

A Comparative Study of Enabling Technologies for Autonomous Vehicles

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Abstract- Autonomous driving technology is an upcoming and fast developing, and a future business booster in the automotive, smart cities, transportation, and other related sectors. The better usage of the concepts such as Artificial Intelligence and Machine learning in the field of automotive industry is a promising one. Certain automobile companies are investing billions of money on research and development of self-driving vehicles. In this paper the author broadly discuss about the autonomous vehicles and their working functionalities, adding to that, the pros and cons of LiDAR technology behind every autonomous vehicles. This paper also throws light on other enabling technology such as GPS, Video Camera, Radar, Position Estimator and Distance Sensors and compare with LiDAR technology.

Keywords: Autonomous Vehicles, self-driving vehicles, LiDAR, GPS, Video Camera, Position Estimator, Distance sensors.

I. INTRODUCTION

The invention of the real autonomous vehicle goes back to 1926. A radio-controlled car devised by Francis Houdini which he drives without anyone at the steering wheel. This was published by New York Times. This car was controlled by radio to start engine, gear change, and horn. John McCarthy, father of Artificial Intelligence in 1969, called “Computer Controlled Cars” capable of navigating a public road via television camera input.

In 1990, Dean Pomerleau from Carnegie Mellon University (CMU) explains how neural networks are used to self-drive a car by taking raw images from road and send steering signals in real time. Pomerleau again in 1995 take their autonomous car on the road and travels over 2000 miles in coastal region of US. Then in the year 2000 sensor technology accompanies autonomous vehicle technology to assist the parking of the vehicle. Over the world each year it has been recorded that 1.2 million lives are lost, and 90% due to human mistakes. Humans are more used to have their own control on the vehicle over the machine control. Now a days people are being familiar by the idea of the vehicle taking over the driving task like automatic emergency decelerate.

Later several locomotive companies started research to improve self driving cars further in that Toyota, Lexus and BMW are prominent. Google ventures into the autonomous vehicle and its project Waymo initiated in 2009 at Stanford Artificial Intelligence laboratory. By the end of 2014 Google announced that their car driven 300,000 miles under computer control with no single accident. From then major automotive companies like GM, Ford, Benz, BMW and

others are working hard to launch their autonomous cars in the near future [1].

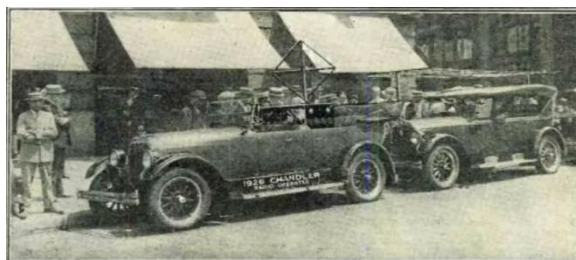


Photo credit Wikimedia Commons

Figure 1: Autonomous car, 1925

The concept of Autonomous Vehicle (AV) is part of robotic technology that uses several sensors for sensing the surroundings. A model called sense-plan-act combination of sensors such as LIDAR (Light Detecting and Ranging) along with GPS, Video Camera, and Radar [2].

Implementation of AV's is a challenging one because decision making must be very fast in severe conditions, infrastructures to facilitate the movement of AV's, communicating with other co-vehicles, the expectation that the AV's will perform better or equal with respect to the existing vehicles, environmental aspects [3]. The cost of these cars would likely not affordable to common people, price might be in the range of Rs. 7000000. If a car crash occurs legal process is a tough task. The AV's rely on information of users and locations would be a major security concerns. On the other side accidents can be minimized, traffic coordination and parking would be easy. The people like disabled, old aged and very young can travel freely. Speed

limits can be varied depending on the traffic; sensor technology works better than human, drastically reduces theft of car [4].

Over the last 10 years a rigorous notifiable developments have been made and many technologies are used in AV's such as Sensor technologies, Graphical Processing, GPS, Radar, LiDAR and many other. Off late the advances in the deep learning are well utilized for the purpose. The concepts like Transfer Learning, which is used for the purpose of detecting objects and its changes for autonomous navigation by a vehicle in real-time. Deep learning is used to detect and classify the traffic lights and lane. GPS system helps in identifying car position and navigation. Various kinds of sensors are used, like LIDAR, which measures the distance to the target [5].

