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Design and Analysis of Driverless Vehicle Control System in Urban Environment

Xiaohua Luo [a], Guihui Shen [b]

School of Electrical Information Engineering, Southwest Petroleum University, China

[a]215882857@qq.com, [b]287057280@qq.com

Abstract

This chapter first introduces the road characteristics of the urban environment, and combines the driver's control of the vehicle with the key problems encountered by unmanned vehicles in motion control of urban roads. Then the architecture and functions of the unmanned vehicle platform's architecture and perception system, decision-making system, control system and hardware of each subsystem of the actuator. Finally, the control system research strategy used in this paper is described.

Keywords

perception system, control system, unmanned vehicles in motion.

1. Problems Faced by Driverless Vehicles in Urban Environments

1.1. Environmental Characteristics of Urban Roads

The classification of urban roads in China mainly includes four types of expressways, main roads, secondary roads, and branch roads (Wen Guowei, Zoos. Traffic rules to be followed by vehicles traveling on different grades of roads are different)[1].Quasi-confirmation of road grades It is a prerequisite for driving on the road. In different types of roads, different traffic regulations require different driving conditions, and driving behavior characteristics and attention focus are also different.

An expressway is a road where the speed can reach a higher range when the vehicle is driving, and it is a vehicle-only road. One

Generally, the speed limit on the expressway is 60-80 km / h. When driving on such a road, the driver must be fast. Generally, there are no traffic lights, and there is no interference from non-motor vehicles or some road infrastructure. The driver's vision is clear. The driver should pass quickly on the expressway in a clear situation without external interference.

The main road is designed for ordinary traffic, and the speed of vehicles is generally limited to 40-60 km / h. The main road is designed to have a lower speed per hour than the expressway because it is mainly responsible for connecting the expressway with the low-speed road. When driving on the main road, the driver is in the main position and should pass quickly within the speed limit. During driving, traffic lights will be set at most intersections, and vehicles should follow the traffic signal instructions. When driving on the main road, it has isolation measures, uneven speed, and may encounter traffic jams. At the intersection, some vehicles may need to change lanes, which may cause traffic conflicts and even cause some safety accidents.

The secondary arterial road is a traffic distribution road with service functions. It is mainly responsible for the main road and the roads of various living and working areas. Vehicles must drive at low speeds on secondary roads, and their driving speeds are generally limited to 40 km / h, and branch roads are limited to 30 km / h. The main function of these two types of roads is to make non-motorized vehicles preferentially accessible. They are more common in

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residential areas, and there are incomplete separation facilities on the roads. At the same time, the traffic situation is more complicated, the roads are crowded with people, and vehicles and non-motorized vehicles are interlaced. Drivers driving on the road should pay special attention to the surrounding environment and various unexpected situations. Intersections are an important part of urban roads, and they are also the main places where traffic conflicts, road congestion, and traffic accidents occur. According to statistics from the traffic department, among traffic accidents on urban roads, intersection accidents account for more than 60%.

There are two types of urban road intersections: planar intersections and three-dimensional intersections[2]. The three-dimensional intersections can effectively improve the traffic capacity of the intersections and can completely resolve road intersection conflicts. However, the design and implementation of three-dimensional intersections will be affected Limitations of road area and construction costs have not been widely used. Plane intersections include: three forks, four forks, multi-branch forks, and ring junctions. The amount of traffic conflict at the intersection increases with the number of forks at the intersection. If the number of crossroads at the intersection is five, the number of traffic conflicts will be as high as 52. When driving through a level intersection, you must strictly follow the instructions of traffic lights, and always pay attention to passing vehicles and pedestrians in all directions to prevent traffic conflicts due to factors such as speed deviation

The characteristics of urban roads are generally: diversified road classifications, mixed traffic flow, many non-motorized pedestrians, diverse vehicle types, complicated traffic organization, many road crossings, more traffic conflicts and more congestion[3], and slower traffic capacity. According to different urban transportation plans, the characteristics of urban road networks are also different. In China, urban transportation has the following characteristics:

1) Cities are mostly densely distributed, densely populated in urban areas, and the construction of the road network is incomplete, which makes it difficult to adapt to the rapid increase in the number of urban cars, resulting in heavy pressure on urban roads.

