Analysis of Traffic Flow Characteristics in Intelligent Networking Environment

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Abstract. In an intelligent networked environment, both the car and the road are more intelligent, and the information interaction between the vehicle and the roadside equipment is more frequent, the vehicle has a greater advantage in information acquisition, processing, decision-making and standardized driving compared to ordinary manual driving vehicles. The study of mixed traffic flow between intelligent networked vehicles and ordinary vehicles in the intelligent networked environment is of great significance to improve the operational efficiency of traffic flow and road capacity. In this paper, we build simulation scenarios in Vissim based on the meta cellular automaton traffic flow model and the Wiedemann model, conduct simulation experiments on the mixed traffic flow of intelligent networked vehicles and ordinary vehicles, and study and analyse the influence of the change in the proportion of intelligent networked vehicles on the flow, density, speed and other characteristics of the traffic flow. The results show that when the proportion of intelligent networked vehicles in the traffic flow is 40% to 80%, with the increase in the proportion of intelligent networked vehicles, the operating speed of the traffic flow, the density of the traffic flow has been improved to varying degrees, and the road passable flow has also been improved.

1. Introduction

1.1. Research background and meaning

With the vigorous development of the global transportation system, a series of traffic problems are constantly emerging, the number of cars is growing rapidly, the need for road traffic is also increasing, traffic congestion cannot be alleviated, energy shortages, environmental pollution and other problems increasingly prominent, in addition, the surrounding environment of the road, the climatic conditions during driving, the driving behaviour of the driver, etc., all affect road traffic safety and operating efficiency. Poor driving behaviour, unfavourable weather conditions, and traffic environment all reduce road traffic. Ability and service level are also easy to cause traffic jams and traffic accidents. The development of intelligent network technology has become an effective way to solve these problems [1].

Road traffic is an important part of the transportation system and has a pivotal position and role in the development of the national economy. Expressways and urban expressways are the main roads that connect inter-city and intra-city transportation. The improvement of road capacity and traffic operation efficiency is of great significance to the promotion of national economic development. With the development of intelligent network technology, the road is more intelligent, and the information interaction with the vehicle is gradually mature. The road traffic congestion will be improved, and the irregular and unsafe driving behaviour, bad weather and other adverse factors will be reduced. The
reliability of traffic accidents is enhanced, and traditional road traffic capacity and operation efficiency will also achieve revolutionary breakthroughs. High-speed and efficient transportation has brought high benefits to the economy, and at the same time promotes the development of road transportation and the national economy[2].

1.2. Research status at home and abroad
Scholars at home and abroad have conducted a lot of research on traffic flow analysis methods in different scenarios such as expressways, urban expressways, construction sections, and different control strategies of intelligent networked vehicles in the intelligent network environment. Due to the background and purpose of the research, the methods used the research methods are different, so the research results obtained are not the same. Liang Zhikang used the highway construction area as the research background to simulate the control strategy of the intelligent networked vehicle in the mixed traffic flow of intelligent networked vehicles and ordinary manual driving vehicles in the intelligent networked environment, and constructed an intelligent network based on cellular automata. Combined with the vehicle driving model, a simulation experiment was performed to analyse the applicability of vehicle control schemes in different highway construction areas. Foreign scholars Talepour and Mahmassani applied the smart vehicle and ordinary vehicle following model, through numerical simulation experiments, gave the mixed traffic flow, speed, and density correlation diagrams of smart vehicles and ordinary vehicles under different vehicle ratios to analyse smart vehicles. And the impact of ordinary vehicles on road capacity. Guler et al. analysed the traffic capacity of the intersection in the intelligent network environment, and simulated the delay situation of the intersection between intelligent vehicles and ordinary vehicles in different vehicle ratios[3].

