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A Concise Survey on Computer Vision in Self-Driving

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ABSTRACT

In this paper, the computer vision with self-driving cars has been discussed. The main points which discussed here are the units of the self driving car, the core components of self- driving cars, Safety problems of road vehicles are also presented.

In this modern world, the technology is growing very fast. One of the path changing technology which is been implementing are Self-driving cars [1]. A Self Driving car is a vehicle that is capable of sensing its environment and able to do the necessary navigation without the human input.

These self-driving cars are being preferred more by the people because less work and safe journey.

The vision-based system can effectively detect and accurately recognize multiple objects on the road, such as traffic signs, traffic lights, and pedestrians. The main idea which has been discussed here is General in-vehicle driver support system architecture [2]. To detect and track vehicles and other kinds of objects often with different sensors are used. Thus, giving humans the capability of using the self- driving vehicle for daily usage will change the current scenario of transportation and helps to improve the user driving experience.

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Keywords

computer vision, LiDAR, radar, object detection.

1. INTRODUCTION

Computer vision is a field of artificial intelligence (AI) that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs and take actions or make recommendations based on that information. If AI enables computers to think, computer vision enables them to see, observe and understand [3].

Computer vision needs lots of data. It runs analyses of data over and over until it discerns distinctions and ultimately recognize images. In recent years, there has been a significant increase in research interest supporting the development of the autonomous vehicle, which is an automobile platform capable of sensing and reacting to its immediate environment in an attempt to navigate roadways without human intervention [4].

There are various moving as well as stationary objects on the road like pedestrians, other vehicles, traffic lights, and more. To avoid accidents or collisions while driving, the vehicle needs to identify various objects. Autonomous vehicles use sensors and cameras to collect data and make 3D maps. This helps to identify and detect objects on the road while driving and makes it safe for its passengers.

2. LITERARURE SURVEY:

Architecture

There is a difference between the normal cars and self- driving cars, the self-driving cars have some extra components in them.

The two main components are

1) LIDAR
2) RADAR

LIDAR:

LIDAR stands for Laser illuminating detection and ranging. Its role is to measure the distance of objects relative to the position of the car in 3-D.

LIDAR

Most LIDAR systems are comprised of four components:

- **Laser**: contracts pulses of light until it hits an object and reflects back to the LIDAR system.
- **Receiver**: captures the laser points pinging back to the system.
- **Scanner**: clusters the received laser points into a "point cloud" to create a 3D model of the objects in its surroundings.

2.1 Global Positioning System

(GPS): LiDAR technology captures the exact location coordinates of scanned 3D objects in relation to the position of its sensor. Known for its precision, LiDAR is essential for collecting detailed spatial data and calculating accurate distances, which significantly enhances the safety of autonomous vehicles [4]. By measuring how far objects are from the vehicle, LiDAR generates a 3D representation of the surrounding environment using laser pulses. This allows the vehicle to effectively visualize its surroundings in great detail. Compared to human vision, LiDAR offers a much broader range of perception, with the capability to detect objects in all directions and determine their distance with high accuracy [5] [1]. Since safety is a critical aspect of autonomous driving, LiDAR plays a vital role by allowing vehicles to make precise, informed decisions without relying on human input, thereby reducing the likelihood of accidents.

RADAR:

Radar stands for Radio Detection and Ranging a RADAR uses radio waves to detect objects and determine their range, angle, and/or velocity. The principle of operation for LiDAR and RADAR are the same, but instead of the light waves used in LIDAR, RADAR relies on radio waves [6]. RADAR in autonomous vehicles operates at the frequencies of 24, 74, 77, and 79 GHz, corresponding to short-range radars (SRR), medium-range radars (MRR), and long-range radars (LRR), respectively. They each have slightly different functions:

- SRR technology enables blind- spot monitoring, lane- keeping assistance, and parking assistance in autonomous vehicles.
- MRR sensors are used when obstacle detection is in the range of 100-150 meters with a beam angle varying between 30° to 160°.
- The automatic distance control and brake assistance are supported by LRR radar sensors. Some applications of radar are in adaptive cruise control (ACC), predictive emergency braking (PEBS) and blind-spot monitoring (BSM) systems [6].

