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# Regional Coordination Control Method of Rail Transit Signal Based on Unmanned Driver

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**Abstract**

In order to reduce the traffic congestion of driverless vehicles in rail transit and reduce the probability of traffic accidents of driverless vehicles, a coordinated regional control method based on driverless rail transit signal is proposed. The operation structure of driverless rail transit is designed based on vehicle network technology. The vehicle information is obtained by radio frequency identification equipment and the wireless communication technology is used. Instructions are conveyed to the built-in speed controller and steering controller of the vehicle. Vehicle speed, steering and running phase are controlled by the unmanned automatic tracking control module and the signal priority control module of the unmanned vehicle. The photoelectric sensor is used in the unmanned automatic tracking control module to convert the test results of the collected rail traffic signal into the lateral deviation to obtain the driving advance of the vehicle. Aiming at the information, adding the "driver" model to automatically control the state of the vehicle; the signal priority control module of the driverless vehicle chooses the vehicle to restore the priority request through the signal priority request and processing flow, adjusts the vehicle operation phase, and ensures the driverless vehicle to pass as first as possible according to the signal priority strategy of the rail transit. The experimental results show that the difference between the angle command and the actual angle is 20°. Within the range, the front wheel angle error does not exceed 1.45°. The average stability of the method is 0.9747, and the stability is good.



*Keywords:* Driverless; Rail Transit; Signal Area; Coordination Control; Automatic Tracking; Priority Control;

## 1. Introduction

Rail transit is a kind of transportation means that carries run on "specific" tracks, which also produces support and guidance. Transportation develops with the development of society. Safety is a concern for all people. In order to ensure the safety of no vehicles in rail transit, it is necessary to coordinate the control of vehicles in the signal area of rail transit so as to realize the safe travel of vehicles [1]. Unmanned driving technology just meets the actual requirements. Unmanned driving technology refers to the use of on-board sensors to obtain relevant data and information in the course of driving, according to the acquired information, to process, analyze, and control the steering and speed of the vehicle, so as to make the vehicle run safely on the road. Since the 1970s, developed countries have begun to study driverless cars and made some progress. As early as the 1980s, China began to develop driverless cars. In 1992, it developed the first driverless car in China, which marked a new technological breakthrough in the field of driverless vehicles in China [2]. This means that the level of driverless vehicles in China has been improved. It is at the advanced level in the world. Unmanned driving has three advantages. Firstly, it can achieve precise control of rail transit transportation, avoid artificial abnormal operation [3]. Secondly, it can save manpower and material resources and liberate a large number of labor forces. In addition, it can prevent rail transit accidents. Because unmanned vehicles can adapt to narrower streets, there will be no traffic jams and reduce energy and save a lot of money for the government [4].

Unmanned vehicle control technology is a multi-disciplinary and multi-industry integrated technology [5], which integrates vehicle engineering, computer technology, automatic control theory, architecture theory and other theories and technologies. It has not only huge military value, but also broad industrial and civil value. It is a national computer science, recognition mode and intelligence. The development level of technology can be controlled, which is also an important symbol to measure a country's scientific research strength and industrial level [6]. Therefore, it is necessary to study the coordinated control method of unmanned driving in signal area of rail transit.

## 2. Materials and methods

### *2.1. Design of unmanned rail transit based on vehicle networking technology*

#### *2.1.1. Design of operation structure of unmanned rail transit*

Unmanned rail transit consists of control center and individual vehicle [7]. The control center should load

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transmitter, central processing unit, GIS live analysis and alarm. The control center receives the signal from the vehicle, transmits the information to the central processing unit for processing, and gives orders to the vehicle by combining the GIS geographic reality analysis. If an accident occurs, the alarm will automatically alert the relevant departments to take measures [8]. Individual vehicles should be equipped with radio frequency identification equipment to acquire surrounding information. Secondly, receivers should be installed to transmit vehicle reality and receive commands. In addition, relevant controllers should be installed to control vehicle acceleration, deceleration and braking. Induction system and digital image processing technology should also be installed, which can not only automatically switch doors for passengers to get on and off, but also can monitor vehicle driving situation in real time and report to the control center. Vehicle individuals should include automatic tracing module and vehicle signal priority control module to realize vehicle unmanned automatic tracing and signal priority control [9]. The operation design structure of unmanned rail transit is shown in Fig. 1.

In Fig.1,the control center give orders to the vehicle individual, then the Transceiver convey information back to the control center.

*2.1.2. Unmanned rail transit operation process*

In the course of driving, vehicle information is acquired by sensing the surrounding vehicles according to the radio frequency identification equipment [10]. The wireless communication technology report is sent to the control center for processing. The control center calculates the auto-tracing and vehicle signal priority control strategy, analyses the speed predetermined value, the angle predetermined value and the vehicle running condition, and transmits the instructions to the built-in speed controller and steering controller of the vehicle through the wireless communication technology. Through the unmanned auto-tracing control module and the unmanned vehicle, the control center transmits the instructions to the speed controller and steering controller of the vehicle. Vehicle signal priority control module to achieve precise parking and rail connection [11]. Vehicle driving data in the form of images are available in the vehicle. If an accident occurs, the vehicle-related central processing unit will report the situation to the control center through wireless communication, and the control center will analyze and make instructions [12]. The operation flow chart of unmanned rail transit is shown in Fig. 2.