2. Car-following model selection of intelligent networked vehicles
2.1. A traffic flow model for the mixed traffic of intelligent networked vehicles and ordinary vehicles
Qiu Xiaoping and Ma Lina combined the classic NaSch model with Arnab Bose's autonomous driving model, and proposed a single-lane cellular automata traffic flow model that considers the speed changes of the preceding vehicle suitable for autonomous driving. The evolutionary update rule of vehicle speed and position is based on the different results obtained by comparing the expected distance D of the preceding vehicle movement with the target distance G passed by the vehicle itself. Among them, the target distance G=haν, ha is the headway time, considering the speed of the vehicle in front, D-G=K, the schematic diagram 1 is as follows[4].

(1) Acceleration rules:
When the vehicle is traveling, the distance the vehicle in front needs to travel is greater than the target distance required by the vehicle. At that time, the corresponding update rules can be executed according to the following situations:

\[ \text{then } K > v_a \Delta t, \quad 0 < D - G \leq v_c \Delta t + 0.5a_{max} ( \Delta t )^2, \] The vehicle is accelerating, and the evolution update rules are as follows:
\[ v_a \Delta t = \min \{ \min ( D - G, v_{ma} \Delta t ), Gap \} \]
then $K > v_n \Delta t$, $D - G > v_n \Delta t + 0.5a_{\text{max}}(\Delta t)^2$, The vehicle is accelerating, and the evolution update rules are as follows:

$$v_n \Delta t = \min \left\{ \min \left( v_n \Delta t + 0.5a_{\text{max}}(\Delta t)^2, v_{\text{max}} \Delta t \right), \text{Gap} \right\}$$

(2) then $K < v_n \Delta t$, $v_n \Delta t - 0.5b_{\text{max}}(\Delta t)^2 < D - G \leq v_n \Delta t$, The vehicle is driving at a reduced speed, and the evolution update rules are as follows:

$$v_n \Delta t = \min \left( D - G, \text{Gap} \right)$$

then $K < v_n \Delta t$, $D - G < v_n \Delta t - 0.5b_{\text{max}}(\Delta t)^2$, The distance between the two vehicles is reduced, which is about to be less than the safe distance. Therefore, the vehicle decelerates at the maximum deceleration and reaches the target distance with the shortest travel distance. The rules for the vehicle to decelerate are as follows:

$$v_n \Delta t = \min \left( v_n \Delta t, \text{Gap} \right)$$

(3) then $K = v_n \Delta t$, When the vehicle is running at a constant speed, but at the same time it is necessary to ensure the safety of the vehicle, the evolution update rules are as follows:

$$v_n \Delta t = \min \left( v_n \Delta t, \text{Gap} \right)$$

(2) Deceleration rules:

When the vehicle is moving, the target distance required by vehicle n is greater than the distance travelled by the preceding vehicle speed in one second, then., and the vehicle will decelerate immediately.

$$v_n \Delta t = \min \left\{ \max \left( v_n \Delta t - 0.5b_{\text{max}}(\Delta t)^2, 0 \right), \text{Gap} \right\}$$

(3) Location update:

Vehicle location update rules, as shown in the following formula:

$$x_{n+1} = x_n + v_n \Delta t$$

$\text{Gap}$ is the distance between the front and rear cars, $\text{Gap} = x_{n+1} - x_n - l_{\text{nf}}$; $x_n(t)$ is the position of the n-th car at time t; $x_{n+1}(t)$ is the position of the vehicle in front of the nth vehicle at time t; $l_{\text{nf}}$ is the length of the vehicle in front; $a_{\text{nf}}$ is the maximum acceleration during the driving of vehicle n; $v_{\text{max}}$ is the maximum driving speed during the driving of vehicle n; $b_{\text{max}}$ is the maximum deceleration of the vehicle n; $\Delta t$ is the simulation time step.

This model better shows the acceleration and deceleration characteristics and traffic flow characteristics of intelligent networked vehicles in the intelligent networked environment. Based on this model, this paper considers the headway distance, headway time, and emergency response time of intelligent networked vehicles and ordinary vehicles. Change the parameter settings of the model such as the difference of the parameters, so that it can reflect the difference of the driving characteristics of different vehicles, meet the needs of mixed traffic flow, and realize the environment of mixed driving of intelligent networked vehicles and ordinary vehicles[5].

