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Autonomous Cars- A Review

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ABSTRACT: Human errors are the major cause of accidents on roads worldwide. Advancement in automobiles are as driver assistance for safe operation. In spite of it, human distraction and mis-judgement are not catered by these advancements. Autonomous car without human intervention is the solution for this situation. Various sensing technologies, for environment perception in Autonomous Prototype cars are in use. There is a sustainable activity of sensor development and other related research areas (such as image processing) in automotive applications. Use of Autonomous cars is bound to improve traffic flow, reduce delays, improve society, save fuel and environment.

KEYWORDS: Artificial Intelligence, Google Maps, autonomous vehicles, sensing devices, LIDAR, camera, radar

I. INTRODUCTION

About (2) six million road traffic accidents take place every year in US [1]. In India this figure is half-a-million. Cause wise analysis indicates that the human failure is responsible for more than 90% of the accidents. In India this figure is 78.4%. Amongst these distraction and/or mis-judgment [1] are the prominent. Various advancements have been done in automobiles to assist driving in order to reduce human failures and make automobiles safe. To mention, some of these are; collision avoidance system, lane departure warning, automated parking system, Adaptive cruise control, Blind spot monitoring, forward collision monitoring etc.

II. AUTONOMOUS CARS

A passenger vehicle, which drives itself is known as an autonomous car (1), driver-less car, autopilot, automated guided vehicle or auto-drive car. It is expected that it will avoid accidents and congestions. Autonomous car will navigate on highway, urban traffic and / or off-road conditions without human intervention [2]. It will optimise for the best route and will be aware of conditions ahead.

The autonomous car such as Google driverless car, is equipped with sensing technologies, data processing capabilities and actuation systems for braking, speed control, automated control of steering etc.

These cars will share information of speed, braking and road conditions with each other. Their movement is coordinated with each other without human intervention. There are many benefits of this coordinated operation. Such as a person who cannot drive can also use it. Since movement is coordinated there will be reduction in accidents and congestions as traffic flow will be smooth [1].

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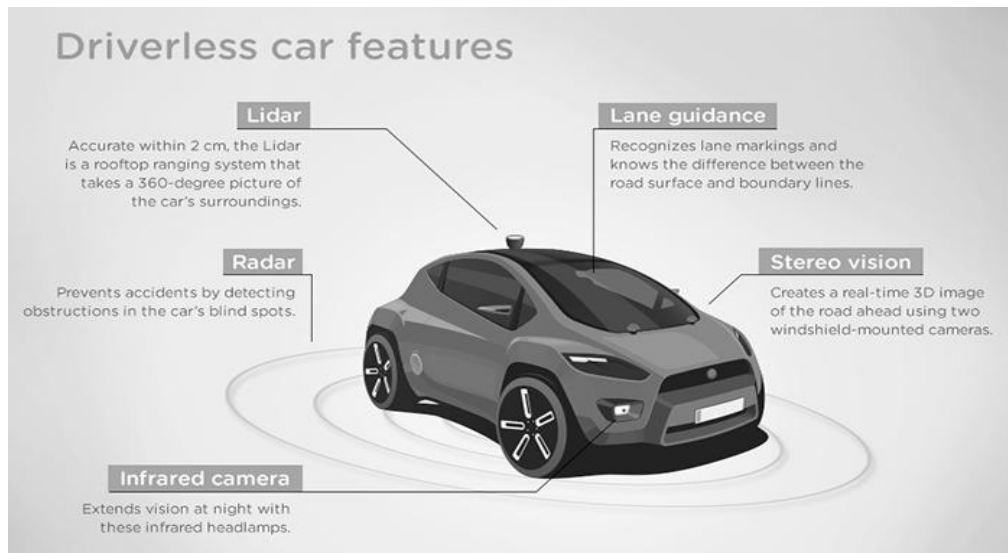


Fig.1: Driverless car features [5]

III. CONTROL SYSTEM ARCHITECTURE

Basic features of autonomous cars are the same as those of autonomous robots [3]. Fig. 1 shows the basic control system architecture of an autonomous robot. In this architecture, sensors send data, which is processed by the perception subsystem, which extracts the useful information. This information is used by planning and control subsystem. Planning and control subsystem generate instructions for actuators.

