Sensors Used In Self Driving Cars

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Abstract

There has been very much progress in technology and self propelled systems. Autonomous cars will be used commonly on the roads in the coming days.

This paper highlights the key technology used in self driving cars (autonomous cars) i.e. Sensors.

Autonomous cars are those in which driver involvement is not required. The main component for all types of self propelling vehicles is sensors which are present at the front and Back of the vehicle. Without the sensors the vehicle is virtually blind.

This paper characterise show entire sensory information from all different sensors merge and get processed by the fusion process to provide the car with extremely correct data. And what are the future sensors that may be used in self- driving cars. This paper concentrates on illustrating the role of every sensor in self driving cars.

Keywords: Autonomous cars, sensors, self-driving cars, Lidar, camera, Radar, sensor fusion

1. Introduction

Self driving is a vague term with a vague meaning as explained by tech emergence magazine. Experiments have been conducted on the automate driving since 1920. For many past years Car Companies have been looking for self-driving cars.

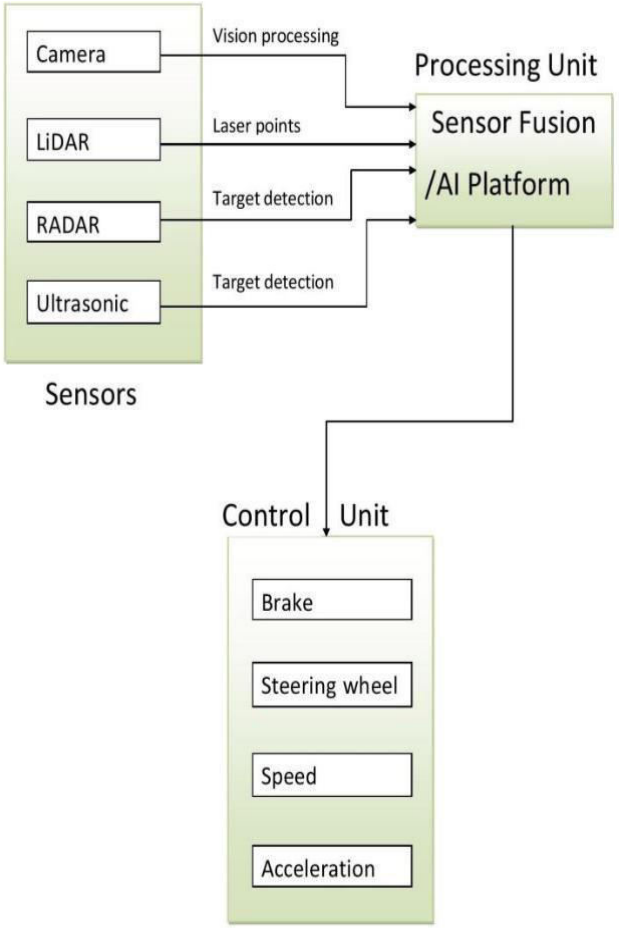
These are the cars which can drive themselves without any human involvement. Just like manual cars the self driving cars are able to pick the passenger and also drop the passenger to his/her destination.

These self driving cars use many sensors like Camera, LIDAR, RADAR, ULTRASONIC etc. these sensors provide the sensory knowledge to determine navigation paths, how to escape from bumps, about pedestrians and also provide information about the road signs. These sensors acts like the sense organs of the car and the fusion process acts like the brain of the car

The self driving cars have three main components, the sensors of the car, the car processing component which include the fusion of the sensory information and control of the car which takes the suitable action.

The self driving cars analyze the environment through many sensors like camera, lidar, radar and ultrasonic. These sensors are seated on the car. The information is collected from various sensors. This sensory information is passed to the processing component of the car where the sensor fusion is performed. The outcome of a sensor fusion of a few sensors is supply to the car's AI. Then the car's AI merges this fused data with the information of another sensor. Sensor fusion may have multiple locations. The AI processing component manages the virtual

design of the environment. The car runs in this environment. This virtual design of the environment is renovated when the new information is arrived from sensors. Once the sensor fusion is completed then AI concludes what action to take and these actions behave as a command to the control of the car like apply brakes, increase speed, decrease speed, turn left, and turn right.



2. Various Sensors

Classification of sensors:

Active sensors: Active sensors are those which transmit energy in the type of radiations and dependent on the data that arrive back to identify the things on the road. Example: Radar sensor disseminate the signal and the signals that were reflected, refracted or scattered by any object in the atmosphere is measured.

Passive sensors: The sensors that do not transmit any energy in the form of radiations and directly grasp the knowledge from the surrounding such as a camera.