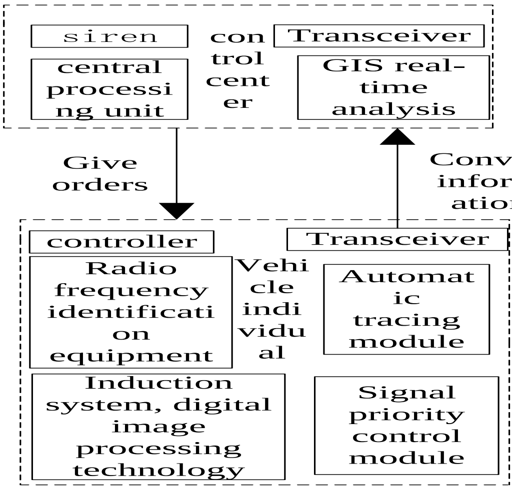



**Figure 1.** Operational design structure of unmanned rail transit

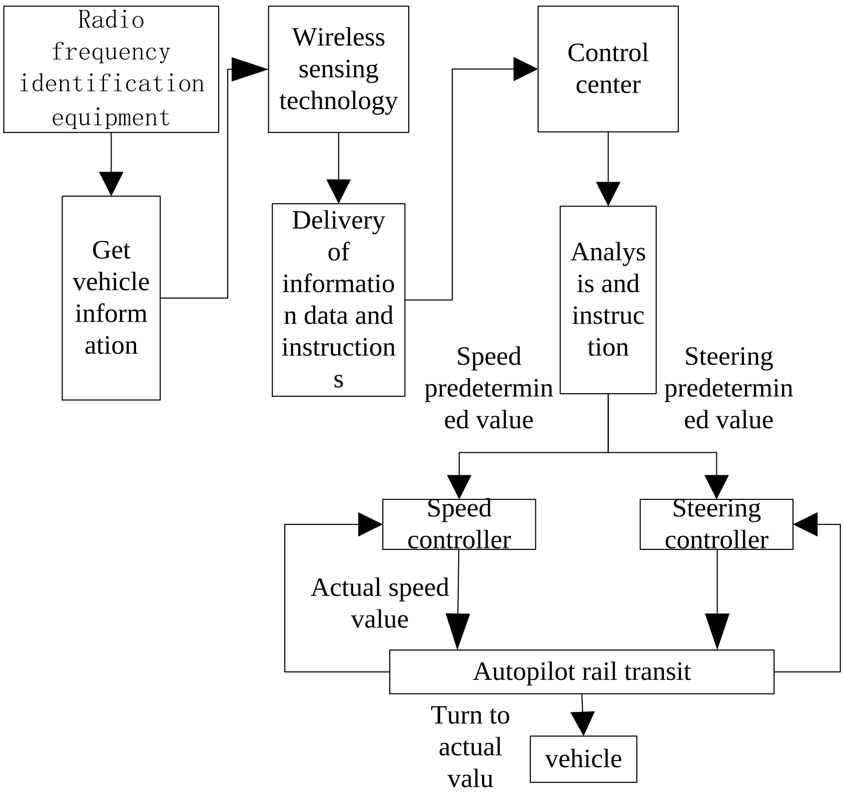



**Figure 2.** Flow chart of unmanned rail transit

*2.2. Unmanned automatic tracking control module*

*2.2.1. Composition of automatic tracking module*

The automatic tracing module of an unmanned electric vehicle is mainly composed of sensor module, control module and actuator [13]. The structure of the module is shown in Fig. 3.

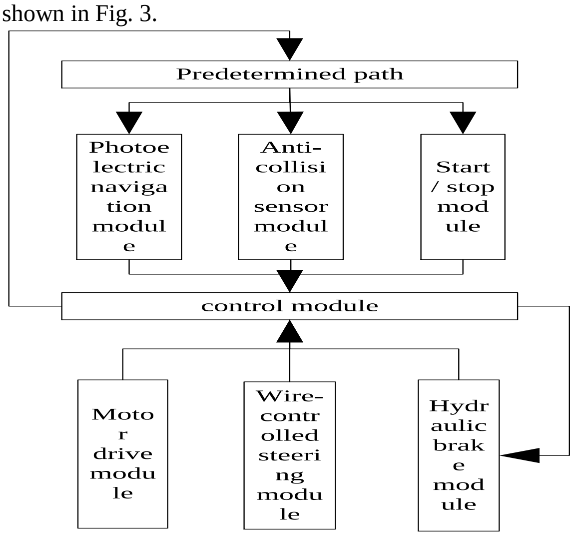



**Figure 3.** Structure diagram of automatic tracing module for self-driving electric vehicle

The sensor module is mainly composed of photoelectric navigation module, collision prevention sensor module and start/stop module. The control module is mainly composed of Micro Auto Box controller from dSPACE Company. The actuator mainly consists of click-drive module, line-controlled steering module and hydraulic braking module. Photoelectric navigation module is mainly composed of light source, photoelectric sensor, shading accessories, signal acquisition and power supply, among which the light source is the most important part [14].

