*Advances in Economics, Business and Management Research, volume 215*
**Proceedings of the 2022 7th International Conference on Social Sciences and Economic Development (ICSSED 2022)**

# Autonomous Vision of Driverless car in Machine Learning

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**ABSTRACT**
As one of the main research directions of machine learning and CNN (Convolutional neural network), Autonomous vision and decision-making have many kinds of applications in various fields, especially in Driverless cars and decision-making on highways. In recent years, Tesla, HUAWEI, Google, and Microsoft, these major giants in Driverless cars gradually shifted their attention from traditional cars to driverless cars. Where Google driverless cars are designed to operate safely and autonomously without requiring humans in the city, it used a series of devices, sensors to collect the data from outside. While the Autonomous car in the unstructured terrain also has many applications, like the Defense Advanced Research Projects Agency (DARPA) UGCV-Perceptor Integration (UPI) program was conceived to take a fresh approach to all aspects of autonomous outdoor mobile robot design, where the main aim of UPI program is to make sure the autonomous robot has the ability be transported from Point A to Point B in the limited time in the unstructured terrain and complex outdoor environment. Machine learning occupies a large proportion in this case where it provides robust and adaptive performance, also reduces the cost of development and time. The report will introduce the features, like the detect capability, applicable terrain and different detect-radar to analyze the differences between the two kinds of autonomous cars, and discuss the future applications of autonomous vehicles in unstructured terrain.

***Keywords:*** *Driverless car, Machine Learning*

## 1. INTRODUCTION

Since the technology of autonomous cars has become more and more mature, humans gradually begun to use the features of driverless cars to complete some tasks that are difficult for humans, such as field rescue and difficult terrain exploration. Modern automobile companies have been introducing new automatic functions in recent models, [9] like the Navia, a robotically driven electric shuttle that operates at a maximum speed of 20 kilometers per hour and was made by Induct Technology, France. It uses four lidar units and stereo optical cameras and does not require any road modifications.[10] Its lidar device and optical camera help to generate a real-time three-dimensional map of the environment.

This report will cover the basics of autonomous vision and driverless cars, and how they work in machine learning. By comparing the difference between Google's self-driving car in an urban environment and a self-driving car in a complex outdoor environment, the future application of self-driving cars in complex outdoor environments and their working principles are discussed. And try to use autonomous vision to complete rescue work in complex terrain or traffic in remote areas.

## 2. THE AUTONOMOUS CAR AND AUTONOMOUS VISION IN MACHINE LEARNING

This section will describe the basic information related to the autonomous car and autonomous vision in machine learning.

An autonomous car is one that can drive itself from point A to point B, our drive in the regular routine (usually the points and the routine are prechecked) by using many kinds of sensors and technologies like adaptive cruise control, active steering (steer by wire), anti-lock braking systems (brake by wire), GPS navigation technology, lasers, and radar.

While "driving mode" means "a type of driving scenario with characteristic dynamic driving task requirements (e.g., expressway merging, high-speed cruising, low-speed traffic jam, closed-campus operations, etc.)" In SAE's automation level definitions.

So, there are six different degrees of autonomous cars (self-driving cars), as shown in Figure 1.

| SAE Level | Name | Narrative definition | | Execution of steering and acceleration/ deceleration | Monitoring of driving environment | Fallback performance of dynamic driving task | System capability (driving modes) |
|---|---|---|---|---|---|---|---|
| ***Human driver monitors the driving environment*** | | | | | | | |
| 0 | No Automation | The full-time performance by the human driver of all aspects of the dynamic driving task, even when "enhanced by warning or intervention systems" | | Human driver | Human driver | Human driver | n/a |
| 1 | Driver Assistance | The driving mode-specific execution by a driver assistance system of "either steering or acceleration/deceleration" | using information about the driving environment and with the expectation that the human driver performs all remaining aspects of the dynamic driving task | Human driver and system | | | Some driving modes |
| 2 | Partial Automation | The driving mode-specific execution by one or more driver assistance systems of *both steering and acceleration/deceleration* | | System | | | |
| ***Automated driving system monitors the driving environment*** | | | | | | | |
| 3 | Conditional Automation | The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task | with the expectation that the *human driver will respond appropriately to a request to intervene* | System | System | Human driver | Some driving modes |
| 4 | High Automation | | *even if a human driver does not respond appropriately to a request to intervene* the car can pull over safely by guiding system | | | System | Many driving modes |
| 5 | Full Automation | | *under all roadway and environmental conditions* that can be managed by a human driver | | | | All driving modes |

**Figure 1** SAE (J3016) Automation Levels [1]

Figure 1 above shows the basic SAE automation levels. There are lots of degrees in the autonomous car, which can be simplified into two levels, driver-in-control and vehicle-in-control. The driver-in-control means the car has sophisticated semi-automated functions for driver assistance, but the driver is still ultimately responsible and in control (level 2). For the vehicle-in-control car, it totally does not need a driver and can work autonomously, but the car may be restricted to certain locations and conditions (level 4).

