Chapter

Obstacle Detection and Track Detection in Autonomous Cars

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Abstract

This chapter illustrates the history and recent advancements in the field of Autonomous Vehicles with regard to two important concerns that play the most vital role in successful implementation and working of an Autonomous Car: (1) Obstacle Detection and (2) Track Detection. The car should be able to detect the obstacles for smooth and efficient working in order to avoid accident and collision. It should also be able to calculate the distance of the obstacle from the car. Similarly, Track Detection is also important as the autonomous car should stay within a predefined track and has to keep itself within the yellow lines on both sides of the road. This chapter elaborates the technologies and advancements that have been presented in the literature till date that deal with Obstacle Detection and Track Detection in Autonomous Cars/Vehicles.

Keywords: autonomous cars, obstacle detection, self-driving cars, track detection, unmanned vehicle

1. Introduction

An autonomous car is a vehicle that can guide itself without human command and control. It is also known as a driverless car, self-driving car, unmanned vehicle or a robot car. Autonomous vehicles are able to perceive their surroundings (obstacles and track) and commute to destination with the help of a combination of sensors, cameras and radars. Advanced control systems can interpret the information provided by sensors to detect obstacles and choose the most suitable navigation path for the vehicle. Enormous research has been carried out to bring the idea of autonomous car to life. Now a days, such vehicles have become a concrete reality and they have been created and extensively tested on roads, although they are not yet commercially available on a large scale.

In autonomous vehicles, one of the most important features is the correct and accurate detection of obstacles as well as the track of the vehicle. The vehicle or car should be able to detect the presence of an obstacle precisely and well in time so that it can stop itself at a safe distance in order to avoid the collision. Track detection is also a very important factor as the vehicle must be able to keep itself within the limits of track and follow the lines on the road in order to remain rightly on the track and to follow the lane as well.

This chapter deals with the study of various different approaches for obstacle detection and track detection that have been studied/implemented in the literature by different researchers. Vehicle safety systems are generally classified into types [1]:

(1) Active (DAS: Driver Assistance Systems) and (2) Passive. Active systems include collision avoidance system, automatic braking, adaptive cruise control and lane departure warning system, whereas, passive systems generally comprise features such as seat belts, air bags, crumple zones and laminated windshields. Therefore, obstacle detection and track detection falls into the category of active vehicle safety systems.

2. Sensor-based approach

The most common and widely used approach for both obstacle detection and track detection is the sensor-based approach. A number of different sensors and related technologies have been discussed in the literature. [1] discusses almost all general types of sensors used for collision avoidance that include: Acoustic, Radar, Laser/LiDAR, Optical sensors and the fusion of sensors. It also discusses their advantages and disadvantages.

Sensors can be broadly classified into two categories [2]: (1) Co-operative sensors and (2) Non co-operative sensors. They are summarized in **Table 1**.

The most commonly used sensors in autonomous vehicles are LiDAR and RADAR that are discussed below:

2.1 LiDAR sensors

In [3], a 2D laser sensor is used for obstacle detection and tracking. In [4], an automatic obstacle detection and tracking system has been introduced that fuses 3D Light Detection and Ranging (LiDAR) and 2D image data for efficient inter-distance and anti-collision management. In [5], a more sophisticated road boundary and obstacle detection scheme has been used using a downward-looking LiDAR sensor. Another study [6] presents a LiDAR and wireless sensor-based real time obstacle detection method.

2.2 RADAR sensors

Many researches have discussed use of radar sensors for obstacle and track detection [1, 7–8]. [7] uses radar sensors and uses vision and radar data fusion system for ground-based navigation. [8] uses radar and vision sensors for accurate detection of obstacles.

Cooperative Sensors	• Traffic Alert Collision Avoidance System (TCAS) • Automatic dependent surveillance and broadcasting (ADS-B)
Non Cooperative Sensors	• RADAR • Sonar • LiDAR • Electro-Optical • Infrared Sensors • Acoustic Sensors
Sensor Fusion	• To fuse the information obtained from different sensors

Table 1.
Types of sensors.

3. Camera-based approach

The second most popular approach is the camera-based approach that is used for detecting the track and obstacles in autonomous vehicles. Some researchers consider it a sub-category of sensor-based approach but due to the diversity and a broad range of camera-based detection schemes, it has been presented as a separate category.

Camera-based detection methods have been classified into three categories: (1) Knowledge based; (2) Stereo vision based, and (3) Motion based [4]. These categories have been summarized in **Table 2**.

In [9], detection and tracking of obstacles is done from a camera mounted on a vehicle with a view to driver assistance. [10] discusses tracking of people and objects with an autonomous UAV using two schemes: (1) Face Detection and (2) Color Detection. In [11], a robust vehicle detection system is described that detects vehicles in the rear view of the host car. It records the motion parameters of the host vehicle to determine the driven path. [12] introduces ROBOG, an image-based detection system, that is meant for road detection for unstructured roads.

Knowledge-based approach	• A priori knowledge of obstacles: symmetry, color, shadow, corners, vertical and horizontal edges
Stereo vision-based approach	• Using a disparity map • Using inverse perspective mapping (IPM)
Motion-based approach	• Using optical flow

Table 2.
Summary of camera-based detection methods.

4. Deep learning-based approach

There are also many deep learning approaches available for obstacle detection and tracking. In [13], one such approach is discussed which uses multiple sources of local patterns and depth information to yield robust on-road vehicle and pedestrian detection, recognition, and tracking. [14] discusses obstacle detection and classification using deep learning for tracking in high-speed autonomous driving.

5. Bio-inspired approach

A relatively uncommon and novel approach is to use a monocular camera to mimic the human behavior of obstacle detection and avoidance applied on UAVs [15]. It can be considered a sub-category of camera-based approach, but due to its novelty from the conventional camera-based approaches, it has been presented as a separate category. Similarly, [16] also discusses a bionic vision inspired approach using radar and visual information.

6. Computer-vision-based approach using PID controller

Another approach discussed in the literature [17] is a mechatronics system comprising a PID controller which predicts and controls the vehicle heading angle in order to follow the lane or to avoid the obstacles.

7. Laser scanner-based approach

Some studies present the use of laser scanner/rangefinder in order to implement obstacle detection and road following in an outdoor environment [18, 19]. This technique outperforms the commonly used camera-based vision techniques in situations such as different weather conditions (e.g. sun, rain, and fog), and different appearances of road (e.g. clay, mud, gravel, sand, and asphalt) [18].

8. Conclusion

Detecting an obstacle and keeping a track of the lane and road is one of the primary objectives in an autonomous vehicle. In this chapter, various studies and researches have been discussed that are present in the literature and focus on the obstacle detection and track detection features in autonomous cars. A wide variety of techniques discussed in the literature have been categorized and summarized according to the methodology and application of a particular technique. This chapter helps understanding and categorizing the different techniques used for obstacle detection and tracking as well as the researches that refer to these techniques.

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