II. WORKING FUNCTIONALITIES

Certain functionalities are used in AV's that detects the position of the vehicle itself and position of other vehicles nearby, edges of the road, lanes, traffic lights. Apart from these altering the steering, acceleration and braking, in conjunction of various systems together are used to control the driverless car.

RADAR: The position of the vehicle nearby can be identified by RADAR sensing technique. The Radar operates in any weather conditions and it can pierce through any objects. A set of radars are used to work in different directions whereas human driver look only in one direction. Obviously it is better than a human.

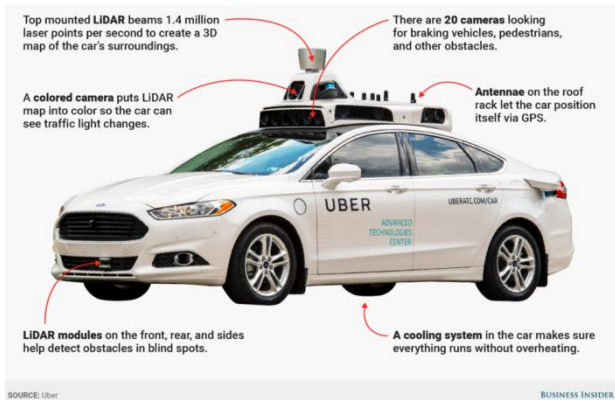


Figure 2. Different enabling technologies of Autonomous Vehicle

VIDEO CAMERA: These are basically used for reading the different signals such as brake lights of other pass by vehicles, traffic lights, the road signals; detect color of the signal, current speed limit used for detecting objects. The cameras upload footages to on board computer and the computer employs different algorithms to paint the picture of the vehicle. These processes are done at real time to draw

important reading and also the movement of the car is controlled [9].

LiDAR: It is abbreviated as "Light Detection and Ranging", developed in 1970, an important core hardware technology of driverless car. First used at National Centre for Atmospheric Research, used to measure clouds. It is a distance Sensor and uses light signal to gauge the objects surrounding the vehicle a number of times in quick succession to generate physical characteristics. The light sensor continuously encounters the laser pulses at 150,000 pulses per second by a target object and it bounce back to another sensor that calculates the time taken for the pulse return. A 3D map of the target object and its surface features will give result. The following copywriter picture shows the different components of LIDAR System that work in tandem for a common goal [11]. This consists of a laser, scanner and optics and a specialized GPS receiver, are very much vital for the movement of the system.

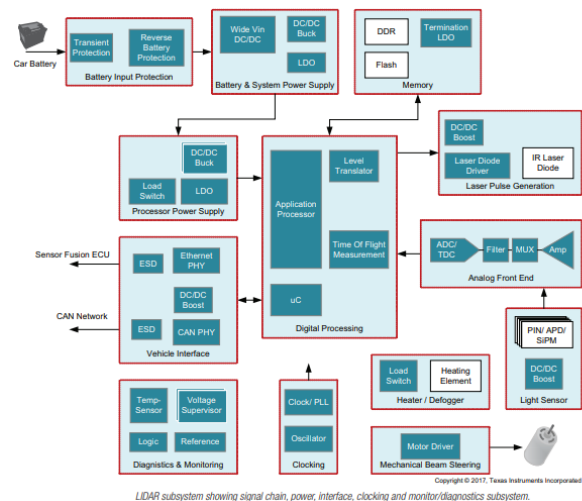


Figure 3. Components of LiDAR Sensor

Presently, there are different companies are using the LIDAR Technology, out of that Google and Uber are basic users. Google is particularly used to detect pedestrians and cyclists, traffic signs and other nearby objects.