There are different systems that help the self-driving car control the car. It combines the car navigation system, the location system, the electronic map, the map matching, the global path planning, the environment perception, the laser perception, the radar perception, the visual perception, the vehicle control, the perception of vehicle speed and direction, and the vehicle control method.[2] Among them, the navigation system plays an important role in an autonomous vehicle. The main challenge for driverless car is to build a kind of control system that can read and analyze the sensory data so that the car can have the function to detect the other vehicle and the road.

Modern self-driving cars basically use Bayesian SLAM (simultaneous localization and mapping) algorithms now. The principle of SLAM is to combine the data collected by different sensors and the off-line map information to the current map location.

Common sensors used in SLAM are LIDAR (light detection and ranging), GPS, stereo vision, and IMU [3] , while some extreme weather and complex terrain may influence the capabilities of sensors on the car, like heavy rainfall, hail, or snow.

## 3. GOOGLE DRIVERLESS CAR OR THE AUTONOMOUS CAR IN THE CITY

One of the typical examples of an autonomous car in the city is the Google Driverless Car. Google's fleet of robotic Toyota Cruises has logged more than 190,000 miles (approx. about 300,000 km). The distance traveled includes busy highways, city traffic, and mountainous roads.

It has three basic functions, self-steering when finding obstacles and correcting speed limits, self-accelerating in any traffic situation, and self-starting or stopping.[4] The main aim of this section is to explain how those different kinds of the sensor work on Google's driverless cars and how the car makes the decision.

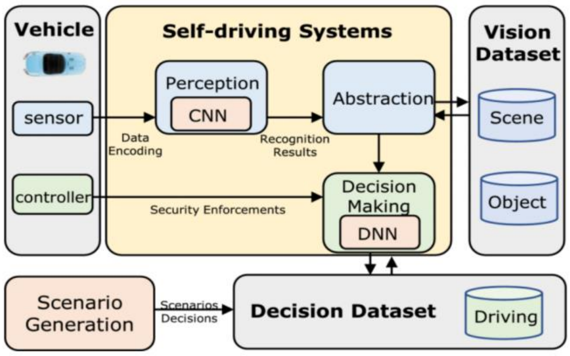


**Figure 2** Basic structure of autonomous car [5]

Figure.2 indicates the basic information on how self-driving system works, like the graph, shows that Autonomous cars rely on sensors, actuators, complex algorithms, machine learning systems, and powerful processors to execute software. The sensor is responsible for the data collection, the data collected by the sensor will be encoded and through the convolutional neural network, after the recognition results, output the abstraction.

For Google's Driverless car, it needs real-time results, and the sensors installed need to monitor the entire driving environment and collect the full data. Basic sensors are LIDAR, VEDIO CAMERA, POSITION ESTIMATOR, DISTANCE SENSOR, AERIAL and COMPUTER.