3. Simulation of the mixed traffic flow of intelligent networked vehicles and ordinary vehicles

3.1. Simulation scene

In order to more truly reflect the changes in the traffic flow characteristics of the mixed traffic of intelligent networked vehicles and ordinary vehicles in the intelligent networked environment, this paper constructs a single-lane simulation scene in Vissim. Vissim is a road traffic micro-simulation tool based on the Wiedemann model in the physiological-psychological model. It is an effective tool for evaluating traffic engineering design and road planning. In order to facilitate the realization of different car-following models and traffic control methods, Vissim also provides secondary development functions[6].
This simulation experiment was carried out in the Vissim simulation software. The simulation road section was set as a single lane with a total length of 3000m, and multiple road sections with the same parameters and detector settings were laid at the same time, so that multiple sets of experimental tests could be carried out at the same time. The intelligent networked vehicle model uses the external driver model in Vissim to input the intelligent networked vehicle driving model based on the cellular automaton considering the speed change of the preceding vehicle. The vehicle length is $l=7.5m$, the initial vehicle acceleration is $a$, and the initial speed $v$ take a random value in $(0, v_{\text{max}})$. Usually, the size of a single cell in the cellular automata traffic flow model is mostly 7.5m. This paper considers that the head-to-head distance and head-to-head distance between the front and rear cars of the intelligent networked car are small. In the simulation, the length of each cell is set to the smaller 0.5m. When the number of vehicles is input, the intelligent networked vehicle and the ordinary vehicle drive in randomly according to the set traffic composition ratio. The simulation diagram is shown in Figure 2:

![Simulation scenario schematic](image)

3.2. Parameter settings

Driving behaviour setting: Because the research content of this paper is mainly for road sections, and the interference of highway vehicles is less, it is more in line with the requirements of this simulation experiment, therefore, the driving behaviour selects the highway driving behaviour, and the model is based on the driving characteristics of the vehicle. The parameters are modified. In the vehicle type, modify the expected acceleration and maximum expected acceleration of the vehicle, and the result is shown in Figure 3.

![Driving behaviour](image)

Link property setting: when paving the road section, select the behaviour type in the link property, which has been set to drive behaviour on the expressway (choose the lane at will).

Traffic composition setting: First, set the expected speed of different vehicle types, and then the traffic composition of each group is different according to the proportion. The vehicle composition can be divided into all ordinary vehicles, and intelligent networked vehicles account for 10%, 20%, 30%... 80%, 90%, 11 types of fully intelligent networked cars.

Detector settings: data collection points are set at the start and end points of the road section to collect road operation occupancy rate, maximum vehicle speed, minimum vehicle speed and other traffic operation evaluation parameters; select a section of 800-1000 meters in the middle of the experimental section to set the travel time detection It records the average travel time and traffic flow of vehicles.
passing through the detected road section, and calculates the average speed and density of vehicles based on this.

3.3. Simulation experiment and result analysis

This simulation experiment sets up two simulation scenarios, one is to simulate the different proportions of intelligent networked vehicles under the same traffic flow conditions, and analyse the influence of different proportions of intelligent networked vehicles on the density and speed of traffic flow; The other is the impact of changes in traffic flow on the density and speed of traffic flow when the proportion of intelligent networked vehicles in the traffic flow is the same.

Experiment 1: The experiment set the same traffic flow unchanged to verify the influence of the change in the proportion of intelligent networked vehicles on the traffic flow density and speed.

Under the same traffic flow, lay 11 road sections and set up different traffic components for simulation. Perform traffic flow simulation according to the above settings to obtain the traffic flow parameters shown in Table 1. When the input flow is 400 vehicles/h, the average vehicle speed and density changes are shown in Figures 4 and 5.