Types of sensors:

1. LIDAR
2. RADAR
3. ULTRASONIC
4. CAMERA

2.1 LIDAR

LIDAR has super exclusive capabilities with which it facilitates these self driving cars to explore the environment.

LIDAR provides the vision of 360-degree repeatedly and also provides the correct information.

The LIDAR is the heavy box seated on the roof of self driving cars that rotate repeatedly.

LIDAR acts like an eye for self-driving cars, because it gives 360-degree view. LIDAR is also known as “eyes of an autonomous vehicle”.

Fig 2: LIDAR Sensor

LIDAR stands for light detecting and ranging. The LIDAR system repeatedly emits thousands of laser beams per second to the environment. This pulse collides with the objects of surroundings and reflects back and LIDAR calculates how far it is according to time taken by reflected beam to come back to the sensor. Since it emits million of beams per second therefore the reflecting beam creates or made a 3D model of an object or a point cloud.

Computers observe each reflecting point and convert this reflecting point into rapidly updating point cloud into 3-D animation of the objects.

Speed of light and distance covered by reflection point cloud is used to represent the 3D animation and this helps to determine the position of the vehicle with the surroundings. This 3D representation also monitors the gap among the front vehicle and other side by side vehicles which help vehicles to command the brake or stop which make self driving cars more safe and efficient and if there is not another vehicle ahead then it also increases the speed of vehicle. LIDAR sensors usually don't have any trouble in detecting the object during fog and in rain.

LIDAR also permits you to create large 3D maps by which you can guess the position of the car. By using LIDAR we are able to learn about the advance time such as we can get the information like the boundary of the lane is ahead and there is a stop signal or traffic light signal1000 meter ahead.

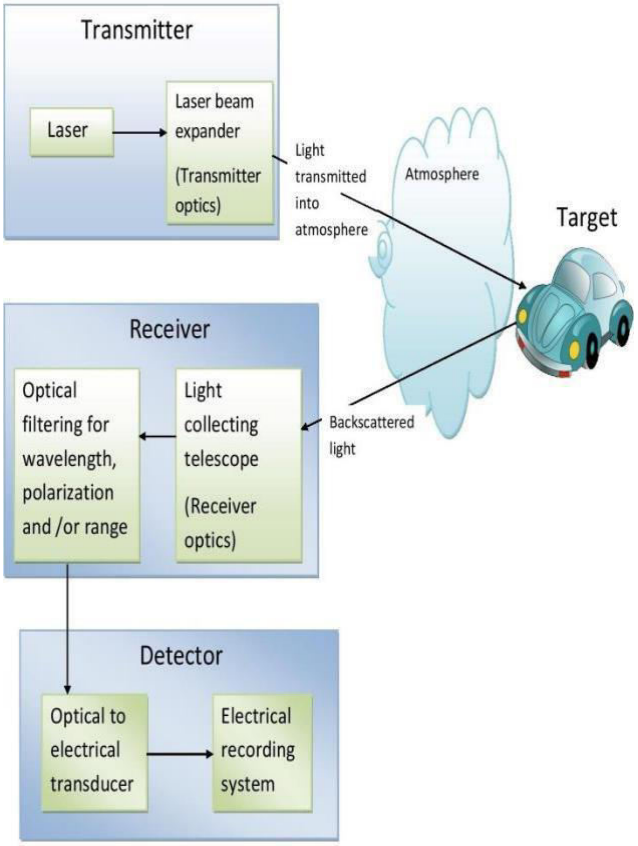


Fig 3 Working of Lidar sensor

2.2 RADAR

We are capable of viewing things because light hitting anything is reflected and entered into our eyes. RADAR works in the same manner.

RADAR stands for Radio Detection and Ranging. RADAR sends radio waves to the surroundings and detects the object speed, angle, distance and range with affinity to the automobile in real time. RADAR uses a transmitter to produce the radio waves this transmitter is called the magnetron. These radio waves when hit to any object get reflected and come back to the receiver where the reflected waves are processed. The time taken by the reflection to come back is used to detect how far the object is.

Radio waves should travel at the same speed of light waves but radio waves are too long. Their range is from a few centimetres to meters. The frequency of these waves are very low. The antenna used in radar is generally curved and also commonly spin therefore it can identify the actions till a big range.

