

Review on Autonomous Vehicle Challenges



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Abstract In the growing of government participation, many countries like USA, UK, Japan attention the production of autonomous car. Google is the first full autonomous car got the license for driving. Autonomous car is a vehicle which is moving from source to destination without human intervention. The technologies embedded into the vehicle like camera, radar, lidar for sensing the feature of environment behavior. To improve the quality of safety, to improve the congestion, and to reduce the accident due to happen by human wrong behavior, autonomous vehicle plays a crucial role. In this paper proposed, many challenges which are come across in autonomous car are described by author. The challenges are sensing the vehicle environment, GPS system must be reliable, avoid obstacle, and multi-sensor fusion must be accurate, path tracking, curb detection. In this paper evaluated, the approach and technologies used overcome the above challenging issues for autonomous car on the road. For detection, tracking, shortest distance, smooth driving in this parameters are solved by different algorithm to get optimal and efficient driving.

Keywords Sensor · Autonomous vehicle · Perception algorithm

1 Introduction

In 1950, first research takes place and began with skill-based driving model. Since 1986, autonomous vehicle concept started by various different country like Japan, USA, Europe, UK. Sensor functionality used for solving the problem tunnel, wet road. Then in 1998, urban traffic problem discussed in autonomous vehicle for highway scenarios. In 2005, author described only some parameter such as localization, mapping, navigation and control. In 2009, Google car started self-driving car and

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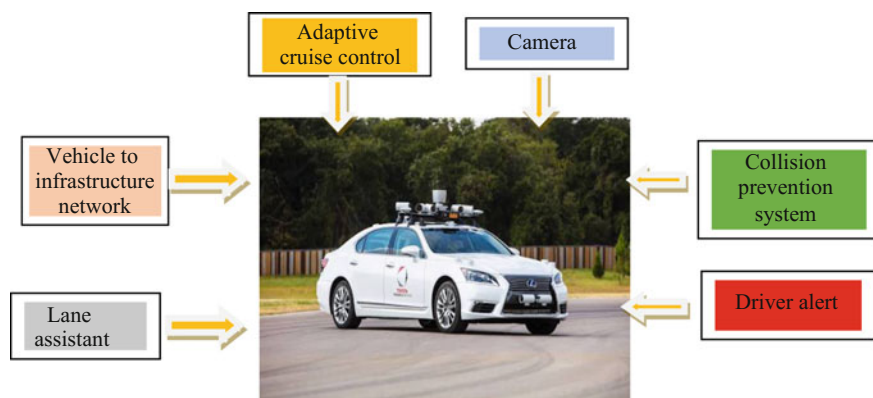


Fig. 1 Autonomous car

it allows to detect pedestrian, cyclist, roadwork, and lane in all direction. Advance driver assistant controller is used to control the movement of full automatic vehicle defined by Joel et al. [1].

The definition of autonomous driver is driving a vehicle from one place to another place without human controller. Automated vehicle is classified into five levels such as level 0 based on no automation, level 1 based on assisted automation, level 2 based on partial automation, level 3 based on high automation, and level 4 based on full automation means no driver is expected discussed by Nishith [2].

The companies estimate their driverless future car such as Tesla motor, Google, BMW, Jaguar, Nissan, Toyota, etc. Autonomous vehicle incorporated in three dimensions of performance: economic, social, environmental. In economic, insurance are provided to the road accident or if any component damage then manufacture company provide the insurance claim defined by Daniel and Kara [3]. In social, human can utilize their driving time in other activities also due to human wrong decision accident happened like drink and drive so it is also reduced. In environmental, the fuel emission increases up to 50%, reduces carbon emission up to 90%, road accident reduces up to 90% and it will help to maintain green in environment proposed by Umit et al. [4].