GPS: These devices again very important for the navigation of un-manned vehicles. They provide HD 3D street maps and deliver large-scale of geographic terrain. Under a single-path condition, a robust GPS device would not only help in millimeter-accurate positioning and data correction, it would also mitigate the risk of spoofing and other vulnerabilities, such as radio interference and terrain-related blockages which means that malicious entities won't be able to intercept and tamper with GPS signals [12]. The advances in the area of positioning and sensor technology have tremendously coined to provide reliability for self-driving vehicles. GNSS or GPS, High precision Global Navigation

Satellite system that is capable of providing decimeter-level accuracy to ensure a vehicle stays in its lane, or a safe distance from other vehicles [13].

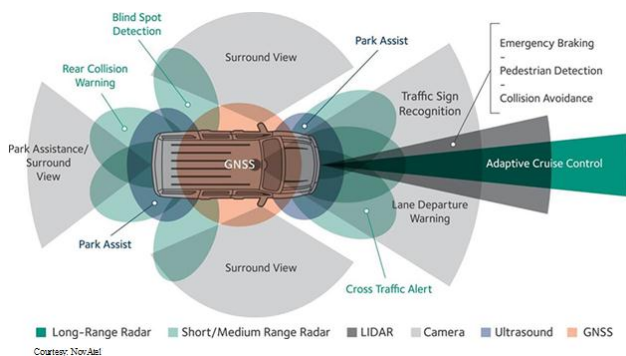


Figure 4: Shows the different technologies used and their application in the Autonomous Vehicles

POSITION ESTIMATOR: It is used to estimate how fast the vehicle is moving, and is implemented in Google car as an example on the left rear wheel and monitors the wheel motions. It is to detect the RPMs of the car, speed, which helps to know a more accurate position of the car [14].

III. PROS AND CONS OF LIDAR

As we gone through LiDAR have many merits as compared to demerits. It is used not only in automotive industry but also construction industry. This is a sensing technology gathers data very quickly and accurately as a result of positional advantage. It gives much higher surface density as compared to other methods. It has high penetrative abilities in densely forested area. Can be used at nights, no geometrical distortion, can analyze complex data automatically, very minimum human dependency, not affected by extreme weather.

On the Cons side, LiDAR, can be expensive and may be affected by heavy rain or hanging clouds, high sun angles or huge reflections. Unreliable in the areas of uneven water surfaces, huge datasets that require high degree of analysis and interpretation. Does not have a proper standards. Laser beams used by LiDAR pulses are usually powerful in some instances and these may affect the human eyes [16].

IV. CONCLUSION

Although the technology will essentially eliminate the need for humans to drive vehicles, bring a host of new infrastructure challenges and pose wider societal questions. There is always a saying that when a new innovation comes to market it reduces the number of jobs. However, this is not going to happen because it requires lot of skilled people required and jobs will be created.

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Bhavyashree P is currently pursuing her Masters in computer applications. She is interested in Artificial Intelligence and Machine learning and interested in many other programming languages also. She have done many technical certification courses. She continues her interest on this field.



Sharon Thomas Takri is pursuing her Masters in computer applications. She is interested in Artificial Intelligence, Machine learning, Blockchain. She has developed her interest in artificial intelligence after using smart assistance siri, amazon alexa, google assistance etc. she is also interested in learning new technologies related to Data science and Block chain and started with certification courses.



Prof. R. Gurunath is a Computer Applications profession with 25 years of experience in the field of teaching, accreditation, and administration activities. He obtained science degree from Bangalore University, Bangalore, India, 1989. He obtained Masters of Computer Application from IGNOU, New Delhi, India, 2002. He obtained Master of Philosophy from Madurai Kamarajan University, Tamilnadu, India, 2007. He has completed NPTEL certification course in the area of Analysis and design of algorithms, Cryptography and network security, and Internet of Things. He is presently working as assistant professor of MCA dept. at Dayananda Sagar College of Arts, Science and Commerce, Bangalore. His area of interest are Computer networks, Network security, Mobile computing, JAVA, Internet technologies, Advanced Web programming, and network programming. He has authored and co-authored of 6 research papers reputed journals. He has written one text book for VTU syllabus for the subject Operating System.