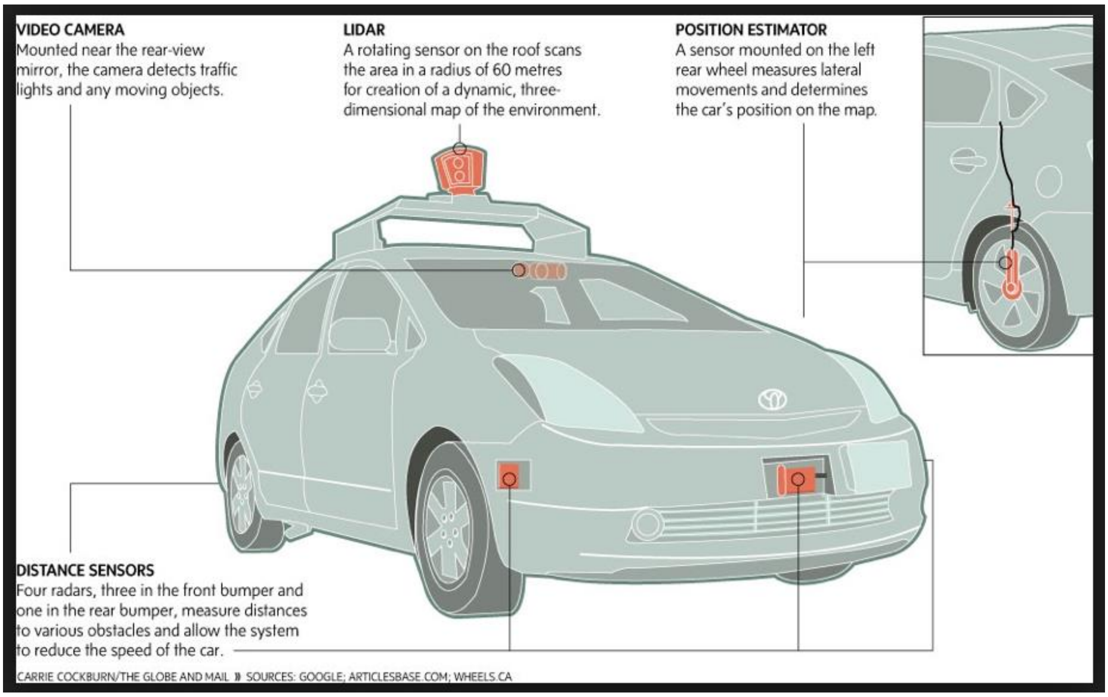


**Figure 3** Google Driverless Car

The figure shown above reveals how google driverless car works, it has four radars on distance sensors, three in the front of bumper and one in the rear bumper. A video camera mounted near the rear-view mirror and a LIDAR (rotating sensor) on the roof scan the area in a radius of 60 meters, while a position estimator mounted on the left rear wheel measures the position of the car on the map.

### *3.1. LIDAR*

The full name of LIDAR is Light Detection and Ranging, it is an optical remote sensing technology that is used to measure the distance of a target with illumination to light in the form of a pulsed laser. It is a laser range finder, also known as the "heart of system", mounted on the top of the spoiler. A detailed #-D map of the environment is generated by the device VELODYNE 64- beam Laser [4].

The light will be reflected by the surface of the target item when it encounters the laser. To get the range, the data from this reflected beam light will be collected by the LIDAR, the direction data is produced by the GPS and inertial measurement unit system scan angles and calibration with the position. The output of sensors will be like a dense "point cloud" which is a group of points consisting of 3D spatial coordinates (including Latitude, Longitude, and Height) [4].

### *3.2. Video camera and Position estimator*

The video camera usually used to detect the traffic light, read the signs and watch cyclists, motorists and pedestrians. While the position estimator is a kind of ultrasonic sensor, also known as a wheel encoder, it is fixed on the wheels of the car and is mainly used to determine where the car is on the map and track the movements of an autonomous car. After getting the data, it will automatically update the status of the car on Google Maps.

### *3.3. Distance sensor (RADAR) and Computer& Artificial intelligence.*

Distance sensors (four sensors) are used to ensure that the car can detect objects far enough away so that the car can correctly identify what object it is and respond with sufficient time (stop the car, keep moving or turn). After getting the data from all the sensors, the computer needs to process the data collected and make the decision, for example, by analyzing the data to decide on steering, or acceleration, or brakes. It also needs to obey the traffic rules and understand some unspoken assumptions of road users. While the AI is used to control more specific parts like After data obtained from the hardware sensors and Google Maps is sent to the A.I for determining the acceleration. The main goal of AI is to drive the passenger safely and legally to his destination [4].

## 4. AUTONOMOUS CAR IN UNSTRUCTURED TERRAIN.

In some unstructured terrain, the autonomous car also has many kinds of applications, like some unmanned cars need to work in a complex outdoor environment, like the crusher autonomous system shown below (Figure 4):

