Signal Light Optimization based on PTV Vissim Software

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Abstract. This paper conducts on-the-spot investigation on the traffic flow of each entry and exit road during the early peak period of the case intersection, and uses the data obtained from the survey to make accurate calculations to obtain the capacity and delay time of the current intersection, and then use PTV Vissim. The simulation software simulates the real-time road condition reduction simulation of this intersection. Finally, based on the results of the PTV Vissim simulation software, a more reasonable optimization plan for the traffic light duration configuration of the intersection is proposed, which can make the interlaced area smooth, fastest, and maximize travel efficiency. A new signal optimization solution based on PTV Vissim software can reduce the delay time of the intersection and improve its traffic capacity.

1. Introduction
The research on signalized intersections is often based on the traffic flow characteristics of a certain road using traffic simulation software to find out the appropriate signal optimization scheme for the road. Therefore, this paper is based on the intersection of Qinglongtan Road and Ziyun Road in the Economic Development Zone of Hefei City. The mouth is the research object, the PTV Vissim software is enabled to simulate the real-time road condition of the intersection, and the most suitable traffic length configuration of the intersection is simulated, and an optimum scheme for the intersection signal light is developed, so that the delay time of the intersection can be made. The scheme has the smallest traffic delay time, the largest capacity and the lowest traffic accident rate.

2. The composition and function of the software
PTV vissim is a microscopic model traffic simulation tool used to solve the real-time profiles of two types of traffic based on urban or public transportation and to study their time intervals and driving behaviors. It can explain the various types of traffic, such as the width and location of the lane, the duration and location of the traffic lights, the sidewalks, the green belts, and the location of the bus stops. The current operation status is also a tool for judging whether the current traffic engineering design, urban planning and management plan are properly applied.

3. Intersection status survey and data analysis

3.1. intersection geometry
An intersection is a place where two or more routes intersect at each important node. The intersection of Ziyun Road and Qinglongtan Road in Hefei City is an important intersection of the economic development zone. It is a “ten” shaped intersection of signal control. Each entrance is not only full of traffic steering functions, but also has a very large traffic volume big.
It can be seen from Figure 1 that the intersection of Ziyun Road and Qinglongtan Road is a cross-shaped intersection, and there are central isolation belts in the four inlet directions. The angle between the west import and the south import is 90 degrees, the east-west direction belongs to the main road, the road section is the three-way ten lanes of Ziyun Road, and the west entrance of Ziyun Road has a dedicated right turn lane, two straight lanes, and one Left turn and U-turn common driveway, a bus lane, a central green belt; Ziyun Road east entrance also has a dedicated right turn lane, two straight lanes, a left turn and U-turn common lane, a bus lane Greenbelt. There is a central stop next to the bus lane in the east-west direction. However, due to route planning problems, it is not used frequently. When the bus does not travel from the bus lane, it is the straight lane and the dedicated right-turn lane that use the entrance lanes in all directions. Make a turn. The north-south direction of Qinglongtan Road belongs to the secondary trunk road. The south entrance has a straight-line and left-turn public lane, a straight-going and right-turning public lane. The north entrance has a right-turning dedicated lane, two straight lanes, and a dedicated left-turn lane. The nearby buildings are densely populated, with restaurants, supermarkets, hotels, companies, houses, clinics, etc.

### 3.2. Intersection peak hours traffic survey

Traffic volume refers to the number of traffic entities passing through a certain location, a section or a certain lane in a unit time period. The survey in this paper is the morning peak traffic volume. The average vehicle data in the direction of each entrance of the intersection during the early peak period obtained from the field survey is shown in Table 1.

| Car import | direction | Car | Medium car | Large car |
|------------|-----------|-----|------------|-----------|
| Ziyun Road | East import | Turn left | 144 | 5 | 11 |
| Ziyun Road | East import | straight | 306 | 19 | 23 |
| Ziyun Road | West import | Turn right | 51 | 2 | 1 |
| Ziyun Road | West import | Turn left | 90 | 5 | 2 |
| Ziyun Road | West import | straight | 555 | 16 | 32 |
| Ziyun Road | West import | Turn right | 441 | 18 | 15 |
| Ziyun Road | West import | Turn left | 34 | 3 | 3 |
| Ziyun Road | West import | straight | 79 | 9 | 9 |
| Qinglongtan Road | South import | Turn right | 122 | 44 | 44 |
| Qinglongtan Road | North import | Turn left | 115 | 1 | 1 |
| Qinglongtan Road | North import | straight | 167 | 8 | 9 |
| Qinglongtan Road | North import | Turn right | 136 | 3 | 2 |
Also, when calculating the traffic volume, it is necessary to convert the data obtained by the survey into equivalent traffic volume. The equivalent traffic volume calculation formula is

\[ V_e = V \cdot \sum_{i=1}^{n} P_i \cdot n_o = V \cdot \left[ 1 + \sum_{i=1}^{n} (N_o - 1) \right] \]