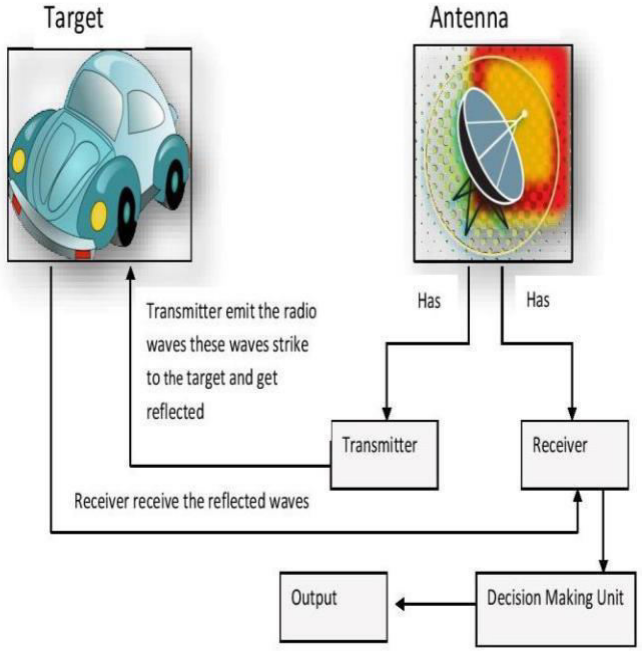


Fig 4: working of radar sensor

RADAR spread both small and huge range radio waves around the car.

Short range radio waves [24 GHz] are used to keep an eye on blind spots, also inform the drivers of hurdles while parking and also support the driver to keep the car in the lane. While a long range radio waves [77 GHz] are used for automatic distance control and brake assistance. RADAR sensors usually don't have any difficulty in detecting the objects during fog and rain.

Fig 5: Place of radar sensor

In this figure it can show that radar is placed on the front of the car.

Currently 2D radar sensor is used which is not capable to predict the height of the item because it predict the item horizontally and it analyze the pedestrian about 90% to 95% which is not sufficient to confirm the security. To solve these problems now 3D radar sensors are being developed.

2.3 CAMERA SENSOR

Self-driving cars use cameras in order to interpret objects in the roads. By implementing a camera at each angle of the car, the vehicle is capable of maintaining a 360 degree view of surroundings just like a human eye. That's why it gets a broader and clear picture of traffic conditions around them. At present 3D cameras are able of display accurate and real images. Images of these cameras are easily identified by the image sensor.

The image sensor can achieve by two technologies CCD (charge coupled device) and CMOS (complementary metal oxide semiconductor). CCD catches immense quality pictures in the less bright circumstances because the CCD cameras are high light sensitive therefore the quality of the picture is good. But the cost of CCD cameras is higher because the power consumption is higher. CMOS was developed to cut down the amount of constructing the image sensor therefore the power consumption is lower but it also compresses its performance.

Just like the human eye, the VIS cameras also take images in between the wavelength 400nm to 780nm.VIS cameras take huge quality and huge resolution images, due to which large amount of data is gathered that builds difficulty for more processing. Therefore the VIS camera on the vehicle can only identify other cars, roads signals, traffic signs, roads marking, cyclists and bridges. In conditions of bad weather like fog, rain etc these cameras do not give efficient output.

In Stereo cameras, two VIS or two digital cameras perform together and provide stereoscopic vision and also provide intense information.

TOF (Time of Flight) cameras measure the intense data and the distance. In a one picture these cameras take the entire view.

But these cameras are not a perfect solution for identify street objects, these self driving car cameras also have the drawbacks, like bad weather conditions, fog, rain, snow etc. That can prevent cameras from capturing clear images which can highly increase the chance of accidents. There is also a limitation of the camera that their algorithm fails when the object and background have the same colour contrast.

Fig 6: Camera sensor

In this figure it can show that camera is must in the car and it can placed or settle everywhere in the car.

2.4 ULTRASONIC SENSOR

These Ultrasonic sensors are not new technology used in a vehicle. From 1990 these sensors have been used in cars for parking. Ultrasonic sensors are used for braking systems in vehicles due to low speed of other vehicles in the lane and detection of nearby objects at low speed. It gives a faster reaction that's why it's mainly used for the parking system of a car. At the time of changing the lane Ultrasonic sensor used to identify other cars in our blind spot.

Ultrasonic sensor has a device transducer which emit the ultrasonic sound waves above the range of human hearing i.e. 40 KHz and when these sound waves hit to any object get reflected and come back to the transducer. The distance of the object is measured by time taken by the waves that come back to the sensor.

Fig 7: ultrasonic sensor

3. SENSOR INTEGRATION

Sensor fusion is phenomenon in which the information collected from different sensors is merged and the combination of best information for the vehicle is provided to the vehicle. Sensor fusion is performed to sensitize the sensory data.