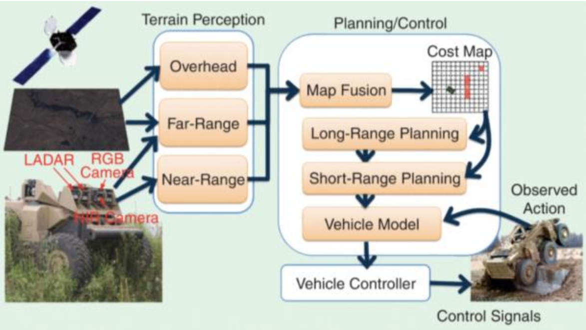


**Figure.4** Crusher autonomous navigation system

Figure.4 reveals the basic flow of the crusher autonomous navigation system, which includes LADAR, RGB Camera, and NIR Camera on the crusher. The system combines the data from the LADAR sensors and the camera on the crusher with the previous satellite image to figure out a correct (safe and efficient) path to get to the target point through the complex outdoor environment[6]. This figure cannot totally represent the structure of the autonomous car, it hides some important parts like positioning, expiration of data, and inter-process communications and timing, but retains the core elements of the system, which are important for a discussion of the role of machine learning.

### *4.1. Near-Range Perception uses a combination of onboard camera and actuated LADAR sensors.*

For the car work in the unstructured terrain, there are still some differences from driverless cars on the road. This crusher system can be separated into two models, and these models include many geometric and appearance-based features assigned to individual 3-D voxel. This 3-D voxel is classified into the barrier, ground by using supervised learning from the different terrain examples.

### *4.2. UPI Program*

The UPI program has developed a new imitation learning technology that allows cost functions to be learned directly from preferred driving behavior examples. These costs, as well as the costs arising from previously available overhead data, are then combined, and transmitted to the crusher's planning system. The processing of overhead data reflects the processing of the crushing locomotive load sensing system, which is described in the section "overhead terrain sensing".[6]

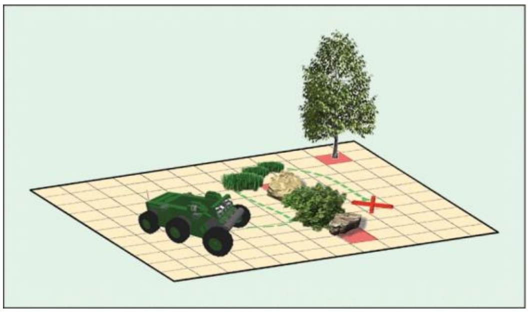

**Figure.5 the abstraction of navigation** [7]

Using a 2-D (two-dimensional) horizontal grid to reveal the scanning world is useful for navigation abstraction.

## 5. CONCLUSION

The type of sensor, the perception method are all different, all these things are based on the specific case and terrain. Different terrain will have different ways of doing the autonomous vision.

For different complex terrain, different sensors will be used to detect the terrain, so as to meet the purpose of driving the car on different terrain. However, due to the wide variety of sensors and different methods of detection, if in the automatic driving technology needs to be improved, more compatible sensors and data acquisition methods need to be used in cars. This ensures that driverless vehicles can better judge the direction and drive normally, whether on roads or in complex terrain.

With the autonomous vision in the complex outdoor environment, it can be used to do some dangerous rescue, which is more efficient and safer than Human rescue.

For autonomous vision in complex outdoor environments, it can be used to do some dangerous rescues, which is more efficient and safer than manual rescue. In special natural disasters or harsh environments, military personnel can use autonomous vehicles to reach dangerous and remote areas, deliver fuel, food, and general supplies, and at the same time help rescuers to smoothly and safely deliver to the disaster site for rescue work. In addition, the adoption of self-driving vehicles can reduce the number of deployment personnel, thereby reducing injuries.

Another future implication is the reduction of emergency drivers when autonomous vehicles are deployed as fire trucks or ambulances. An advantage could be the use of real-time traffic information and other generated data to determine and execute routes more efficiently than human drivers. The time savings can be invaluable in these situations.[8]

This article mainly discusses the different detection methods (autonomous vision) of autonomous vehicles on different terrains from the perspective of machine learning, and the program content related to machine learning is not mentioned in this article. Therefore, in the future, from the perspective of machine learning programs, we will explore more about deep learning and CNN to provide new ideas for the upgrade of self-driving cars.

In addition, data can be combined with respect to radar detection, as well as the different ways in which data is collected, to discuss the differences between future radar imaging and computer imaging.

## ACKNOWLEDGMENT

In this project, I would like to thank my supervisor, Professor Goyal, for his guidance through each stage of the process. His class is interesting and provided lots of ideas about this project which helped me a lot when I was doing the research. in addition, I want to thank my parents and friends, they always are patient with me, and I always can share my ideas with them. Their encouragement makes me feel confident. I could not have completed this dissertation without their support of them.

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