The light source part adopts 48 high-brightness white light LED. For the photoelectric sensor, adopts 40 photo resistors (5 mm in diameter, working temperature range: -30℃-+70℃) with 2% precision cds5562 are arranged at an equidistance of 7.68 mm. Based on the principle that the resistance value decreases when the light intensity of the photosensitive resistance is enhanced, the voltage change at both ends of the photosensitive resistance is measured through the half-bridge partial voltage to reflect the intensity of light as well as the change of light intensity [15]. The measuring circuit of photosensitive resistance is shown in Fig. 4.

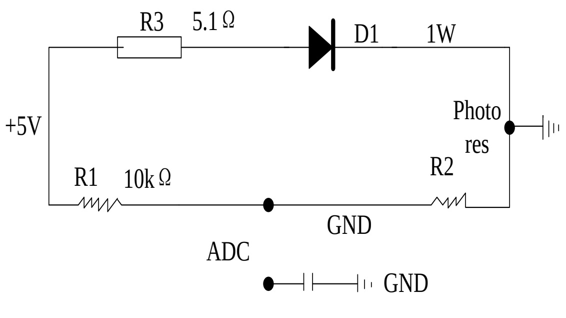



**Figure 4.** measuring circuit of Guang Min resistance

The system uses visible light source, so outdoor sunlight and adjacent light source will interfere with the signal in the module, and the path sensor module needs to be shaded. By adding a black plastic sleeve to each photosensitive resistor to avoid interference from adjacent light sources, the interference of sunlight to the unmanned automatic tracking control module can be prevented [16].

*2.2.2. Principle of automatic tracing control*

The principle of automatic tracking driving control is shown in Fig. 5. The control module controls the vehicle steering according to the preview information of preview point P.The speed of the current car is the acceleration, and Kp is the upper controller, and M (s) and F (s) are the control module and the actuator, respectively. Mg (s) is the train quality:

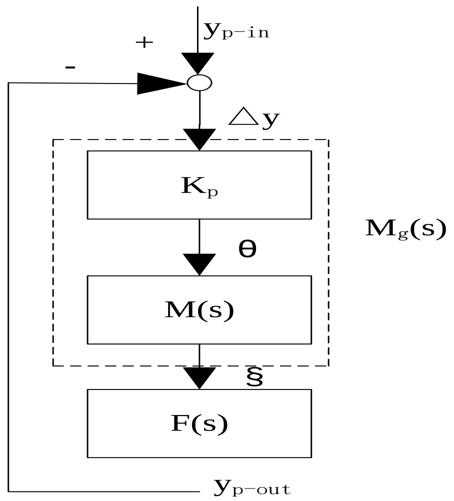



**Figure 5.** principle of auto-track-seeking driving control for vehicles

The function of the controller module is to convert the test results of photoelectric sensors into transverse △y, obtain the preview information of vehicle driving, add the "driver" model, automatically control the state of the vehicle, carry out program design, and control the vehicle driving according to the predetermined conditions [17].

*2.2.3. Lateral deviation calculation*

The controller assigns 40 sensor channels to the corresponding digital $y_i$ (i-1, 2, ..., 40), compares the received 40 channel data with the preset threshold U, and obtains the corresponding control threshold $a_i$ as follows:

$$a_i = \begin{cases} 1 & U_i > U \\ 0 & U_i \leq U \end{cases} \quad (1)$$

Then the lateral deviation △y is expressed as:

$$\Delta y = d \sum_{i=1}^{40} y_i a_i \sum_{i=1}^{40} (a_i - 20) \quad (2)$$

In the formula, d denotes the distance between adjacent photoelectric sensors.

*2.2.4. Vehicle model*

The horizontal vertical excitation of the left and right wheels of an automobile is the same, and the vehicle is symmetrical about the longitudinal axis of the vehicle, that is, the vehicle does not have roll vibration, no lateral displacement, no yaw vibration, and is regarded as a vehicle body system for the consistency of the motion between the passenger and the vehicle body. And the body system is regarded as a rigid sprung mass regardless of the effect of the engine and the drive train on the body. The body's contact mass is zero, that is, the front and rear parts of the body are independent of each other. The axle and the main wheel associated with it are considered to be unsprung masses and the wheels are in point contact with the road surface on the centre line. due to the damping of the tire with respect to the damping of the vehicle shock absorber, And therefore only the stiffness of the tire is taken into account. By the above assumptions, the complex vehicle system becomes a relatively simple two-degree-of-freedom suspension system simplified model.The two-degree-of-freedom vehicle model and the preview point p model are used to express the transfer function of the vehicle model as follows:

$$F_{\xi}(s) = \frac{0.012s + 2.17}{0.0001s^3 + 0.04s^2 + 2.93s} \tag{3}$$

*2.2.5. Driver model*

Under zero initial condition, the ratio of Laplace transform of output of linear time-invariant system to Laplace transform of input is defined as the transfer function of linear time-invariant system. Namely:The exact model transfer function of driver linear control is simplified as follows:

$$M_R(s) = K_R \frac{1+T_2 s}{1+T_1 s} e^{-s^{\tau}} \tag{4}$$

In the formula, $K_R$ denotes the human factor, $T_2$ denotes the lead time, $T_1$ denotes the lag time, and $\tau$ denotes the delay time. Considering the sampling frequency (2 ms) of the controller, the delay link can be neglected, so the transfer function of the driver model is changed to:

$$M_R(s) = K_R \frac{1+T_2 s}{1+T_1 s} = K_P K_M \frac{1+T_2 s}{1+T_1 s} \tag{5}$$