![Figure 4. Average velocity change curve](image1)

![Figure 5. Density change graph](image2)

According to the analysis of the data and the graph, when the input flow is 400, the speed increases with the proportion of intelligent networked vehicles, and the vehicle speed continues to increase until the proportion of intelligent networked vehicles reaches 80% When the time reaches the highest value except for fully intelligent networked vehicles; the density value continues to decrease as the proportion of intelligent networked vehicles increases, but the average speed of the vehicle does not change significantly at this time, indicating that it is not due to the fast speed of the vehicle By leading to a decrease in road traffic density, but a decrease in the density caused by the increase in the distance between the fronts, the intelligent networked vehicles accounted for 30% to 40% of the stage. The density increased, and the average speed also increased slightly. The vehicles should have passed the road more quickly. The density value continues to decrease, but the density value increases at this time.
In the range of 40% to 70% of the intelligent networked vehicles, the speed of the vehicle does not change very much, but it continues to increase. In this range, the vehicle density has always been. The volatility is reduced until around 80% of the vehicle speed is greatly increased, and the vehicle can quickly pass through the section of the road. The vehicle density drops off a cliff. When intelligent networked vehicles account for 90%, the reason for the decrease in vehicle speed is that the speed and density occur over time. The specific changes. From this, it can be judged that under the premise that the vehicle speed does not change significantly, with the increase in the proportion of intelligent networked vehicles, the impact on density is mainly due to the small head-to-head distance between the intelligent networked vehicle and the preceding vehicle, resulting in higher density. High, but the increase in density has an impact on the speed, the characterization is not very obvious, and follow-up experiments are needed to continue to verify.

Experiment 2: The experiment sets the ratio of intelligent networked vehicles to ordinary vehicles to remain unchanged, and examines the impact of changes in traffic flow on the density and speed of traffic flow.

Comprehensive analysis of the above test results found that when the ratio of intelligent networked vehicles to ordinary manual driving vehicles is 4:6, the traffic operation state is the best. Therefore, the proportion of intelligent networked vehicles remains unchanged, and the traffic composition is set to intelligent in the experiment. The ratio of networked vehicles to ordinary manually driven vehicles is 4:6, and the traffic flow increases from 400, 800, 1200 to 4000 vehicles/h, and other parameters are not modified for simulation experiments.

Perform traffic flow simulation according to the above settings to obtain the traffic flow parameters shown in Table 2. When the proportion of intelligent networked vehicles does not change, the average speed and density of vehicles when the input flow changes are shown in Figures 6 and 7.

| Input flow (vehicles/h) | Percentage of smart vehicles | Travel time (s) | Through flow (vehicles/h) | Driving distance (m) | Average speed (km/h) | Density (vehicles/km) | Occupation rate |
|-------------------------|-------------------------------|----------------|--------------------------|---------------------|----------------------|-----------------------|----------------|
| 400                     | 40%                           | 42.4           | 377                      | 786.8               | 66.80                | 5.64                  | 0.1            |
| 800                     | 40%                           | 48.2           | 730                      | 856.7               | 63.99                | 11.41                 | 0.2            |
| 1200                    | 40%                           | 51.6           | 1211                     | 888.6               | 62.00                | 19.53                 | 0.3            |
| 1600                    | 40%                           | 57.8           | 1546                     | 956                 | 59.54                | 25.96                 | 0.4            |
| 2000                    | 40%                           | 60.6           | 1707                     | 962                 | 57.15                | 29.87                 | 0.5            |
| 2400                    | 40%                           | 49.2           | 1755                     | 786.8               | 57.57                | 30.48                 | 0.1            |
| 2800                    | 40%                           | 56.2           | 1717                     | 856.7               | 54.88                | 31.29                 | 0.2            |
| 3200                    | 40%                           | 58.7           | 1712                     | 888.6               | 54.50                | 31.41                 | 0.3            |
| 3600                    | 40%                           | 62.5           | 1711                     | 956                 | 55.07                | 31.07                 | 0.4            |
| 4000                    | 40%                           | 61.1           | 1732                     | 962                 | 56.68                | 30.56                 | 0.5            |
| 4000                    | 40%                           | 42.4           | 377                      | 786.8               | 66.80                | 5.64                  | 0.1            |