Around 1.25 million people were killed every year and millions of people injured due to wrong driving. So, human behavior is very important characteristic in road safety and increases the collision risk also explained by Lynn et al. [5]. Figure 1 shows many technologies equipped into vehicle like sensor, radar, GPS, lidar, and camera to detect the pedestrian, lane, and tunnel. Autonomous vehicle is safer for pedestrian behavior. The ACC controller used to maintain the speed and brake of the vehicle.

The vehicle infrastructure network works to collect all the data from environment and send to the entire vehicle. The collisions occur and then break the vehicle to prevent the accident. If any break is needed to control, then alert is given to driver. The main important goal of autonomous car is to reduce accident, traffic, parking

space, pollution emission, etc. In urban area perception, capability must be reliable for autonomous vehicle [5]. Every system having some advantage and disadvantages defined by Kransnigi [6]:

- Advantages of autonomous vehicle are:
- 1. Improvements of safety on the road without driver.
 - 2. Independent mobility for elder, younger, and disable.
 - 3. Improve the road congestion and driver utilized that time in other activities.
 - 4. Less congestion so improve the fuel efficiency and parking space.
- Disadvantages of autonomous vehicles are:
- 1. Cost of car is increased.
 - 2. More unemployable due to driverless.
 - 3. Automobile insurance provides by manufacture industry.
- Challenging issue of self-driving vehicles is explained by Umit et al. [4]:
- 1. Sensing capability of the vehicle environment;
 - 2. Perception of unknown behavior;
 - 3. Insure safety performance of the vehicle;
 - 4. Traffic control capabilities;
 - 5. Lack of good software;
 - 6. Lack of road ahead.

2 Literature Review on Research Challenges

See Tables 1 and 2 .

Table 1 Comparison between autonomous and non autonomous car defined by Todd [7]

Parameters	Autonomous car	Non autonomous car
Driverless	Driverless means no human intervention	Control by driver
Avoid driving drunk	Avoid driving drunk	Driving drunk
Safety from accident	Increase safety from accident	Less safety due to human poor judgment
Independent mobility	Independent mobility for younger, elder, and disable	No mobility for younger and disable
Fuel efficient	Improve fuel efficient	Fuel utilization more
Utilize driving time	Driving time utilized for other activities or take rest	Driver concentrates on driving

Table 2 Comparison table of literature survey based on autonomous vehicle technology and functionality

Title of paper	Author name with published year	Methodology	Description
Technology need for autonomous car [8]	Claudiu et al. (2016)	Hierarchical control structure such as strategic level, tactical level and low level control	This system based on AC design consists on solving unexpected driving problem. All the action had been taken in the form of states. Locomotion problem which was solved by learning technique because it was improved the capability of the system and also managed more complex locomotion problem
Curb detection and tracking [9]	Jamein et al. (2011)	Hough transformation is used for driving such as road detection, obstacle detection, curb and lane detection	The laser range finder technology used for detecting correct curb, firstly curb detection through curb geometric shape and detect the position, second curb estimation and tracking using particles filters. Extracted the feature from the assumption and calculated similarity between points by pattern recognition algorithm. The curb detection technology is a fast and robust but not used to control the steering of vehicle

(continued)

Table 2 (continued)

Title of paper	Author name with published year	Methodology	Description
Facial recognition and geo location services [10]	Mohammad et al. (2016)	Virila Jones algorithm is implemented to identify face with stages such as Hear feature selection, creating integral image	These paper proposed stages correctly identified the front view of face and real time result. As every system has some corn and porn. In this system face with head portion is not detected accurate result
IoT technology to drive the automatic industry [11, 6]	Supriya et al. (2016) Kransnigi et al. (2016)	RFID, WIFI, 5G, and DSRC, v2v communication	Author also proposed the market forecast to connect autonomous vehicle. It also described 5 phases for car evaluation path
Visual perception system in autonomous vehicle [12]	Weijing et al. (2017)	ADAS(Advanced Driver Assistant system) provided simple and partial feature of low level of autonomy	At the level of autonomous car require to sense signalization, location, moving pedestrian decided by human making decision. The visual perception is one of the critical technology, if there is no correct perception then decision will be taken by vehicle and it is not safe
Platooning autonomous mobile robot [13]	Satoshi et al. (2013)	Adaptive cruise control system used to define the relationship between velocity	In this system bottleneck for lane crossing and inter vehicle communication based on ACC and create a small cluster of platoon. In this paper author proposed to solve the jam or congestion method for moving efficiently to reduce the travel time of the robot

