railway' that literally paves the way for a positioning inaccuracy of less than one decimeter. We have tested the technology at a variety of speeds and the results so far are promising," says Jonas Ekmark, Preventive Safety Leader at Volvo Car Group.



FIGURE - 5 VOLO'S ROAD MAGNET IDEA

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