Therefore, according to the highway engineering reference materials, the conversion factor of the vehicle can be found as shown in Table 2.

| Vehicle Type | Minibus | Medium car | Large car | Car train |
|--------------|---------|------------|-----------|-----------|
| Conversion factor | 1.0     | 1.5        | 2.5       | 4.0       |

It can be seen from the data of Table 1 and Table 2 that the total number of cars at the intersection of Ziyun Road and Qinglongtan Road is 2,240, the total number of medium-sized vehicles is 133, and the total number of large vehicles is 152, which can be calculated. The total number of vehicles at the intersection is 2,525. The specific calculation results after the conversion are shown in Table 3.

| Car import | Turn left | straight | Turn right |
|------------|-----------|---------|-----------|
| Qinglongtan Road south | 46 | 107 | 226 |
| north | 119 | 252 | 146 |
| Ziyun Road east | 176 | 392 | 57 |
| WEAT | 103 | 659 | 506 |

### 3.3. Intersection signal timing scheme survey

The intersection of Ziyun Road and Qinglongtan Road is two phases.

| Signal phase sequence | Signal phase | Cycle | Green light | Yellow light | Red light | Full red time | Effective green light | Green time ratio |
|-----------------------|--------------|-------|-------------|--------------|-----------|---------------|----------------------|------------------|
| First phase           | North and South straight and turn left | 98    | 40          | 3           | 55        | 12            | 40                   | 0.3              |
| Second phase          | Go straight and turn left             | 98    | 40          | 3           | 55        | 12            | 40                   | 0.3              |

### 3.4. Data Analysis

In order to make a reasonable evaluation of the signal timing scheme at the intersection of the current situation, it is necessary to make a corresponding evaluation of the existing service level and operation status of the intersection. A key criterion used to evaluate blockage at the intersection is the service level of the intersection. Therefore, it is necessary to calculate the traffic capacity of the intersection of Ziyun Road and Qinglongtan Road and the delay time of each lane, so as to calculate the service level of each imported lane. The content of this section is mainly to simplify the calculation of the survey data, calculate the traffic capacity and delay time of the intersection of Qinglongtan Road and Ziyun Road, and calculate the service level.

After calculation, the above results can be sorted out to obtain the traffic capacity of each entrance of the intersection as shown in Table 5.

| Car import | Turn left | Straight |
|------------|-----------|----------|
| Qinglongtan Road south | 516 | |
| north | 85 | 1064 |
| Ziyun Road east | 76 | 1596 |
| WEAT | 76 | 1596 |

When the car is obstructed at the intersection of the plane signal, the driving delay time here is an evaluation basis that can be regarded as the loss of the driving time of the vehicle. The size of driving delay can not only reflect the geometric design of the signal intersection, but also reflect the
rationalization of traffic organization and signal timing. This paper uses the Webster method to calculate the delay time analysis and determine the service level of the intersection of Qinglongtan Road and Ziyun Road.

The driving delays at the intersection of Qinglongtan Road and Ziyun Road can be found in Table 6.

Table 6. Traffic delay at the intersection of Qinglongtan Road and Ziyun Road

| direction   | East import straight | East import turn left | West import straight | West import turn left | South import straight | South import turn left | North import straight | North import turn left |
|-------------|----------------------|-----------------------|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Delay (s)   | 32.4 52.9 50.5 52.5 | 49.5                  | 35.4 48.5            |

It can be seen from the above data that the delay time of the left turn of the entrance of Ziyun Road and Qinglongtan Road is longer than that of the right turn lane, and because there is a delay between the size of the delay time and the service level of the intersection. The inseparable relationship can be seen that the service level of the east import straight line between 21s and 35s is C, and the delay time of the other import roads is between 35s and 55s, and the service level is D.

4. PTV Vissim simulation analysis

4.1. Status Simulation and Analysis

Restoring simulation of real-time road conditions at intersections based on simulation software PTV Vissim.

Figure 2. Simulation of the current situation of the intersection of Qinglongtan Road and Ziyun Road

It can be seen from the simulation results of PTV Vissim software that since the south entrance of Qinglongtan Road has a straight left mixed lane and a straight right mixed lane, it is relatively feasible to use the two phases for the current signal plane intersection. However, it is not difficult to see that the intersection area of the intersection is too much, the delay time is too long, and the service level is low, so the traffic capacity of the intersection is too low, so it is inevitable to propose a reasonable optimization scheme for the intersection. Generally speaking, the optimization of the intersection mainly starts from the geometric design of the road and the timing of the signal light. This paper uses the time length displayed by changing the red, yellow and green color lights in the signal group to reduce the traffic organization. The conflict zone enhances the capacity of each entrance lane of the road, reducing the queue time and traffic delay time of the vehicle.