The driver model essentially consists of two parts, one is the proportional link $K_P$, which is mainly the proportional gain in angle conversion, the other is a correction link $M(s) = \frac{K_M(1+T_2 s)}{1+T_1 s}$, in which $K_M$ is the correction gain coefficient.

*(1) Proportional link*

According to the angle conversion, the relationship between the angle β of pinion and the lateral deviation △y measured by the sensor is as follows:

$$\beta = i_w \arctan \frac{2L\Delta y}{(\Delta y^2 + D^2)^2 - 4L^2\Delta y^2 - B\Delta y} \frac{180}{\pi} \tag{6}$$

In the formula, $i_w$ represents the transmission ratio of the gear-rack steering system of a vehicle, $i_w$ =13.8. According to the definition of parameters of driverless electric vehicle, the relationship between steering gear angle and transverse deviation of photoelectric sensor is as follows:

$$\beta = f(\Delta y) = K_P \Delta y = 6135\Delta y \tag{7}$$

*(2) Correction link*

Through practical research, it is found that the stability of the method is enhanced after the correction step. The open-loop coefficient transfer function $G_1(s)$ expression without correction link is formula (8).

$$G_1(s) = K_P F_{\delta}(s) = \frac{6135(0.012s + 2.17)}{0.0001s^3 + 0.04s^2 + 2.93s} \tag{8}$$

The transfer function $G_2(s)$ of the open-loop system with the correction link is expressed as an expression (9).

$$G_2(s) = M_R(s) F_{\delta}(s) = \frac{4046(0.012s + 2.17)(0.2s+1)}{(0.0001s^3 + 0.04s^2 + 2.93s)(0.4s+1)} \tag{9}$$

*2.3. Signal priority control module of unmanned vehicle*

*2.3.1. Signal priority request and processing flow*

The signal priority control module of driverless vehicle consists of the following parts:

(1) Vehicle-mounted equipment. It includes vehicle information module, signal priority module and WIFI antenna.

(2) Signal control module of driverless vehicle road intersection. It includes signal controller of driverless vehicle, information acquisition module (four groups of detectors: request detector P1, request detector P2, request detector P3, request detector P4) and special signal lamp.

(3) Road signal control module at intersection. It includes traffic signal controller, traffic signal lights and intersection correlation detector and other equipment.

(4) Central control module. It includes driverless vehicle signal center and road traffic signal control center.

The P1 detector is set at the $S_{P1}$ position from the parking line of the driverless vehicle. The driverless vehicle passes through the P1 point and immediately sends out a priority traffic request. The signal machine gives priority to the recovery. The P2 detector is set at the $S_{P2}$ position from the parking line of the driverless vehicle. This signal is sent out. The signal machine should ensure the response of the priority traffic confirmation if the priority traffic is ensured. The signal plane should adjust the phase before point D, the P3 detector should be set 2 meters behind the parking line of the driverless vehicle to detect whether the driverless vehicle enters the intersection, the P4 detector should be set at the exit, and the distance from the intersection is about 35 meters, which is used to verify that the driverless vehicle passes through the intersection smoothly [18]. Expressed by formula as follows:

$$S_{P2} = S_b + S_{r+s} \tag{10}$$

$$S_{r+s} = v_{t2}(t_r + t_s) + \frac{1}{2}a(t_r + t_s)^2 \tag{11}$$

$$v_{t2} = v_0 + at_p \tag{12}$$

$$S_{P1} = S_{P2} + v_1 t_p + \frac{1}{2}at_p^2 \tag{13}$$

In the formula, $S_b$ denotes the braking distance of driverless vehicle (about 60 m), $S_{r+s}$ denotes the driving distance of vehicle response time and module response redundancy time, $t_r$ denotes the driving time of driverless vehicle, takes 2 s, $t_s$ denotes module response redundancy time, takes 1 s, $v_1$ denotes the speed of driverless vehicle at P1, $a$ denotes deceleration acceleration (negative value), $t_p$ denotes the minimum phase time (Depending on the actual configuration of the intersection), $v_{t2}$ represents the speed of the driverless vehicle at point P2.

*2.3.2. Signal control strategy*

According to the delay time, full load rate and operation scheduling plan of driverless vehicles, the priority of driverless vehicles at intersections is divided into three levels: high priority at level 1, low priority at level 2 and no priority at level 3. When two conflicting traffic priority requests are received at the same intersection, the higher priority requests are responded to. According to the regional traffic demand and background traffic of driverless vehicles, the current road service level is judged in real time. When the priority request is received, the priority signal of driverless vehicles is determined according to the current service level. Generally, the first-level priority requests should ensure the first-level priority, the second-level priority requests should consider whether to ensure the first-level priority according to the actual situation, and the third-level priority requests should consider not to ensure the first-level priority. Therefore, the signal control of driverless vehicles at intersections should adopt conditional active signal priority [19].