2) The traffic structure is complicated, and various traffic such as pedestrians, non-motor vehicles, motor vehicles and other special vehicles

The streams are interlaced.

3) Citizens have poor traffic awareness, and traffic participants, especially vehicle drivers, have violations. Be vigilant when driving on mixed traffic vehicles.

The above are the main characteristics of urban road traffic in China, and also cause various problems in traffic safety and traffic management of urban road driving. In addition, in the intricate urban roads, the safe passage of vehicles also needs clear and reasonable lane alignment, well-isolated roadside pavements, open road intersections and complete tunnels. However, in actual driving, there will always be some unsatisfactory road conditions, such as lane line interruptions, intersections with obstacles blocking the line of sight, etc., which will also cause problems for the driver during driving.

2. Tasks for Drivers to Complete on Urban Roads

The driver's behavior of manipulating the car is to adjust the direction and speed of the car to make the car move forward safely, including the driver's perception of the road traffic environment, the planning and processing of the feasible area of the car, the prediction and decision of the expected trajectory of the car, and the vehicle Steering wheel, gear, throttle, brake operation and control correction.

The main tasks of the driver during the driving process include: driving the vehicle in the correct lane according to the road marking rules, including lane demarcation lines, guiding

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lane lines, guiding arrows, stop lines, and pedestrian crossing lines. Reasonably control the driving speed according to the speed limit regulations of the road and the conditions of traffic flow, road conditions and weather conditions. According to the vehicle speed, road, terrain and other changes, reasonable control of driving distance and driving lateral distance. In the process of meeting, passing or overtaking, the driver must take care of the front, rear, and both sides of the vehicle according to the position and speed of the vehicle, turn on the turn lights in advance, and reasonably control the speed to find opportunities to merge. Passing the intersection requires observing the signs and signal lights at the intersection, decelerating in advance when approaching the intersection, and passing the intersection at a speed not exceeding 20km / h. At the same time, pay attention to avoid pedestrians and other vehicles that have the right of way.

2.1. Put Forward the Problems Faced by Driverless Vehicles in Combination with Driver Driving Behavior

Based on the characteristics of vehicle motion control problems in urban highway environments, the driverless vehicle control systems studied in this article mainly face the following problems:

1) The urban road environment discussed in this article has obvious structured road features, such as lane lines, zebra crossings, traffic lights, and other external environmental information. Under such specific conditions, the choice of the planning and control methods for the decision-making system of driverless vehicles must be restricted by the environment. This requires us to be able to quantitatively describe the constraints brought by this structured environment, so that we can Use mathematical language to describe decision making.

2) The ultimate design[4] goal of unmanned vehicles is to enable the vehicle to drive the vehicle like a "driver" and reach its destination. This requires the design of vehicle decision-making and control methods to be as "anthropomorphic" as possible. For example, control When the system controls the steering of the vehicle, it should control the steering smoothly like an experienced driver. However, the existing research theories of driverless vehicles have not achieved good results.

3) In urban road environments, different levels of roads have different restrictions on vehicle speed. This requires the control results of the longitudinal and lateral controllers of the unmanned vehicle to be accurate, timely, and adaptive and robust.

2.2. "Smart Pioneer," Unmanned Vehicle Architecture and Functions

Since 2008, Hefei Institute of Material Science of the Chinese Academy of Sciences has carried out research on key technologies and platforms for unmanned vehicles for integrated urban environments, and has successfully developed a smart vehicle platform with environmental awareness, path planning, behavioral decision-making, and autonomous control capabilities. Smart Pioneer, '. In 2010 and organized by the National Fund Committee

In the 2011 GAC Toyota Cup, “Smart Car Future Challenge,” won first and third place respectively. "Smart Pioneer", the overall structure of the self-driving car system adopts a distributed structure, which is mainly composed of an environmental sensing system, a decision system, a sensor subsystem, a vehicle control system, and a vehicle execution mechanism. The subsystems except the vehicle operation interface subsystem In addition, all Ethernet connections are used to ensure high-speed and reliable data transmission. Figure 2.1 shows the hardware block diagram of the unmanned vehicle system.

