

# Autonomous Vehicle: Challenges and Implementation

R. Sushma<sup>1</sup>, J. Satheesh Kumar<sup>2</sup>

<sup>1</sup>Student, Department of Electronics and Instrumentation Engineering, Dayananda Sagar College of Engineering, Bangalore, India

<sup>2</sup>Associate Professor, Department of Electronics and Instrumentation Engineering, Dayananda Sagar College of Engineering, Bangalore, India

E-mail: <sup>1</sup>sushmarajanna1712@gmail.com, <sup>2</sup>jsatheeshngl@gmail.com

## Abstract

Autonomous vehicles are the upcoming smart vehicles expected to be efficient, crash avoiding and driver less ideal urban vehicle. To attain this goal many organizations started research in this field to solve the real time problems faced during the development of autonomous vehicles. The first challenge in this phase is to customize the existing technology to develop autonomous vehicle with latest technologies. The future expectation is to develop fully automated vehicle without any flaws. This can be achieved by integrating various sensors, navigation software and various control algorithms, etc. However, the challenges and uncertainties are still vast because the application of autonomous driving environment involves not only the complex automotive technology but also the human-behavior, traffic management strategies, ethics, liability, policies etc., So as the result carmaker's does not expect to commercially launch an autonomous vehicle in less time. From the technical perception the detection of the obstacles at high speed and a long distance is one of the highest difficulties. This survey paper shows an overview of the challenges faced by the autonomous vehicle and the technological implementations applied. Based on the research works of various researchers this literature survey is carried out and it can be used for future references.

**Keywords:** Autonomous vehicle, Automatic Brake System, Traffic Efficiency, Sensor

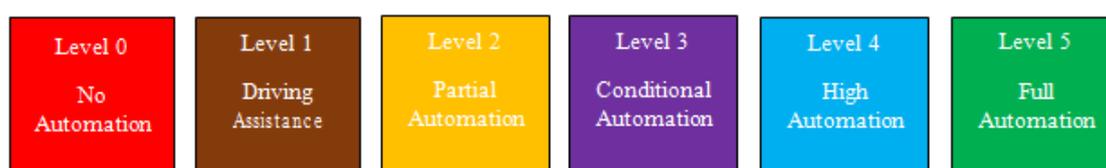
## 1. Introduction

Autonomous-Vehicles are capable of sensing the environment & operate with-out human interaction. The drivers are not needed to control the vehicle and need not to be

present in the vehicle. This can go anywhere as the normal car does and can do everything as experienced driver does. The autonomous vehicles with adaptive control strategy are closer to become the reality [1-4]. As the time passes, a research on autonomous vehicles is bringing the huge-effects that may imply on the different fields. Significance of the vehicles automation on a global- mobility, on competitiveness, on traffic efficiency, on the occupancy of a territory, on the labor- market although it is unexpected with the high confidence level it has already been drawn. Current study laid a foundation for the future investigations and show a possible weakness that should be kept in mind as a technology & the vehicles evolves [21]. This paper has been organized as following: Section-2 shows the levels of driving automation. Section-3 addresses the challenges faced by autonomous vehicles. In Section-4 various implementations for autonomous vehicle. Section-5 elaborates the conclusions and scope for continuous research.

## 2. Levels of Driving Automation

Automatic Driving is said to be the big troublesome innovation in the upcoming years, because of controlling capacity of the vehicle and the collision problem. Collision free autonomous systems are developed using Model predictive control [5]. Considering this problem, it is supposed to have massive societal impact in all kinds of fields. Autonomous vehicle creates and maintains the maps of their surrounding created by many sensors placed in a different portion of the vehicles. RADAR sensors are used to monitor a position of nearby vehicles. Video cameras are used to detect traffic-lights, track of the other vehicles, road signs and looks for pedestrians [6]. An autonomous car includes RADAR, Artificial-Intelligence (AI), Cameras and Sensor to reach the destinations with-out human operators [19]. The levels of driving automation are shown in Fig 1.



**Figure 1.** Levels of Driving-Automation

**Level 0:** No Automation- It is a manual control where the driving tasks such as steering, braking, acceleration etc., is performed by human.

**Level 1:** Driver Assistance- Cruise control monitors the speed that is the vehicles feature is a single automated system.

**Level 2:** Partial Automation- The action like acceleration and steering is performed by vehicle that is automatic driving assistant system. The human can still monitor the task & take over the control of vehicle at any time.