Active control signal priority strategies usually include green light extension, red light shortening, insertion phase and jump phase. On the premise of guaranteeing the minimum green light time of intersecting road phase and the safe green light interval between phases, according to the real-time arrival time of driverless vehicles and the current stage of signal control, the selection rules of signal control strategy for driverless vehicles are formulated, as shown in Table 1.

**Table 1**. General signal control policy selection rule

| Regional traffic condition | Priority 1 | Priority 2 | Priority 3 |
|---|---|---|---|
| Normal | 1/2/3/4 | ½ | |
| More congestion | 1/2/3/4 | ½ | |
| Congestion | 1/2 | | |
| Stop up | | | |

Note: No-no priority, 1-green light extension, 2-red light shortening, 3-insertion phase, 4-jump phase.

(1) The green light is extended. When the driverless vehicle arrives at the end of the traffic phase (green light), the module extends the length of the notification phase to make the driverless vehicle pass smoothly.

(2) The red light is shortened. When the driverless vehicle arrives at the non-traveling phase, the module opens the traveling phase ahead of time (the green light turns on early), and tries to let the driverless vehicle pass preferentially.

(3) Insert phase. When an unmanned vehicle is detected to arrive at a non-passing phase, a special phase for unmanned vehicle is inserted after the end of the current phase. The length of the phase is calculated for the whole vehicle of the unmanned vehicle only. When the insertion phase is finished, the subsequent phase interrupted by the insertion phase is continued and the original phase sequence is run.

(4) Jump phase. When an unmanned vehicle arrives at its non-passing phase, it jumps directly to the driving phase of the unmanned vehicle at the end of the current phase with the minimum release time. At that time, the signal of the Chang'an Cleaning Detector and the whole vehicle can be calculated. When the driving phase of an unmanned vehicle ends, it runs in the original phase sequence [20].

## 3. Results

### *3.1. Automatic tracking control effect*

During the experiment, an unmanned electric prototype car was used to drive counterclockwise along the trajectory shown in Fig. 6, and its speed was maintained at 5 km/h.

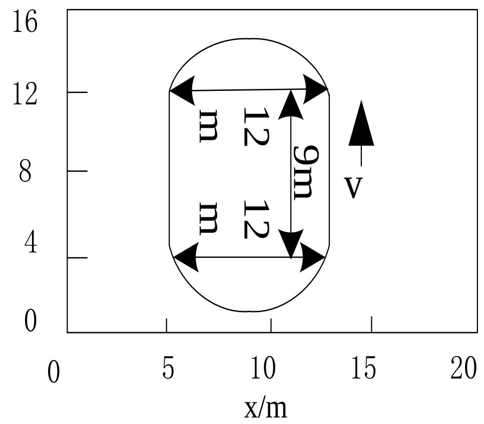



**Figure 6.** Vehicle experiment path

Through the above experimental path, two ways are used to test the effect of this method on the automatic tracking control of the experimental driverless vehicle. Firstly, the effect of this method on the automatic tracking control of the driverless vehicle is judged by detecting the difference between the angle command and the actual angle. The test results are shown in Fig. 7.

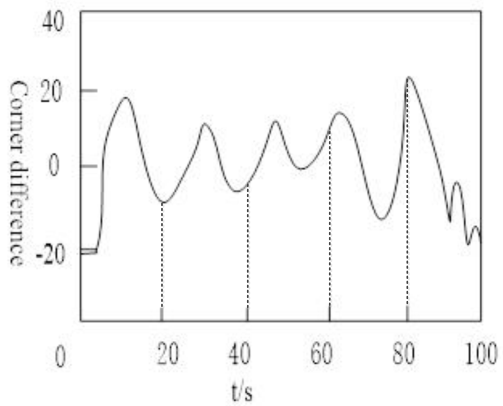
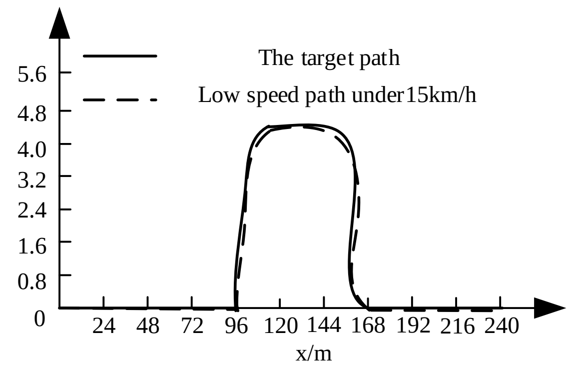
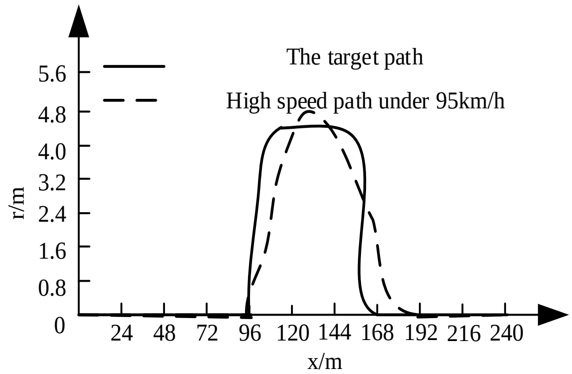



