Research on Path Tracking Control of Unmanned Vehicles based on Vision

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Abstract: With the in-depth study of unmanned vehicle technology, highly efficient, stable and low-cost trajectory tracking control system has become the key technology for intelligent and practical unmanned vehicles. The technical level of automobiles and their popularity are important indicators to measure the material living standard and modernization level of a country or region. Path tracking and motion control play a very important role in intelligent unmanned driving technology. At the same time, accurate tracking of the expected feasible path and stable motion control are the basis for realizing intelligent unmanned driving. The task of path tracking is to control the vehicle to drive along the planned path, and at the same time to ensure the safety and handling stability of the vehicle. The precise control of driverless vehicle is obviously the key technology in the research and development of automatic driving. Therefore, based on the vision navigation system, this paper studies the target path tracking control of driverless vehicle.

1 INTRODUCTION

The technical level of automobiles and their popularity are important indicators to measure the material living standard and modernization level of a country or region. With the progress of science and technology and the rapid development of economy and society, the living standard of human beings is improving day by day. Cars enter the homes of ordinary people rapidly, which greatly facilitates people's daily travel (Zhang Jiaqi, 2017). With the quickening pace of modern life, frequent traffic accidents caused by rapidly increasing car ownership and increasingly serious driving fatigue have severely restricted people's good life (Li Wei, Tang Zheng, Wang Hongmin, 2019). Due to the limitation of human's own perception ability and congenital reaction delay, the incomplete and delayed grasp of external information is easy to lead to wrong judgment and wrong operation. In order to improve the safety and stability of vehicles, make efficient use of vehicles and roads, and reduce road congestion and environmental pollution, the slogan of Intelligent Transportation System (ITS) arises spontaneously. Unmanned vehicles play an important role in ITS system. Path tracking is one of the main research contents of driverless cars. Its content is to design a controller to ensure the car to follow a preset trajectory. Under a certain control architecture, the path tracking of unmanned vehicles can accurately track real-time road information, and can follow the planned virtual path without real-time road information (Li Yongdan, et.al, 2019).

In the process of modernization, the automobile industry has developed rapidly. Electronic technology, computer technology and control technology have injected fresh vitality and power into the automobile industry. Cars bring great convenience to people's lives and improve the quality of life. As an intelligent comprehensive body, the automobile has made indelible contributions to the progress of human civilization and social development due to its unique superiority. The unmanned vehicle is a typical four-wheeled mobile robot, involving many interdisciplinary knowledge, and is a product of the highly integrated and development of contemporary computer science, pattern recognition, and control technology (Wang Zizheng, Cheng Li, 2016). Unmanned driving technology mainly includes several key parts: environment perception, path planning, path tracking and bottom-level control. The task of path tracking is to control the vehicle to travel along the planned path,

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while ensuring the safety and stable operation of the vehicle. Sex (Lan Jing, 2019). Unmanned driving obtains the vehicle's own position and posture and surrounding environment information through various modern sensors. It has a high degree of self-adaptive and self-planning capabilities, and can obtain accurate information about its own posture and surrounding environment through the sensor. The trajectory tracking control system for driverless cars based on visual navigation is of great urgency and necessity (Zhao Chunchang, et.al, 2019). The precise control of driverless cars is obviously the key core technology in the research and development of autonomous driving. Therefore, based on the visual navigation system, this paper has carried out related research on the target path tracking control of driverless cars.

2 UNMANNED VEHICLE ARCHITECTURE

With the progress of communication technology, microelectronics technology and the development of intelligent construction, more and more equipment such as household appliances, electricity meters, industrial terminals and so on have the demand of networking, and a large amount of data need to be transmitted. On many occasions, wired connection cannot meet people's needs. Wireless access makes up for the shortage of wired connection with its advantages of convenience, quickness and low cost. With the development of electronics, computer and information science and technology, the development of communication system is also very rapid. From wired to wireless, from voice to data, images, from local to wide area, there are many communication networks and communication methods used in unmanned vehicle positioning system. The sensors of the unmanned vehicle are mainly used to sense the environmental information around the intelligent unmanned vehicle and the body state information of the intelligent unmanned vehicle (Zhang Haiming, et.al, 2019). In addition to autonomous navigation, unmanned vehicle positioning and navigation systems all need the support of communication networks to facilitate the transmission of various data and information. The whole system is designed with the idea of modularization, and the main functions are divided into independent modules, thus reducing the complexity of the system and making the functions of each module of the system clear at a glance.