**Level 3:** Conditional Automation- Environmental Detection capability, the most of the driving tasks are performed by vehicle but human over-ride is required.

**Level 4:** High Automation- In this under the specific circumstances a driving-task is performed by vehicle and a human override is still an option. Geo-fencing is required.

**Level 5:** Full Automation- Human interaction and attention is not required, under the entire conditions vehicle performs all the tasks [5-6].

### **3. Challenges Faced by Autonomous Vehicle**

Fully automated cars mentioned in level 5 is undertaking tests in several places of world, but till today it is available for general public usage. There are various challenges in different aspects. Some of the major challenges are mentioned below:

#### **3.1 Traffic Conditions**

Autonomous vehicles will get into the road, where they are required to drive in all kinds of traffic situations. They are supposed to drive with different autonomous vehicles on a same road at a same time the movement of pedestrians also need to be monitored. Traffic could be self-regulated and highly moderated. But there are situations we may need to face uncertainties. Any kind of objects may come in unexpected situation. In this case an intelligent system can take appropriate decisions. One cannot wait limitlessly for a traffic to get clear by itself and has some precondition to move. If several vehicles on a road are waiting for a traffic to get clear, finally it may result in traffic deadlock [7-8].

#### **3.2 Road Conditions**

Road-conditions are extremely unpredictable and varies from a place to place. There are some smooth and marked broad highways also. But in some case, road conditions are highly not acceptable and not suitable for the regular transports. The autonomous vehicles are expected to operate in automated road ways. These vehicles are instructed to follow the

predefined trajectories [9]. Different algorithms are used for following the trajectory. This is one of the emerging research areas, where many researches work towards developing an optimal algorithm.

### **3.3 Accident Liability**

One of the greatest important fact of autonomous vehicle is accident liability. Who will be liable for an accident caused by self driving cars? In the case of autonomous vehicles, the software will be one of the main sections that drive a car and make the decisions. The initial designs were having a person who will physically place behind the steering wheel; newer designs do not have dash-board and a steering-wheel. In such a design, where the cars do not contain controls like brake pedal, steering wheel, accelerator pedal, how will the person in a vehicle supposed to control a car in the case of unfortunate incident? Moreover, due to behavior of an autonomous vehicle, the tenants are in a comfortable state & may not require pay much attention to the traffic circumstances. In the situations where the attention is wanted by a time they react, it may be late to prevent the circumstances [16].

### **3.4 Lidar and Radar**

Lidar is trying to reach the right balance of the range & resolution even though it is expensive. If many autonomous vehicles are on same lane, will the lidar signal interfere with each other?

If many radio-frequencies are there, will the range of frequency is enough to support mass- production of an autonomous vehicles? It is said that people relying on Lidar is doomed. To detect the objects near vehicles and to generate 3 dimensional pictures a Lidar uses infrared-light however the technology is also costly. Radar cannot pass through walls with real accuracy because a false positive will be created when the beams spreads while hitting the wall [14-15].

### **3.5 Artificial and Emotional Intelligence**

Humans rely on delicate signal and non-verbal communication for example identifying facial expression, body language of other drivers and making eye contact with pedestrians, just to predict behavior and make judgement calls in split second. Autonomous vehicles will not be able to emulate these connections. And autonomous vehicles will not have same life-saving character as drivers. It is very difficult for a non-living thing to understand the human emotion.

## **4. Implementation on Autonomous Vehicle**

### **4.1 Technology used in Autonomous Vehicle**

Advance in technologies like electronics and sensors has led to the build of many advanced vehicles, which helps in assist the drivers in controlling the vehicle at normal condition and avoid effect during emergencies. These are not new system such as electronic stability control or anti-lock braking has been used to control discrete vehicle systems. What makes the different in recent innovation is the capacity to intercommunicate and control greater proportion of vehicles operation and making common for vehicles to supplement driver input. The process of autonomous vehicles has three major controls i.e., Acceleration, Direction and Braking [13].

Sensors used in Autonomous vehicles are:

- **RADAR:** Use the bursts of sounds for the measurement of distance by measuring the time takes for the sound to return to the sensor.
- **LIDAR:** Instead of sound this uses laser to measure distance ranging upto 200m.
- **Video Cameras:** Captures two dimensional pictures and records in multiple still shots.
- **Ultra-sonic Range Sensor:** Measures the distance between the objects by using high frequency sound waves.
- **Inertial Measuring Unit:** Determines the vehicle angular and linear motion by accelerometer and gyroscopes.
- **Global Navigation Satellite System:** Provides autonomous geo spatial positioning using satellite. Subset of global navigation satellite system is Global-Positioning System (GPS) [17].