**Figure 7.** Corner instruction and actual corner difference

From Fig. 7, it can be seen that the difference between the measured angle command and the actual angle during the whole experiment is 20°. Within the range, that is, the front wheel angle error does not exceed 1.45°. It can be seen that the control effect of this method is better for the experimental unmanned vehicle. Secondly, starting from the experimental speed of the driverless vehicle itself, the effect of this method on the automatic tracking effect of the driverless vehicle is validated. The tracking results at low speed of 15 km/h and high speed of 90 km/h are selected and compared to test the control effect of this method on the automatic tracking of the driverless vehicle at different speeds. The results of driverless vehicle tracking at two speeds are shown in Fig. 8.




(a) Automatic tracing effect at low speed



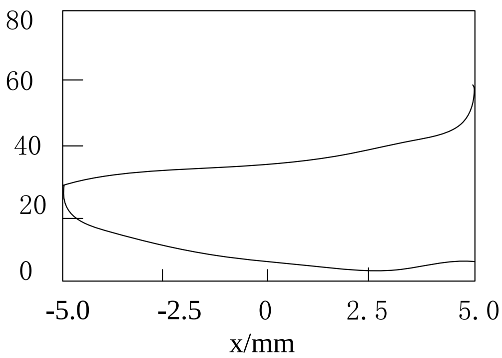

(b) Automatic tracking effect at high speed

**Figure 8.** Automatic tracking effect at different speeds

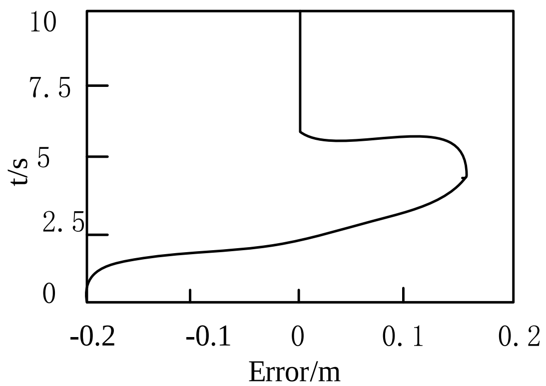
From Fig. 8, it can be seen that although the auto-tracing effect of driverless vehicles at high speed is slightly lower than that of driverless vehicles at low speed, the error of auto-tracing at different speeds is smaller and the effect of auto-tracing is better. It shows that the method in this paper has better effect of controlling the auto-tracing of driverless vehicles. The method in this paper is more effective and can realize the auto-tracing effect of driverless vehicles. Vehicle automatic tracing control ensures the safe and smooth operation of driverless vehicles in the signal of rail transit area.

### *3.2. Horizontal control in the process of automatic tracking control*

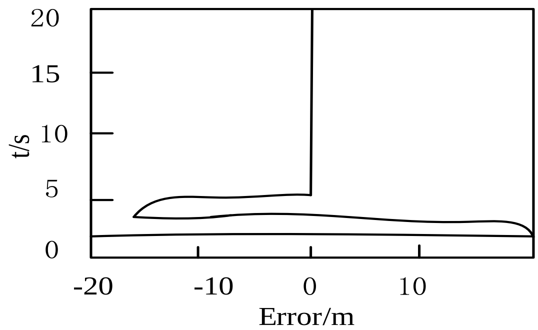
In order to test the effect of horizontal control of unmanned vehicle in this method, it is necessary to detect the rear wheel speed, lateral displacement tracking error and front wheel rudder angle of experimental unmanned vehicle in the process of lateral driving. The test results are shown in Fig. 9.




(a) Rear wheel speed




(b) Transverse displacement tracing error




(c) Front wheel rudder angle

**Figure 9.** Horizontal control result

From Fig. 9, it is known that when the longitudinal speed of the car body changes, even when the longitudinal speed is zero, the driverless car body can still track the established track automatically in the lateral direction, with better dynamic characteristics and stable tracking accuracy, which shows that the lateral control effect of the driverless car body under the automatic tracking control is better.

### *3.3. Contrast of three methods of signal control*

In order to verify the signal control status of the intersection, a city intersection is selected for detection. The effectiveness of this method in signal priority control of driverless vehicles is tested by comparing the method, timing signal control method and first-come-first-service control method. The test results are shown in Table 2.

As can be seen from Table 2, compared with the first-come-first-served control method and the timing signal control method, the evaluation indexes have been greatly improved after using the priority control signal method. The average traveling time of emergency driverless vehicle in this method is 10.11% less than that of first-come-first-service control method, and the average traveling time of ordinary driverless vehicle is 17.6% less, and the average stopping time is 17.6% less than that of the first-come-first-service control method. The number of vehicles decreases by 21.56%, which shows that the method of priority control signal has better effect, and the first-come-first-service control method has worse effect. At the same time, the excessive start-up and stop behavior of driverless vehicles under the control of first-come-first-service method is liable to cause traffic accidents.