(continued)

Table 2 (continued)

Title of paper	Author name with published year	Methodology	Description
A Multi sensor fusion for moving object detection [14]	Hyunggi et al. (2014)	It is based on classification algorithm	For intelligent vehicle system detection and tracking of object is play vital role. By using radar vehicle obstacle detection is not get qualities result. To improve this approach author proposed multisensory feature
Computer vision for autonomous vehicle [1, 15]	Joel et al. (2015) Chandra et al. (2008)	Support vector machine (SVM) used to the marginal line to classify simple and efficient image either 2D or 3D	For Dynamic Environment the PPS i.e. pedestrian protection system detect the presence of stationary and moving people around the vehicle in this way author proposed may state of art on different issues like recognition, reconstruction, tracking and end to end learning
Path tracking in autonomous vehicle [16]	Matthew et al. (2016)	Path planning and path tracking	In this paper author discussed about two part of vehicle modeling: first accurate capture vehicle dynamically second reduce modeling error. Nominal path is very precise sequence from higher level path planner of the vehicle behavior and environment
Strategic and operational concern [17]	Neda et al. (2017)	Greedy heuristic algorithm and the SVOR (Shared vehicle ownership and Ridership) used to form the cluster and cover all essential trip through spatio-temporal proximity	The Autonomous vehicle is providing more safety and mobility and environment benefits. It reduces the vehicle to perform task which based on daily for household. One solution given by autonomous vehicle is shared ownership with others

3 Challenges

3.1 *System for Safety and Autonomous Behavior:*

DARPA: The operation which performed by autonomous car is car following, lane keeping/lane changing, emergency stopping, traffic control capabilities, obstacle avoidance. So, it is expected to sense all the operation by self-sensing with respect to some coordinates, maps, speed and acceleration explained by Rodrigo et al. [18]. In 2005, DARPA involved in this technology and got some challenges such as sensing the vehicle environment, control over an unknown course, insure the safety performance of the vehicle, testing and validation. [4] proposed the automatic path which is detected by A* algorithm. This algorithm used to find the optimized the path with distance travelled, slope grade, negative bias. After sensing the obstacle, vehicle must be stopped automatically to assure safe performance.

3.2 *Generation of Roadway Map for Autonomous Cars*

Localization algorithm also used for the same concept. There are two requirements for roadmap, first geometric requirement which is for find out the quality of the map. Second, implementation requirement based on data structure to reduce data storage define by Chandra and Baskaran [19]. In proposed system, author [20] defined three steps: data acquisitions, sensor data fusion, road modeling. The data generated from data acquisition which equipped into vehicle, i.e. through RTK GPS To overcome this problem mathematical road model algorithm used for perception, vehicle localization, path planning through B-spline curve and get optimal smoothing process. This system based on 2D coordinates only not supported to 3D coordinates and map database management system for autonomous vehicle.

3.3 *Traffic Light Detection and Recognition*

While driving autonomous car on road, appropriate traffic action is required in urban environment. There are many types of traffic light such as vertical, horizontal, circle with color. In conventional system, traffic light used with fixed camera but for autonomous car more cameras are used for capturing image from front view or rear view. In proposed system, author [21] explained the new system which has been detected and recognized traffic light in real time. The environment perception consists of camera and radar for detecting lane, obstacle, traffic light signal. The decision making module based on data fusion sensor and the automatic control module based on steer control and speed control operation. Some of the featured detected under

traffic light system such as preprocessing, detection, recognition defined by Pawel and Inga [22].