These subsystems are very complex for autonomous cars as they have to share information among themselves and other systems. In addition, autonomous cars move in a coordinated way on a larger area and encounter diverse obstacles.

For ACs, both perception and planning and control subsystems are very complex, containing several blocks, such as obstacle detection and tracking, road detection, lane mapping, position detection as well as navigator, mission and motion planning respectively [3].

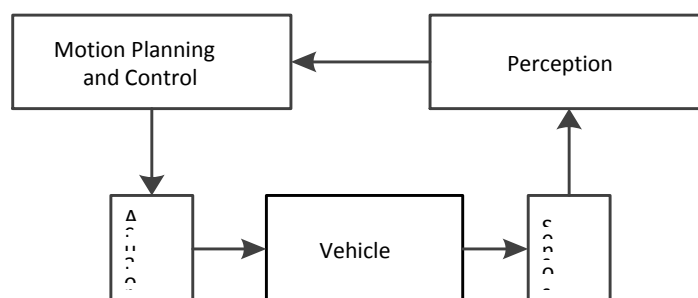


Fig. 2: The control system architecture of an autonomous robot [3]

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IV. CHALLENGES FOR AUTONOMOUS CARS

Autonomous cars have many challenges. They have to detect the pedestrians, other vehicles, the traffic lights, road signs, conditions of lanes and the shape of the road in real time and in all weather conditions. It takes decision while maintaining an optimum route towards the destination.

This detection is done with the help of sensors. Lot of work has been done in this area, still their range, capability and sensitivity is different for different conditions. The conditions may be high-speed movement, complex and dynamic environment due to other cars in front, rear and/ or lateral, pedestrians etc. Detection requires relative motion, distance etc. That is why multiple sensing in different locations is done [2].

4.1. Environment Perception:

Environment perception means detection of other vehicles, pedestrians, obstacles and adjacent environment with their condition such as relative speed and distance. This is done with the help of sensors. Various prototype autonomous cars use following type of electronic sensing devices. LIDAR (Light Detection and Ranging) sensors, cameras, radars, ultrasonic (US) sensors, contact sensors etc. Position detection requires GPS and IMU (Inertial Measurement Unit). LIDAR, radar and US come in the category of active sensors.

4.2. Electronic Sensing Devices on Autonomous Car Prototypes

Various electronic sensing devices used on driverless or autonomous prototype cars are given in Tables I [2].

Table 1 Sensors on Different Autonomous Car Prototypes [2]

Self-driving car	Laser	Radar	Cameras	GPS	IMU
2007 Talos (MIT) urban	<ul style="list-style-type: none"> 1 3D LR (top) 11 planar LR for obstacle detection 1 planar looking downward for hazard detection 	1 LR - to detect fast moving vehicles	5 Cameras for road paint detection	Yes	Odometry, inertial sensors
2007 Junior -2nd place at urban DARPA (Stanford)	Frontal: <ul style="list-style-type: none"> 1 3D long range (top) 1 LR (top) 1 LR (bumpers) 2 mid-range (side-mounted) lane detection Rear: <ul style="list-style-type: none"> 2 LR 	2 long LR (bumpers)		Yes	Integrated; Wheel odometry (distance measurement unit)
2011 Japan	<ul style="list-style-type: none"> 1 multi-layered in front, to detect distant obstacles 1 LIDARs 1 3D LR (top) 1 LIDARs (on sides) to detect lane markers 	1 in front, for distant obstacles		Yes	DMI, IMU 2 GNSS receivers, Kalman filtering
2012 Google	<ul style="list-style-type: none"> 1 3D LR (top) 	4 LR on the	1 camera	GPS	IMU, wheel

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car		front (3) and rear (1) bumpers	(for traffic lights detection)		encoder
2007 BOSS (winning at DARPA 2007 Urban Challenge)	Frontal: <ul style="list-style-type: none"> • 3D LR (top) • 1 LR • 1 LR around, • 1 short range sensor pointable • 2 mid-range (side-mounted) lane detection 	3 LR (2 fronts, 1 rear) 1 long range pointable		Yes	

V. THE CONTROL MECHANISM

There are three main blocks in the control mechanisms of an autonomous car, as given below:

- (i) Sensors, GPS, etc
- (ii) Logic Processing units for Decision, functionality and interface.
- (iii) Servo motors and relays for mechanical control systems [2].