### **4.2 Benefits of Autonomous Vehicle**

#### **4.2.1 Traffic Efficiency**

The major benefit of autonomous car is the ability of communicating with each other's. The ability of communicating in real-time helps the vehicles to travel efficiently at augmented distance from each other's. They determine the best routes for a traveler and eliminate the bumper-bumper traffic jams. The autonomous vehicles keep buffer in-between

cars in front and themselves while speeding up, which helps them to force the brake often less. The autonomous cars can improve the traffic flow by upto 40% [22].

#### **4.2.2 Prevention of Car Crashes**

Most of the accidents are because of human errors. Computer based-system will eliminates the human errors. Major accidents plus drunk and drive or distracted-driving will not be in autonomous vehicles. The accidents are reduced up-to 90% by this autonomous vehicle. Autonomous cars not only sense the environment but can also anticipate which humans cannot predict. Some of the events are predicting the vehicle movement ahead and behind. By the latest technologies like forward-collision warning, lane-departure warning, pedestrian automatic emergency-braking system and automatic emergency-braking autonomous vehicles senses, anticipates and take corrective actions.

#### **4.2.3 Better Access Mode of Transportation**

Autonomous vehicles are mostly useful, safe and reliable for the people who feel difficult to drive and those who cannot drive the normal vehicle. Aging people and people with disability can rely on autonomous vehicles [10]. Because the autonomous vehicles are capable of reacting in real time which leads to avoid many crashes and accidents.

Places with less public-transit exposure can be benefited from autonomous vehicles. And can also reach areas easily where infrastructures are lacking.

#### **4.2.4 Environment Friendly**

Another important factor in autonomous vehicle is environment. Rather than consuming internal combustion engines these are likely to be electric vehicles. These vehicles speed are consistent so there is less braking as well as accelerating action which helps in reduction of emissions and becomes environmentally sustainable [18].

### **5. Conclusion and Future Scope**

The principle of autonomous vehicle is a successful phenomenon, which has helped in so many driving scenarios like advanced driving assistant system, automatic braking system etc. This paper explains the challenges faced by autonomous vehicles and the technologies used for autonomous vehicles. However, it highlights that several conditions must be satisfied to achieve the fully automated vehicles. Completely autonomous vehicles will not be marketed soon. The time required to over-come the technological issue must be utilized to

design supportive traffic management strategies which will guarantee success over the introduction [11]. Special attention is required for ethical and legal issues, which will determine when the society is ready for the future autonomous driving environment. This survey is of great importance in improving the number of autonomous vehicle and control of vehicle under complex conditions which is helpful for the further improvement and development of intelligent vehicle driving assistance [12].

The technologies used by autonomous vehicles are improving everyday which leads for the further research and implications. Hence, many get an opportunity for developing a fast and reliable technology to be used for future autonomous vehicles. This can beat the current technology and make the autonomous cars more stable and more compatible [20]. The technologies like forward-collision warning, lane-departure warning, pedestrian automatic emergency-braking system and automatic emergency-braking were only available in luxury cars. But now it can be used in commercial vehicles like public transport system i.e., buses and also in trucks. Very soon various autonomous vehicles are expected to be launched in the market. This new era brings more opportunities for the research community in the field of autonomous vehicles.

## References

- [1] Neelam Naz, Muhammad Khurram Eshan, “Intelligence of autonomous vehicles: A concise Revisit”, *Journal of sensors*, Hindawi, volume 2022, Article ID 2690164, 2022
- [2] Jingjing Tian, Hongfei Jia, “A long term shared autonomous vehicle system design problem considering relocation and pricing”, *Journal of Advanced Transportation*, Hindawi, volume 2022, Article ID 1905526, 2022
- [3] M. Li, Y. Chen, A. Zhou, W. He, and X. Li, “Adaptive tracking control for networked control systems of intelligent vehicle,” *Inf. Sci.*, vol. 503, pp. 493–507, Nov. 2020.
- [4] M. Zhou and D. Wang, “Generational differences in attitudes towards car, car ownership and car use,” *Transp. Res. D, Transp. Environ.*, vol. 72, pp. 261–278, Jul. 2019.
- [5] Z. Wang, G. Li, H. Jiang, Q. Chen, and H. Zhang, “Collision-free navigation of autonomous vehicles using convex quadratic programming-based model predictive control,” *IEEE/ASME Trans. Mechatronics*, vol. 23, no. 3, pp. 1103–1113, Jun. 2018.
- [6] C. Liu, S. Lee, S. Varnhagen, and H. E. Tseng, “Path planning for autonomous vehicles using model predictive control” in *Proc. IEEE Intelligent Vehicles*