The on-board vision system of unmanned vehicles can effectively identify lane lines, traffic signs and traffic lights, and can also detect obstacles in driving lanes and adjacent lanes. As shown in Figure 1, the system architecture takes a hierarchical form. With high cohesion and low coupling, the output of the previous layer is the input of the following layer. By decomposing the work from top to bottom, the accuracy of the design system is improved.

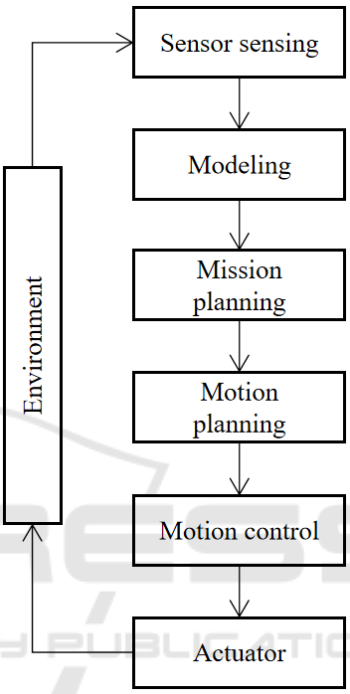

Figure 1: Hierarchical system architecture.

The available error correction codes of the system can be shared by all users of the system and have the function of automatically selecting error correction codes. It is a multi-purpose and high-performance wireless dispatching communication system that shares resources, costs and error correction coding equipment and services. The actions generated by the hierarchical system are not the direct feedback processing results of the data collected by the sensors, but are processed through the stages of perception, modeling, planning and control. The effective connection between transportation and the whole social and economic system is realized through information technology. The integration of transportation information into the information flow of the supply chain will promote transportation to truly become an organic part of the supply chain. Establishing a global environment is not only based on the user's understanding of the known objects in the environment and the analysis of their

relationships, but also based on the independent construction of sensor data. The global environment model is universal and suitable for planning many tasks. Special short-range communication system mainly uses special short-range communication technology to identify relevant information of vehicles through signal transmitting and receiving devices of roadside units, and automatically carries out intelligent management such as identity identification, real-time monitoring, dynamic guidance and the like on vehicles to complete dynamic collection of relevant information of vehicles. In order to carry out communication in an orderly way and to obtain the maximum successful communication, some mechanism is needed to arbitrate and decide who has the right to use error correction codes.

3 PATH TRACKING CONTROL OF UNMANNED VEHICLES

3.1 Motion Model of Unmanned Vehicle

The main sensor of the lane line detection module is a vehicle-mounted monocular camera, whose main function is to capture the real-time lane line of the vehicle while it is running. Firstly, the area where the lane line is located in the camera image coordinate system is determined, then the lane line position information is obtained by feature extraction, and then the coordinate is transformed to the vehicle body coordinate system. The vehicle data transmission system, which is composed of data transmission based on conventional communication network, has an effect range related to the band of error correction coding, antenna height of central station and transmission power. Two methods of wireless transmission are simulated by adding convolutional codes respectively, and the number of error code frames in the simulation is recorded. The simulation conditions are shown in Table 1.

Table 1: Simulation conditions.

Condition category	Numerical value
Bit rate	850bps
Maximum Doppler shift	9.25Hz
Speed of vehicle	50km/h
Carrier frequency	445MHz
Signal to noise ratio	20dB
Error correction coding parameters	15
Modulation system	2FSK

Suppose the longitudinal displacement of the car at time k is x_k, the lateral displacement is y_k, and the yaw angle is j_k. Assuming that the acceleration of the car is constant in a short time, as shown in Figure 1, the displacement of each point is x_{k-3}, ..., x_{k+1}, the instantaneous speed is v_{k-3}, ..., v_{k+1}, then:

$$\begin{cases} v_{k-2} = \dfrac{v_{k-1} + v_{k-3}}{2} = \dfrac{x_{k-1} - x_{k-3}}{2T}, \\ v_{k-1} = \dfrac{v_k + v_{k-2}}{2} = \dfrac{x_k - x_{k-2}}{2T}, \\ v_k = \dfrac{v_{k+1} + v_{k-1}}{2} = \dfrac{x_{k+1} - x_{k-1}}{2T}. \end{cases} \quad (1)$$

From $v_k - v_{k-1} = v_{k-1} - v_{k-2}$, we get:

$$x_{k+1} = x_{k-3} + 2x_k - 2x_{k-2} \quad (2)$$

If the longitudinal displacement of the vehicle at time k-3,..., k is known, the predicted value of the longitudinal displacement at time k+1 can be obtained:

$$\hat{x}_{k+1} = x_{k-3} + 2x_k - 2x_{k-2} \quad (3)$$

As a bearer network, ITS system itself adopts a network structure and assigns independent addresses such as or addresses to users. When the error correction code is 1, the blocking rate is as shown in Figure 2. The blocking rate when the error correction code is 4 is shown in Figure 3.