Perception system: For complex urban traffic environment, 3D lidar is used for 3D modeling of urban complex environment. The fusion of 2D lidar and camera information is used to quickly detect and accurately identify obstacles, lanes and traffic signs. Millimeter wave radar is used. Detection of dynamic targets and their speed.

A GPS / INS integrated navigation system, an attitude heading reference system (AHRS), and a high-precision odometer are used to form an unmanned vehicle positioning module to perform track estimation and positioning of unmanned vehicles. Sensor installation

Equipped with multiple laser sensors, vision cameras, and equipped with two computers for receiving, processing

The raw data transmitted by the sensor.

Decision system: Based on the results of the surrounding environment identification, the positioning information of the span-cpt and the assistance of the wheel speed sensor are used to judge the current environment. Tasks are planned and tracked in real time. The calculated control targets pass The Ethernet network sends to the control system, and finally, passes. An network sends to the corresponding motor to perform the action.

Intelligent decision making is a core issue in the research of driverless cars. It is the brain of unmanned vehicles, and its goal is to find a path for unmanned vehicles that meets vehicle control constraints, collision-free, and even meets traffic regulations in a complex traffic environment with obstacles.

Control system: The CAN2.OB bus[5] is used to build the vehicle control system network, and the CAN gateway communicates with the body CAN network to establish a distributed automatic control system for unmanned vehicles based on the CAN bus. Each control object and status detection unit is connected via the CAN bus. The control system, the control system computer can directly obtain the vehicle status information through the CAN bus of the vehicle body, and send control instructions to each control Liu Yixiang through the CAN bus to achieve vehicle steering, braking, throttle, gear, lights and speakers control.

Vehicle Executive: "Smart Pioneer, developed based on Chery Tiggo 3. The compact and simple independent suspension system of Tiggo 3 makes the vehicle have good driving stability and passability, all of which are independently developed by Chery. The system makes the vehicle very scalable. Various sensors and actuators can be made into the form of CAN nodes, which can be easily connected to the network to achieve system integration. The vehicle control system includes steering control, brake control, throttle control, and gear Position control, light and horn control, etc.

3. Control System Design Methods and Design Indicators

The function of the control system is to convert the path planning trajectory generated from the decision-making system into the actions of each actuator, and control each actuator to complete the corresponding actions, to achieve accurate and stable tracking of the path and speed. It is the lowest level of the entire unmanned vehicle system. It consists of a series of traditional control laws and logical reasoning algorithm groups.

Complete, including speed control, steering wheel control, brake control, gear control, light, horn controller Etc composition. In order to determine the parameters related to the control law that performs path tracking, we first need to specify the vehicle schedule

Look at the trajectory and state of expression. Based on the given desired trajectory, the control system will With the control strategy, a point in a given trajectory is specified, the relative position of the point and the vehicle is calculated, and the steering wheel angle signal is determined according to the current speed of the vehicle, so that the vehicle moves toward that point. Through the update of the trajectory and the transformation of the preview point, this process is repeated to realize the vehicle's lateral movement control. According to the given desired speed, the control system will select the corresponding control law and control

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its acceleration under certain safety constraints, and establish corresponding switching control rules for brakes and throttles to achieve a smooth tracking of the vehicle speed.

4. Summary

Roads in urban environments are characterized by diverse functions, complex compositions, large speed differences, and many intersections. Therefore, the tasks faced by unmanned vehicles in urban environments are more complex and diverse. This chapter combines the driver's control method with the vehicle, and proposes the design goal of unmanned vehicles' motion control methods on urban roads: it should be "humanoid" to the greatest extent, and it can control steering and vehicle speed as experienced drivers. This paper introduces the architecture and functions of the "smart pioneer" unmanned vehicle platform architecture and the perception system, decision-making system, control system, and the subsystems of the actuator. Finally, according to the characteristics of vehicle driving, the control system of "Smart Pioneer" is divided into horizontal control and vertical control, and the design indicators of horizontal control and vertical control are proposed according to the driving behavior of the actual driver, and the control system design strategy is proposed according to the indicators.

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