The real time decisions are provided by Artificial Intelligence. Sensors and Google Maps provide data to AI. for determining the acceleration i.e. how fast it is; when to slow down/stop and to steer the wheel. AI ensures guided drive to the autonomous car.

5.1 Operation Sequence

Following sequence takes place, while working an Autonomous (Google) car. However, override function allows human intervention. Destination is set and software of car calculates a route and ensures driving of car on its way. 3-D map of immediate area is created by roof mounted sensors and scanners. Left rear wheel mounted sensor monitors movement on 3-D map. Sensors on front and rear bumpers detect obstacles. Data from sensors and Google is fed to AI software which ensures guided drive of the car.

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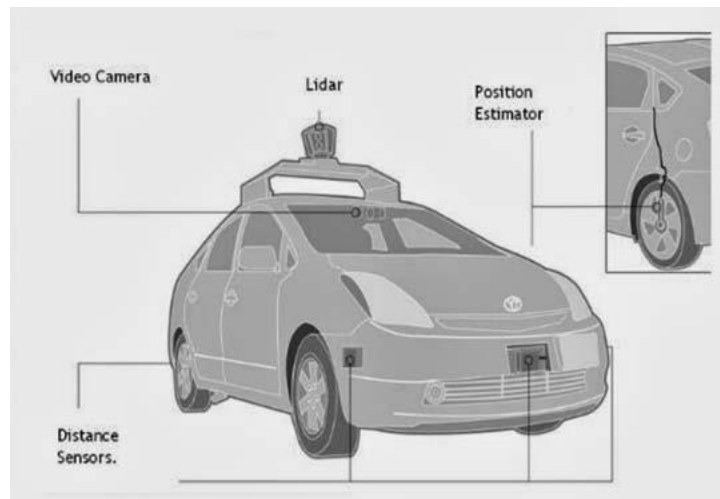


Figure 3: Google car [1]

5.2 Driverless car Manufacturers

The most influential autonomous car companies expecting to be produced by 2020 are Google, Intel, GM, Mercedes Benz, Audi, Nissan, Apple, BMW, Volvo and Rio Tinto [5].

Identifying the Waymo Fully Self-Driving Vehicle

The Waymo fully self-driving Chrysler Pacifica Hybrid minivans can be easily identified by the white color with Waymo logos, roof assembly, front fender additions, or rear roof additions below.

During driverless testing and operation, Waymo's vehicles are fully self-driving at all times, and will not have any person in the driver's seat either steering or otherwise controlling the vehicle.



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Fig. 4: Waymo self-driving car [6]

VI. TRIPLE BOTTOM LINE

Autonomous cars bring a wide change in the vehicle and transportation technology and will reduce the numbers of road accidents. These will increase the safety and improve the mobility. It will also create healthy surrounding and save natural resources.

The section triple bottom line framework includes 3-dimensions of performance of an autonomous car i.e. social, environmental and economic.

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6.1 Economics:

Autonomous cars will impact Insurance companies. In the recent report[9] of “Deloitte” it is expected that car insurance premium approximating \$200 billion will continue for another 7 to 8 years, then it will decrease to about \$40 billion in 2040. Risks covered will be an algorithm failing or cyber-attack for driverless cars.

According to the Society of Automotive Engineering(SAE) the telecommunication sector will have to develop high quality capacity products and services in order to manage the increase in data traffic.

Park associates an internationally recognized market research and consulting company has AT&T Verizon will be making about \$1 billion each year in connected car revenue by 2018.

Uber is aiming to make the service more economical by replacing its fleet with self-driving cars. It will decrease the pricing as it will now cost for the cars only and not for the drivers anymore.

Currently the cost of per ride of uber and lyft are twice that of using one’s own car. However, the cost of these companies per ride will be very low once driverless technologies become popular.