There are more important things to look into while talking about the architecture and working of self- driving.

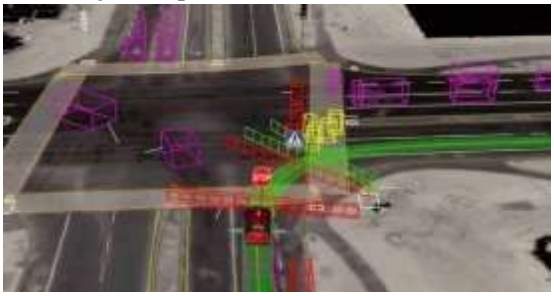
A self-driving car has five major components:

- Computer Vision
- Sensor Fusion
- Localization
- Path Planning
- Control

3. Computer vision

Like a human driver, we need to be able to *see* the environment around us, whether that's looking ahead for traffic or reading road signs, vision is the key.

Similarly, computer vision is how a car *sees* its environment.

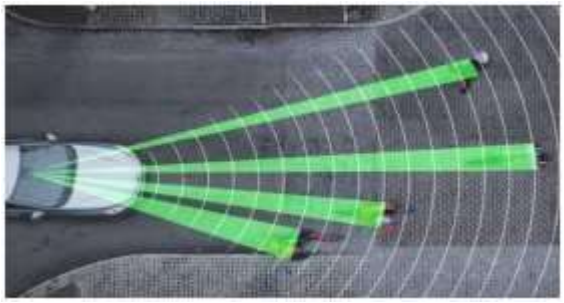


It is split into three stages:

Stage 1: To identify and classify objects, we use an algorithm called the You Only Look Once algorithm (YOLO). This algorithm divides images into smaller squares and each of these squares is run through a Computational Neural Network (CNN).
Stage 2: At this stage, all the bounding boxes are present, and none of the possibilities are ruled out. Our goal is to find the most accurate bounding box for each object. We can do this using a method called Non-Maximum Suppression (NMS)**.** Stage 3: After performing YOLO and NMS on an image,we obtain the result. The computer vision
is called as eye of the self driving cars.

3.1 Sensor fusion

Sensor fusion is using multiple sensors to augment the vehicle's perception of the world. We will be using sensor fusion to track objects.the sensors include the lidar and radar .it is a fusion which is not fusing the raw data together, but combining the output of radar with the output of a LIDAR [7].



Sensor fusion To combine the respective outputs of RADAR and LIDAR, we use Kalman Filters. Kalman filters are unimodals and use Gaussians to represent state and uncertainty.
Kalman filters rely on probability and a "predict- update" cycle to gain a better understanding of the world. The sensor fusion is mainly used to understand the environment in a detailed manner. Because there are a bunch of sensors equipped on a self driving car, we can take all the necessary data and fuse them to provide a richer diagram to our car, hence the name sensor fusion.

3.1.1 Localization

Localization is determining the vehicle's precise location on the map. By this function we can determine where other elements are, such as the center of the lane, the distance from the vehicle to the curb, or the distance to the next intersection.
There are two commonly used methods to localize a vehicle:
APPROACH #1:

We can identify specific landmarks (e.g. poles, mailboxes, curbs) and measure the vehicle's distance from each landmark.
APPROACH #2:

The second approach is Matching. We can match the point cloud the vehicle sees to the point cloud in the map.

3.1.2 Path Planning

Path planning is figuring out how to get from where the vehicle is now, to where it wants to go. The vehicle uses path planning algorithms to find different routes and their feasibility [6] [7].

The algorithms convert the urban environment into a digital configuration that enables it to search for and detect space and corridors in which a vehicle can drive[8].