Compared with the method of timing signal control, the evaluation index of each phase has been improved after using the method of priority control signal. The average passing time of emergency driverless vehicle in this method is 13.1% less than that of timing signal control method, the average passing time of ordinary driverless vehicle is 14.5% less, and the average parking times are 20.6% less. This shows that this method has priority. The effect of control signal is good. To sum up, the priority control signal based on this method can realize the priority of driverless vehicles on the right of passage at intersection time and reduce the interference of driverless vehicles to other vehicles.

### *3.4. Method energy consumption comparison*

In order to verify the low energy consumption of this method in controlling unmanned vehicles, the method, the control method based on fuzzy control and the control method based on image processing technology are compared. The comparison results are shown in Fig. 10.

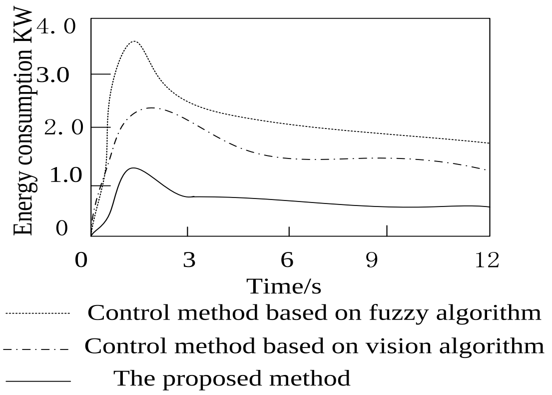



**Figure 10.** Energy consumption comparison results

As can be seen from Fig. 10, the energy consumption of this method is lower than that of the two comparison methods at the same time. That is, this method can effectively optimize the energy consumption while effectively controlling the unmanned vehicle, and reduce the energy consumption of controlling the unmanned vehicle.

**Table 2.** Comparison of results between three methods

| Control strategy | Number of experiments | Emergency driverless vehicle passage time (seconds/vehicle) | Average passage time of ordinary self-driving vehicles(seconds/vehicle) | Average parking times/s |
|---|---|---|---|---|
| Timing signal control method | 1 | 45.6 | 50.1 | 0.87 |
| | 2 | 44.8 | 49.8 | 0.84 |
| | 3 | 44.1 | 49.1 | 0.85 |
| | 4 | 43.8 | 48.9 | 0.81 |
| | 5 | 43.1 | 48.6 | 0.83 |
| | 6 | 42.6 | 47.5 | 0.8 |
| | 7 | 41.7 | 47.1 | 0.79 |
| | 8 | 41.3 | 46.9 | 0.76 |
| | Mean value | 43.37 | 48.50 | 0.81 |
| | Variance | 2.21 | 1.47 | 0.0012 |
| First-come-first-serve control method | 1 | 40.6 | 60.5 | 0.91 |
| | 2 | 40.1 | 59.7 | 0.89 |
| | 3 | 39.5 | 54.3 | 0.87 |
| | 4 | 38.9 | 55.6 | 0.85 |
| | 5 | 39.1 | 57.8 | 0.81 |
| | 6 | 38.7 | 58.6 | 0.92 |
| | 7 | 38.2 | 59.4 | 0.86 |
| | 8 | 37.9 | 54.1 | 0.85 |
| | Mean value | 39.12 | 57.50 | 0.87 |
| | Variance | 0.83 | 6.30 | 0.0012 |
| This paper method | 1 | 31.9 | 50.1 | 0.7 |
| | 2 | 31.5 | 49.6 | 0.65 |
| | 3 | 31.1 | 49.7 | 0.71 |
| | 4 | 30.1 | 49.3 | 0.76 |
| | 5 | 30.9 | 48.1 | 0.79 |
| | 6 | 30.4 | 48.6 | 0.67 |
| | 7 | 30.8 | 48.5 | 0.68 |
| | 8 | 30.5 | 47.6 | 0.64 |
| | Mean value | 30.9 | 48.9375 | 0.7 |
| | Variance | 0.30 | 0.66 | 0.0009 |

### *3.5. Method stability comparison*

In order to verify the control performance of the proposed method, the stability of the three methods is compared and analyzed, and three road types are set up: straight line, turn around and bend. The stability of driverless vehicle acceleration controlled by three methods is analyzed. The results of acceleration comparison are shown in Table 3.

From Table 3, it can be seen that under the three road types, several experiments have been carried out. Compare the average value of the Forthright, Turn-around turn,and the Winding course ,the mean stability of the proposed method is (0.9762+0.9725+0.9752)/3=0.9747. According to the above calculation, the mean stability of the two methods is 0.7081 and 0.4792 respectively. Through comparison, it is found that on three different types of roads, this method controls the driverless vehicle. Vehicle stability is the best.