Fig.5: Challenges for an autonomous car [7]

6.2. Social

The basic of autonomous vehicle aims to a better and cleaner transportation ecosystem with a better experience for human. Autonomous vehicle results in decrease in road congestion and improvement in road design as many vehicles in seamless coordination with each can be added on the road, transportation will be safer and will increased the mobility. Its result to bring a large change in culture as well as in the idea of someone driving itself. The autonomous cars will improve the safety on roads. According to by Mc Kinsey [10], self-driving cars will reduce the number of road accidents by 90% and will make safe driving with the saving up to \$190 billion a year.

Human error is one of the biggest causes of road accident though driver is distracted by phones or lack of skill or by drinking and road rage. Autonomous cars will eliminate the chance of human error while driving.

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Companies of automobiles are already looking to adopt new business model of vehicle sharing, rental or taxi services rather than car retail. If cars are required for rental then ownership of personal vehicle may become an idea that is obsolete. This will lead to an equality to all the people and they will not be dependent anyone anymore for any event or trip. Even the disable will have equal opportunity and the ability to get from one destination to another destination. Human productivity will be increased very much as they will able to use their times that is spend on driving on another such activities. According to Mc Kinsey report, it is noted the autonomous vehicular technology will aim in persons having a 50 minutes per day extra for another work and would also have millions of square feet for parking.

6.3.Environmental

The autonomous vehicular technology and the availability of transport option rather than personal cars owner promises to improve safety by finding the shortest routes with minimum fare and with minimum time in search of parking eliminating the unnecessary acceleration and honking. By avoiding the pointless driving, we can obtain a huge fuel efficiency upto 55% and reduction in carbon emission upto 91%. Due to decrease in road congestion there will be no additional roads needed to be constructed which would be free for green and clean environment. The need for traffic lights and lights will also be decreased. Recently roadways and traffic lights are made because human need for visual input. Uber the passengers to work, sleep and entertain themselves while in the trip making for them to live in as started thinking beyond driverless cars to flying cars. Where people will travel in flying vehicle from one place to another place, it will decrease the need for parking thus giving spaces for the parks, biking tracks and for public amenities to the city. While the positive impacts of autonomous vehicular technology on the surrounding are evident there are certain factors which could negate some of the positives as it will makes the fare cheaper and allowing far flung suburbs. The autonomous cars will increase the average distance travelled by vehicle per day. Public transport might be threat as cheap driverless alternatives. If passengers shift from big vehicle such as buses to driverless ride services, the congestion in dense cities might be adversely affected.

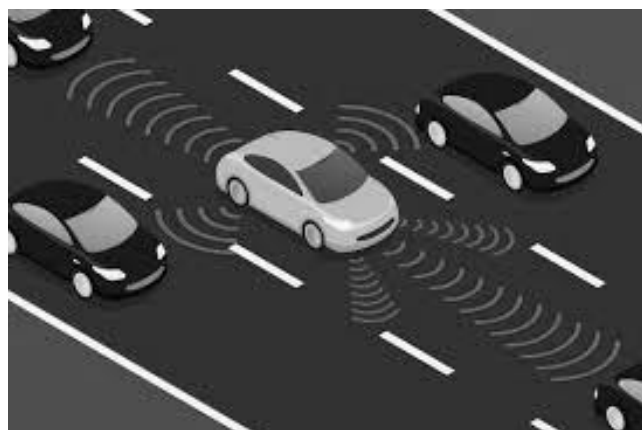


Fig.6: Autonomous car communicating with other cars [8]

The net effect on the environment is negative or positive will depend upon the choices that autonomous companies and policy maker makes in prioritizing efficiency. Vehicle could be programmed to choose the most fuel-efficient route. Rules and regulation should be implemented to penalize vehicle that drive unsafely or reward those who allow their vehicle to be used as ride sharing or on a rental.

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VII. CONCLUSIONS

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Various sensing technologies used for environment perception in Autonomous Prototype cars are in use. There is a sustainable activity of sensor development and other related research areas (such as image processing) in automotive applications [2]. Use of Autonomous cars is bound to improve traffic flow, reduce delays, improve society, save fuel and environment.

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