According to the analysis of the data and the graph, when the ratio of the intelligent networked vehicle to the ordinary manual driving vehicle is 4:6, the speed will continue to decrease with the
increase of the traffic volume, and the traffic volume will reach 2800 vehicles/h. After h, the speed of the vehicle remains basically unchanged; the density continues to increase with the increase in traffic flow until the density is basically full when the flow value reaches 2400 vehicles/h, and the speed is also decreasing as the density increases, so it is impossible to judge the density increase. The reason is that the traffic flow causes the speed to decrease, which in turn causes the traffic flow to travel slowly, resulting in an increase in density, or it is only caused by changes in traffic. If it is simply caused by traffic, there is no comparison of the proportions of different intelligent networked vehicles, which cannot reflect the intelligent networked vehicles. Impact on traffic flow.

Experiment 3: Analysing the results of the above two simulation scenarios, a single variable cannot truly and accurately determine the impact of intelligent networked vehicles on traffic flow. Therefore, simulation experiments are carried out for different fixed traffic flows and different proportions of intelligent networked vehicles. To compare the experimental results.

It is known from the above experimental results that the experimental effect ratio of traffic flow above 2000 vehicles/h is not ideal, so only the speed and density changes when the input flow is below 2000 vehicles/h are analysed and processed. The experimental results are shown in Figure 8 and Figure 9 below:

![Figure 8. Graph of the change in traffic speed with the share of smart networked vehicles](image)
![Figure 9. Graph of the change in traffic density with the share of smart networked vehicles](image)

Based on Figure 8 and Figure 9 analysis the impact of changes in the proportion of intelligent networked vehicles under different traffic flows on speed and density. There is not much difference from the analysis results of the above experiment. The difference is that the greater the traffic flow, the intelligent network connection the increase in the proportion of vehicles has a greater impact on the speed and density of traffic flow. From this, it can be judged that the greater the value of traffic flow, the greater the impact of the increase in the proportion of intelligent networked vehicles on the traffic flow, and the greater the impact on the efficiency of traffic operation. The improvement is also greater.

![Figure 10. Graphs of the speed of the vehicle share of different smart networks as a function of traffic](image)
![Figure 11. Graph of the density of the vehicle share of different smart networks as a function of traffic](image)
Based on the analysis of Figure 10 and Figure 11, it is known that the changes in density and speed are caused by changes in traffic flow, but the proportion of different intelligent networked vehicles, the impact of changes in traffic flow on density and speed is different, intelligent networked vehicles. When the proportion is relatively large, the change in speed is not very obvious when the proportion is relatively small, but the change in density is more obvious. From this, it can be judged that the proportion of intelligent networked vehicles has increased, and the increase in density is mainly caused by the decrease in the distance between the fronts of the vehicles.

4. Conclusion and suggestion

The main conclusions of this article are as follows: The proportion of intelligent networked vehicles is in the range of 40% to 80%. As the proportion of intelligent networked vehicles increases, the impact of the increase in traffic flow on vehicle speed and traffic density decreases, and the saturated traffic value that can be operated on the road increases. High vehicle speed and traffic density have also been greatly improved, road capacity has been greatly improved, and the efficiency of traffic flow operation has also been greatly improved.

The main recommendations for the intelligent transportation industry are as follows: Accelerate the development of intelligent network connection technology. Intensify the research and development of intelligent connected technology, accelerate the investment in the intelligent connected vehicle market, and support the research on the mixed traffic flow of intelligent connected vehicles and ordinary vehicles. Improve the intelligent vehicle driving model. Improve the existing smart car model to make it more in line with the driving behaviour and characteristics of the vehicle.

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