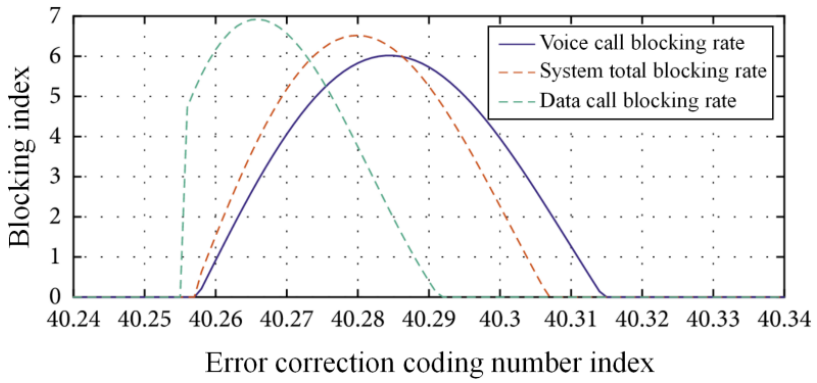

Figure 2: Blocking rate when the error correction code is 1.

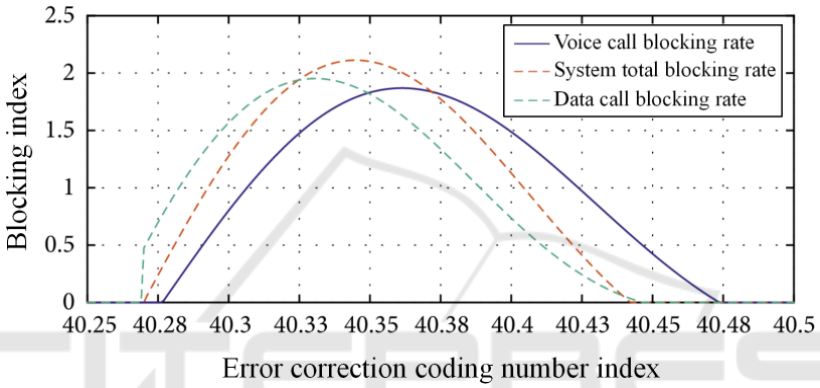

Figure 3: Blocking rate when the error correction code is 4.

In the automatic driving mode, since the steering wheel is not controlled by the driver, there is no need to detect the steering wheel input torque (Su Fandi, 2016). However, in order to realize the closed-loop control of the automatic steering system, the steering angle information of the steering wheel needs to be detected in real time as the feedback quantity. The traditional organization form of the transportation industry, the traditional transportation management mode, the traditional transportation concept and the traditional transportation technology will all undergo changes due to the construction of the intelligent transportation system. Considering that the external environment of the intelligent urban traffic information system in practical application may be in the downtown area, all kinds of electromagnetic interference around it are more serious, and the same frequency interference is even more serious. Therefore, it is particularly important to improve the communication reliability of the whole system. The planning layer acquires the data of the decision layer, generates a planning path from the initial point of the vehicle to the punctuation point, and periodically changes and updates the path of the vehicle according to the environmental information.

3.2 Path Tracking Controller

If an unmanned vehicle encounters an emergency during driving, it can execute an emergency stop command to ensure the safety of the vehicle. The remote control receiving module on board the unmanned vehicle receives the signal and transmits it to the microprocessor, thus controlling each execution module on the bottom floor to realize emergency stop. In order to reduce the complexity of the intelligent urban traffic information system, the centralized control error correction coding access method is generally selected (Fan Rongwei. Yanfang, 2016). Because the communication in the system has the characteristics of short time and small amount of data, it is not suitable to adopt the reservation mode, and usually the circular and competitive modes are selected. If the acceleration of the vehicle is too large or there is a sudden change, the body will have a large impact, making passengers in the vehicle uncomfortable. The control system should limit the