- Symposium. Beach, CA, USA, Jun. 2017, pp. 174–179.
- [7] J. Funke, M. Brown, S. M. Erlien, and J. C. Gerdes, “Collision avoidance and stabilization for autonomous vehicles in emergency scenarios,” *IEEE Trans. Control Syst. Technol.*, vol. 25, no. 4, pp. 1204–1216, Jul. 2017.
- [8] Loria, J. Dasdemir, and N. Jarquin-Alvarez, “Decentralized formation tracking control of autonomous vehicles on straight paths,” in *Proc. 53rd IEEE Conf. Decis. Control*, Angeles, CA, USA, Dec. 2014, pp. 5399–5404.
- [9] M. Park, S. Lee, and W. Han, “Development of steering control system for autonomous vehicle using geometry-based path tracking algorithm” *ETRI J.*, vol. 37, no. 3, pp. 617–625, Jun. 2015.
- [10] J. Yang and J. F. Coughlin, “In-vehicle technology for self-driving cars: Advantages and challenges for aging drivers,” *Int. J. Automot. Technol.*, vol. 15, no. 2, pp. 333–340, Mar. 2014.
- [11] P. R. Ouyang, J. Acob, and V. Pano, “PID with sliding mode control for trajectory tracking of robotic system,” *Robot. Comput.-Integr. Manuf.*, vol. 30, no. 2, pp. 189–200, Apr. 2014.
- [12] H. Yoshida, N. D. A. o. J. Department of Mechanical Systems Engineering, M. Omae, T. Wada, “Toward next active safety technology of intelligent vehicle,” *J. Robot. Mechatron.*, vol. 27, no. 6, pp. 610–616, Dec. 2015.
- [13] Intel Go Autonomous driving solutions. Product brief: 'Autonomous driving, accelerated', 2016.
- [14] Saad UI Hassan Syed, “Lidar Sensor in Autonomous Vehicles”, Research gate, March-2022, <https://www.researchgate.net/publication/359263639>.
- [15] Bilik, Oren Longman, Shahar Villeval, “The Rise of Radar for Autonomous Vehicles: Signal Processing Solutions and Future Research Directions”, Sep-2019, *IEEE Signal Processing Magazine* 36(5):20-31, doi:10.1109/MPS.2019.2926573.
- [16] Muhammad Uzair, Joeri Van Mierlo, “Who is liable when driverless car crashes?”, *World Electric Vehicle Journal* 12(2), 62, 2021, <https://doi.org/10.3390/wevj12020062>.
- [17] Enrique Marti, Miguel Angel, Fernando Garcia, Joshue Perez, “A review of Sensor Technologies for Perception in Automated Driving”, Sep-2019, *IEEE Intelligent Transportation Systems Magazine* PP (99):1-1, doi:10.1109/Mits.2019.2907630.
- [18] Guériaux, M., Billot, R., El Faouzi, N.-E., Monteil, J., Armetta, F., 2016. “How to assess the benefits of connected vehicles? A simulation framework for the design of

- cooperative traffic management strategies”. *Transportation Research Part C: Emerging Technologies* 67, 266-279.
- [19] Diakaki, C., Papageorgiou, M., Papamichail, I., Nikolos, I., 2015. Overview and analysis of Vehicle Automation and Communication Systems from a motorway traffic management perspective. *Transportation Research Part A: Policy and Practice* 75, 147–165.
- [20] Madrigal, A.C., 2012, “Driverless Cars Would Reshape Automobiles and the Transit System”, *The Atlantic*.
- [21] Zmud, J., Goodin, G., Moran, M., Kalra, N., Thorn, E. *Strategies to Advance Automated and Connected Vehicles: Report of the National Cooperative Highway Research Program*. Transportation Research Board, 2017.
- [22] Bernhard Friedrich, “Effect of autonomous vehicles on traffic”, May-2016, *Autonomous Driving*-pp.317-334, doi:10.1007/978-3-662-48847-8.