**Table 3.** Comparative results of different methods for controlling self-driving vehicles

| Number of experiments | This paper method | | | Self-driving vehicle Control method based on Fuzzy Control | | | Control method of self-driving vehicle based on Image processing Technology | | |
|---|---|---|---|---|---|---|---|---|---|
| | Forthright | Turn-around turn | Winding course | Forthright | Turn-around turn | Winding course | Forthright | Turn-around turn | Winding course |
| 1 | 0.99 | 0.95 | 0.99 | 0.78 | 0.79 | 0.73 | 0.59 | 0.58 | 0.54 |
| 2 | 0.98 | 0.97 | 0.97 | 0.65 | 0.74 | 0.74 | 0.54 | 0.51 | 0.51 |
| 3 | 0.99 | 0.98 | 0.98 | 0.69 | 0.71 | 0.71 | 0.51 | 0.53 | 0.42 |
| 4 | 0.96 | 0.96 | 0.96 | 0.74 | 0.75 | 0.76 | 0.49 | 0.54 | 0.48 |
| 5 | 0.97 | 0.99 | 0.97 | 0.71 | 0.68 | 0.71 | 0.43 | 0.47 | 0.49 |
| 6 | 0.95 | 0.98 | 0.99 | 0.73 | 0.67 | 0.69 | 0.42 | 0.42 | 0.4 |
| 7 | 0.99 | 0.96 | 0.98 | 0.61 | 0.71 | 0.68 | 0.49 | 0.41 | 0.39 |
| 8 | 0.98 | 0.99 | 0.96 | 0.64 | 0.69 | 0.69 | 0.46 | 0.49 | 0.38 |
| Mean value | 0.9762 | 0.9725 | 0.9752 | 0.6937 | 0.7175 | 0.7137 | 0.4912 | 0.4937 | 0.4512 |

## 4. Discussions

Unmanned vehicle is an integral part of intelligent transportation system in the future. It is necessary to coordinate and control the unmanned vehicle in the signal area of rail transit. Therefore, this paper proposes a coordinated control method for driverless vehicles in the signal area of rail transit. Firstly, the operation structure and process of the driverless rail transit are designed based on the vehicle network technology. The driverless rail transit is composed of control center and individual vehicle. The most important part of the individual vehicle is the automatic tracking control module and the vehicle signal priority control module. Individual vehicle loads radio frequency identification equipment, obtains surrounding information, installs relevant controllers, controls vehicle acceleration, deceleration and braking, installs induction system and digital image processing technology. It can not only automatically switch doors to facilitate passengers getting on and off, but also monitor vehicle driving situation in real time, so as to report to the control center. According to the received information, the control center can divide the vehicle into several parts according to the geographical conditions of GIS. At the same time, the control center also calculates the vehicle speed predetermined value, the corner predetermined value and the vehicle operation condition through the automatic tracking and the vehicle signal priority control strategy. In the light source part of the unmanned auto-tracking control module, the interference of sunlight on the unmanned auto-tracking control module is reduced by shading the path sensor module. Through the calculation of lateral deviation, the preview information of the vehicle is obtained, and the vehicle model and driver model are constructed to control the vehicle running according to the predetermined conditions. The signal priority control module of the driverless vehicle detects whether the driverless vehicle passes through the intersection by establishing the signal priority request and processing flow, and ensures that the driverless vehicle passes through the intersection as first as possible through the signal control strategy.

The experimental results show that the difference between the measured and actual corners of the driverless vehicle controlled by this method is 20°. Within the range, that is, the front wheel angle error does not exceed 1.45°. From the point of view of different speeds of driverless vehicles, the error of automatic tracing is smaller and the effect of automatic tracing is better, which shows that the method in this paper has better effect in controlling the automatic tracing of driverless vehicles. The method in this paper is more effective and can realize the control of the automatic tracing of driverless vehicles and ensure that the driverless vehicles can communicate in the rail transit area. It is safe and smooth to drive on board. In addition, by detecting the rear wheel speed, lateral displacement tracking error and front wheel rudder angle under lateral control, it is found that the driverless vehicle body controlled by this method can still track the established track automatically in the lateral direction when the longitudinal speed of the vehicle body changes, even when the longitudinal speed is zero. The dynamic characteristics are good, and the stable tracking accuracy can reach zero static error. It is shown that the lateral control effect of this method under automatic tracing control is better. Compared with the method in this paper, the control method based on fuzzy control and the control method based on image processing technology, it is found that the energy consumption of this method is lower and the stability is higher, and the control effect of this method is better.

## 5. Conclusions

This paper presents a coordinated regional control method for urban rail transit signal based on unmanned driving. The operation structure of unmanned rail transit is designed based on vehicle network technology. The operation flow of unmanned rail transit is given. The most important part of the operation structure of unmanned rail transit is the unmanned automatic tracking control module and the signal priority control module of unmanned vehicle. The automatic tracking control module obtains the preview information of the driverless vehicle by calculating the lateral deviation, and realizes the automatic tracking control of the driverless vehicle by combining the vehicle model with the driver model. The signal priority control module of the driverless vehicle establishes the signal priority request and processing flow, detects whether the driverless vehicle passes through the intersection smoothly, and ensures that the driverless vehicle passes as first as possible through the signal control strategy. This method has good control effect on automatic tracing and signal optimization control of driverless vehicles. The method also has high effectiveness. It can realize automatic tracing control of driverless vehicles and ensure the safe and smooth running of driverless vehicles in the signal of rail transit area.

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