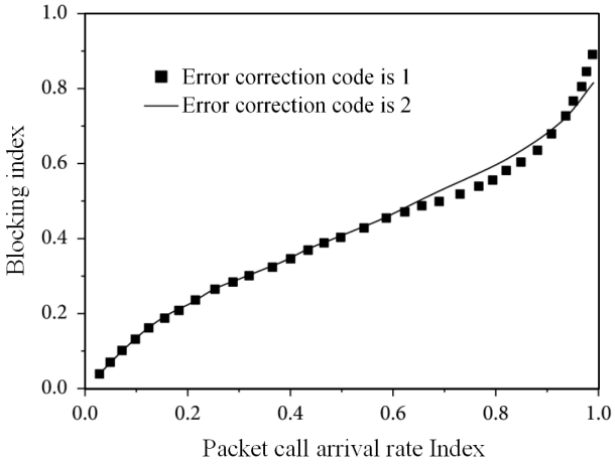

Figure 4: Packet blocking rate when voice call is 0.08.

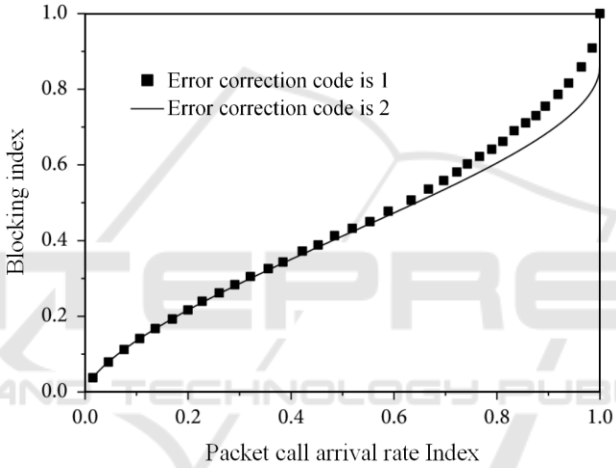

Figure 5: Packet blocking rate when voice call is 0.12.

maximum acceleration range to make the vehicle more stable. From the perspective of the whole system, intelligent transportation is the embodiment of many technologies. From the perspective of the system as a whole, intelligent transportation is the embodiment of many technologies. The receiving end checks the relationship between the information symbol and the supervised symbol according to the established rules. Once an error occurs during transmission, the relationship between the information symbol and the supervised symbol is destroyed, so that errors can be discovered and even corrected.

Change the arrival rate of packet calls and voice calls, and observe the blocking rate of packet calls. Figure 4 shows the packet blocking rate when the voice call arrival rate is 0.08. Figure 5 is the packet blocking rate when the voice call arrival rate is 0.12.

The receiving end checks the relationship between the information symbol and the supervision symbol according to the established rules. Once errors occur in the transmission process, the relationship between the information symbol and the supervision symbol is destroyed, thus errors can be found and even corrected (Yu Jiawei, Luo Feng, 2016). The dynamic model of a vehicle usually studies the mechanical characteristics of the vehicle, such as tire mechanics, vehicle driving mechanics, vehicle aerodynamics, etc., and strives to establish the expression of the relationship between the acceleration and the stress of the vehicle, so as to find out the control rate of the vehicle.

4 CONCLUSIONS

With the increasing annual production of automobiles, the following major problems are traffic congestion, energy consumption and automobile safety. Since driverless vehicles completely exclude the influence of human factors, they can greatly solve the problem of traffic safety. In this paper, the vision-based trajectory tracking control system in unmanned driving technology is mainly studied, including overall scheme formulation, hardware construction, algorithm research and controller design. In the design of electronic control system, some electric equipments are very sensitive to low voltage due to more electric equipments and serious power consumption when the intelligent unmanned vehicle runs autonomously in actual road environment. Because the communication in the system has the characteristics of short time and small amount of data, it is not suitable to use the reservation mode, usually choose the circular and competitive mode. If the driverless vehicle encounters an emergency in the process of driving, it can execute the emergency stop order to ensure the safety of the vehicle. A stable and reliable path tracking system is the necessary condition for the industrialization of intelligent vehicle. Subsequently, the control algorithm needs to be transplanted to other embedded systems and fused with multi-sensor data to realize the real-time control of the vehicle, so as to verify the stability of the control algorithm.

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