There are some merits and demerits of each sensor used in the autonomous cars.

Camera is good in detecting roads, identifying other vehicles and also good in reading the signs. Simply camera gives the duplicate copy of the human vision but camera is not capable to identify the object's distance and influenced by nature changes like brightness, occlusions and weather changes.

LIDAR is good at detecting the vehicles position but bad weather such as snow and rain influence the lidar's functioning.

Radar is good at calculating vehicle speed and distance over a range of 500 feet, also identify the car ahead. Radar's accuracy in identification and resolution is too low.

Ultrasonic sensor is good at detecting the near objects over a range of 3 to 6 feet.

So it is necessary to merge the data from various sensors to better the various functions like distance detection, object detection, speed detection etc.

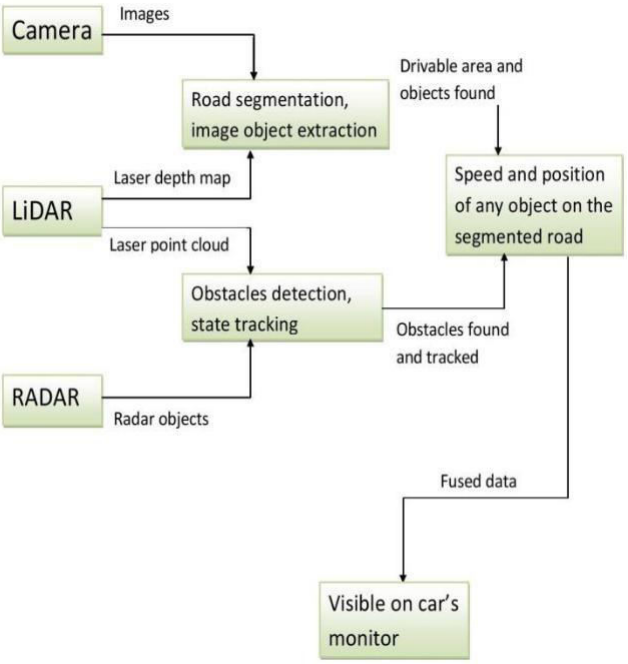


Fig 8: Sensor fusion of Camera, LIDAR and RADAR

LIDAR creates 3D view of the environment. LIDAR functionality when merged with the functionality of camera, radar and ultrasonic sensor then a better view of the surrounding is made.

Detection of moving objects is very difficult in autonomous cars, to make it easier all the sensors information is used.

The input from the sensor is fed into a high performance centralized AI computer i.e. NVIDIA DRIVE AGX platform. The best part about this process is that it does not depend on a single input, and if there is a problem from input or one input fails then there are other inputs to process the decision. For a single function, car use several parameters to take decision.

4. FUTURE SENSORS

There is a growing concerned among the designers that self driving cars are not just discerning enough to forge them adequately safe. So engineering is now taking its consideration to practise more sophisticated sensors and technology such as tech that can look over underground. Bobby Hambrick the chief executive of an Autonomous Stuff's said – "There are still many deficiencies in sensor suits". He more and more accounts that the problem is that cars can't start to figure what's around them, if we parlance in the field of autonomous vehicle engineering, observation has to be precise enough to facilitate classification.

The main issue in autonomous cars that these cars not able to see safely in the heavy traffic. The Standard model of an autonomous car use only four primary sensors, these are camera, radar, LIDAR and ultrasonic sensor. Video cameras can be difficult to recognise in a blaze. Ultrasonic sensors only observe close by objects. LIDAR can create 3-D models of street signs and people but it is also limited to a particular distance and also impedes heavy rain.

To fill these limitations of traditional sensors companies are considering technology like from sci-fi movies.

1. Far Infrared sensors- far infrared sensors unveil the ghostly or illusory images which are usually invisible by the naked eyes of the humans. It uses ground penetrating radar which discovers the subterranean features and also a military system to figure out the autonomous puzzle.

2. AdaSk's sensors – AdaSk's sensors also known as thermal cameras, which can discover wavelength under the visible spectrum. They are generally best at discovering people or animals in the dark or at night. It can sense or see people 100 feet ahead even in a rainstorm and even people wearing white against a white background. [5]

5. CONCLUSION

In this paper we make a review on the sensors used in these self driving cars or in an autonomous car or vehicle. What types of sensors are used in a self driving cars and working of each sensor individually? How all the sensors combine together and make a car more safe and efficient? What are the drawbacks of traditional sensors? What are the upcoming technologies or sensors that will be used in self-driving cars and will make the self-driving cars safe and more efficient?

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