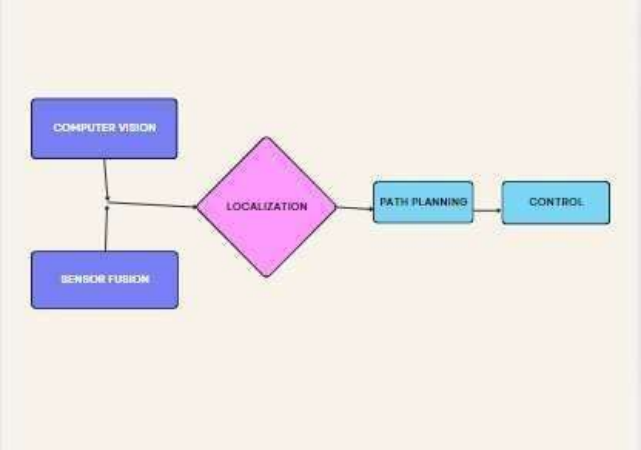
PATH PLANNING Autonomous vehicles can consider each path using three principles:

- First, the fewer lane changes, the better.
- Second, the larger the distance to the moving object ahead, the better the score for maneuvers.
- Third, the greater the velocity of the object ahead, the faster the car can drive in the lane

3.1.3 Control

Control is the final step in the process, The goal of the control module is to generate an angle for the steering wheel and control acceleration in a way that allows you to follow your predetermined trajectory [8].

Once we have the trajectory from our path planning block, the vehicle needs to turn the steering wheel and hit the throttle or the brake, in order to follow that trajectory.



A FLOW CHART REPRESENTING THE COMPONENTS OF SELF DRIVING CARS.

3.1.4 Overview

The self-driving cars to ensure safe driving condition captures data about the location, road & traffic conditions, terrains, number of people in the areas and more. These data sets are used for situational awareness while driving. The same data sets are useful for deep learning model training.

For instance, the images of traffic signals at various junctions captured by the camera are used by computer vision to check traffic signals while training deep learning models. It also helps to identify and classify various types of objects on the road [9].

- Computer vision is the identification and classification of objects using cameras and algorithms such as YOLO and NMS.

- Sensor fusion is using multiple sensors and tools such as radars, LIDARs, Unscented Kalman Filters, and prediction/update cycles to track objects [10].

- Localization is determining the vehicle's precise location on the map through the identification and localization of nearby landmarks.

- Path planning is Path planning is the brain of a self driving car. It is the module that tries to replicate the thinking and decision-making we humans do while driving [11].

- Control is used to generating an angle for the steering wheel and control acceleration in a way that allows you to follow your predetermined trajectory.

FUTURE SCOPE:

In future most of the cars we see will be the self driving cars ,as they are more safer with less human work than the cars at present . The Technology Trend of Artificial intelligence especially deep learning will improve significantly and make driverless car possible . Regulations **The Comparison between different** will change quickly within countries **levels of automation are:** regarding the use of autonomous vehicles because of a global autonomous race.
Entire cities will flip from drivers to driverless all at once, and they'll change how we live and commute. Over 90% of accidents today are caused by driver errors, Once driverless cars become more widely adopted, the future of cars without human drivers looks bright and much safer. With nearly 40,000 people killed in motor vehicle crashes in 2020 alone, autonomous vehicles will prevent accidents caused by human error and driver fatigue or impairment .
Self-driving cars could also increase vehicle occupancy and efficiency, as well as reduce traffic congestion

In 2050,self driving cars are expected to create approximately
$800 billion worth of opportunities for automakers and technology developers .

Once all these technologies are optimal, society will be one step closer to the utopia of flying cars most people dreamed of as children.

CONCLUSION

In this paper I provided a general survey on Safety problems in the road vehicles, Units of Self Driving car and components of self-driving car why they are necessary for functioning of the self-driving car and a brief description of computer vision for autonomous vehicles are also described which is used for vehicle detection and obtained recognition consist of many subsystems. Computer vision with an AI-based algorithm is the "eye" of self-driving vehicles. The main objective of computer vision is to ensure the safety of its passengers and to deliver a smooth self-driving experience.

As technology expands throughout the world, self-driving cars will become the future mode of transportation universally [12]. The legal, ethical, and social implications of self-driving cars surround the ideas of liability, responsibility, and efficiency. Autonomous vehicles will benefit the economy through fuel efficiency, the

environment through reduced carbon emissions, society through more togetherness, and the legal system through a simpler system of liability. These ideas revolve around two central aspects of autonomous vehicles, how they work and how they are kept secure. As technology advances, the security technology regarding self-driving cars will also continue to grow to combat hackers, improve the accuracy of internal systems, and prevent accidents.

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