4.2. Signal Timing Optimization and Simulation

The signal timing optimization design is to change the length of time displayed by the red, yellow and green three color lights. It is mainly optimized from the following five steps. The established optimization scheme is again simulated by PTV Vissim software, and the obtained results are compared with the previous results to obtain the best optimization scheme.

The first step: select the critical lane and calculate the flow ratio of each entrance lane.
Table 7. Flow ratio of each approach channel

| Imports          | West straight | West left | West turn left | East straight | Turn left | South straight | North straight | Turn left |
|------------------|---------------|-----------|----------------|---------------|-----------|----------------|----------------|----------|
| Flow rate ratio  | 0.24          | 1.40      | 0.25           | 2.40          | 0.30      | 0.24           | 1.40           |          |

Step 2: Calculate the total loss time per cycle \( L = \sum_{i=1}^{n} (1 + I_i - A_i) = 2 \)

Step 3: Cycle duration calculation (where \( y = 0.36 \) ) \( G_O = \frac{1.5L + 5}{1 - Y} = 22s \)

Step 4: Effective Green Light Duration Calculation \( G_e = G_O - L = 75s \)

Similarly, \( g_{NSL} = 44s \), \( g_{EW} = 44s \).

Step 5: Display the green light duration calculation.

\( G_{NS}=g_{NSS-A+I}=75s \), \( G_{NSL}=g_{NSL-A+I}=44s \), \( G_{EW}=g_{EW-A+I}=44s \)

The delay time of the new timing scheme calculated by the delay analysis theory is

- West import straight 18.2s; West import left turn 18.7s; East import straight 28.5s;
- East import left turn 48.7s; South import 49.5s; North import straight 32.3s; North import left turn 42.4s.

It is clear from the improved optimization scheme that the delay time of the intersection is reduced and the service level of the road intersection is mostly improved. Although the service level of the traffic lane at the intersection of Ziyun Road and Qinglongtan Road remains unchanged, there is still no delay in the import lane, such as the south import, but the delay time of other import lanes at the signalized intersection has become smaller. Although the overall service level has not improved much at the intersection using the improved optimization scheme, it has already improved the road capacity based on the current intersection and improved the congestion during peak hours. The following uses an improved signal timing scheme to use the PTV VisSim software for traffic simulation and verification of the model. By setting the output of the PTV VisSim detector and the output of the simulation result, the travel time and delay time of the vehicle can be output. If the error value of the data is too large, it needs to be adjusted and then simulated. Otherwise, it can be output. The data is further evaluated based on the outputted data for the intersection after the optimization. The simulation results are shown in Table 8.

Table 8. Simulation results of the intersection of Qinglongtan Road and Ziyun Road

| Schedule | West straight | West left | West right | East straight | East left | south left | South straight right | North straight | North left | North right |
|----------|---------------|-----------|------------|---------------|-----------|------------|---------------------|----------------|------------|-------------|
|          | 33.0          | 40.7      | 34.4       | 32.1          | 45.4      | 48.8       | 35.4                | 37.9           | 39.8       | 33.4        |
| Delay    | 19.9          | 40.1      | 19.8       | 18.5          | 48.3      | 35.7       | 25.4                | 19.3           | 37.5       | 23.7        |

5. Summary

Through the field investigation of the intersection of Ziyun Road and Qinglongtan Road, it is concluded that a reasonable signal timing scheme is proposed to improve the traffic capacity of the road, the service level of each imported road, and solve the road traffic jam and traffic infrastructure. Protection and other aspects have important implications. Firstly, the artificial investigation of the early peak of the current traffic port is carried out. Some basic parameters such as peak hour traffic flow, saturated flow rate, signal period, red and yellow time, etc. are obtained from the intersection, and the data obtained from these actual investigations are used to find out. Based on the investigation data, the traffic capacity and traffic delay time of each entrance at this intersection are calculated, so as to analyze the service level and traffic congestion of each entrance. You can understand the investigation by using PTV VISSIM simulation software to simulate the actual road condition and traffic flow at the intersection. The service level of the entrance lanes at the intersection is relatively low, and the service level of the entrance lanes in each direction needs to be improved. To improve the service level of the intersection, this paper uses the change of signal timing, that is, using Webster calculation method and
delay analysis to find the most suitable signal period for the intersection of Ziyun Road and Qinglongtan Road, and calculate the calculation of each imported lane again. The flow rate is selected as the key road, and the new signal timing scheme is calculated on this critical road. The delay time of the improved intersection is calculated and compared with the previous timing scheme. Improve the service level of most imported roads. Finally, use PTV Vissim simulation software to simulate the running condition of the optimized road intersection again, adjust the travel time and delay time of the intersection, and compare and analyze the current situation simulation results of the original intersection, and finally establish the best. Signal light optimization program.

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