3.4 Ecall System for Autonomous Car Accident Detection

Author [23] proposed autonomous car accident detection are made by ecall system which is used to save the life and respond emergency. For this reason, European country built new regulation that is called ecall technology. Ecall technology is equipped in each car (semi or automatic) by 2015. The characteristic of MSD is message identified either call type or test call through vehicle direction. The sensor is equipped into the car that detects the accident and sends the alert message to admin. The Retro fill ecall module is equipped in the application of SAE vehicle to detect crash and detect emergency alert.

3.5 Human Dynamic-Based Driver Model for Autonomous Car

The autonomous vehicle moved road in the near future widely. The behavior of humans influences their driving. The important goal of autonomous vehicle is to reduce accident, collision, and eliminate human error and poor judgment. It is determined by attitude, subjective norms, perceived behavior and depends on age and gender explained by Li et al. [24].

3.6 Autonomous Driving System for Unknown Environment

While the autonomous vehicle drive which are considered all situation like speed, traffic signal, crosswalk, parking space etc. Some algorithms are very important like prediction for feature extraction, color-based detector for traffic information and sensor for obstacle detector discussed by Alfred et al. [25]. The local map building modules access the image detection, obstacle detection. The process for handling this module is based on three factors: computing power, network traffic, and memory usage of the module. For detecting traffic information, author [26] proposed an approached called unified map. It converts the traffic environment into imaginary obstacle.

3.7 Perception of Autonomous Vehicle: Relationship with Road Users

Now, full autonomous car used to drive by self without any driver. The number of advantages while used AC like reduce the collision, improve the road safety than conventional way. In this [5] proposed autonomous car interact with people and percept the route of people where they want to travel. Around 1.25 million people were killed every year and millions of people injured due to wrong driving. However, human behavior acted as important role in road safety and collision risk also.

3.8 Optimal Driving Path of a Car Using Modified Constrained Distance Transformation

As some method used for finding smooth path finding but only absence of obstacle. The optimal path based on the characteristics such as size, orientation of car, obstacle of arbitrary shape, smoothness of timing, and direction of cost. [27] proposed the static and dynamic properties for autonomous car. The static car defined shape and orientation but in dynamic properties described smoothness and direction. The chamfer is optimal algorithm which is to get numeric computation instead of floating point. The algorithm defines if the value is infinity, then the algorithm does not find feasible path from source to destination.

3.9 Dynamic Bottleneck Congestion

The speed of autonomous car is fast than normal car. Autonomous car is used for transportation application. There are some effects by congestion with three channels such as the resulting increase in capacity, value of time (vot) and implementation. [28] proposed only effect of bottleneck not any safety or transportation system. The mathematical consist two problems one is routing and other is on demand car sharing. To solve this model problem, find out the minimum number of autonomous vehicle used in a cluster with optimal routing status and also increase the car sharing request.

4 Conclusion

As conventional vehicle compares with autonomous vehicle, it is provided better safety from accident. Autonomous car basically used for transportation purpose. The number of steps processed in autonomous vehicle is vehicles' infrastructure network, lane detection, driver alert, camera, collision prevention. To described the number

of challenges from DARPA grand which have been occurred in autonomous car on offline road. By using different algorithm need to overcome the challenges. Also, describe the Internet of Things applied to autonomous car as one of the applications for smart cities. In urban environment, 90% safety provides than non-autonomous car from accident. While driving car path tracking and planning done by discrete transformation method. Through unified map representation, avoid the obstacle occurred due to driving. For avoiding the accident, human dynamic behavior is playing major role also their age and gender. Multi-sensor fusion used for detects the pedestrian, lane detection but not traffic signal with classification algorithm. In this way integrate most of the challenges occurred in autonomous car in this paper.

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