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# Intelligent traffic light control algorithm based on Webster

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***Abstract*—Traffic lights ensure the orderly and smooth traffic flow of the whole road network, while the traditional traffic lights control mode often can not achieve the purpose of dynamic adjustment of traffic lights according to the real-time traffic flow of the intersection, resulting in the intersection congestion. Therefore, this paper introduces the linear regression algorithm to fit on the basis of the adaptive timing algorithm Webster, and obtains an improved algorithm with higher efficiency than the traditional method. The improved algorithm obtained is obviously superior to the traditional traffic light timing algorithm in the case of different traffic flows.**

***Keywords—Webster algorithm; intelligent transportation; light control***

## 1. INTRODUCTION

The purpose of the intelligent traffic light control algorithm based on Webster is to increase the passing rate of traffic intersection and alleviate the degree of urban traffic congestion. Traffic lights can ensure the orderly and smooth traffic of the whole road network. However, because the traffic flow on the road is increasing greatly every year, the traditional traffic light control method can not achieve the purpose of dynamic adjustment of traffic lights according to the real-time traffic flow of the intersection, resulting in the intersection congestion. Therefore, improving the traffic light control algorithm and improving the traffic capacity of intersections is an important key issue in the field of intelligent transportation.

At present, the commonly used control methods for traffic lights include timing control, induction control and adaptive control. With the increase of traffic volume in the city, the past traffic light control methods (timing control and induction control) cannot adjust the traffic lights according to the real-time traffic flow, and it can no longer meet the traffic demand of the current urban development. The flexibility, availability and optimality of the adaptive control method can effectively alleviate traffic congestion, so the adaptive control method has become a mainstream scheme. The adaptive timing methods of timing signal mainly include Webster method, ARRB method and HCM method, and there are "stop line method" and "conflict point method" in China. Among them, Webster timing method is commonly used, and its principle and steps are classic in traffic timing method.

Therefore, the system is based on the Webster timing method, and the optimal cycle length C obtained by the Webster algorithm is only the theoretical optimal cycle length, so the linear regression algorithm in machine learning is introduced to fit the optimal cycle length closer to the reality.

## II. WEBSTER ALGORITHM AND LINEAR REGRESSION ALGORITHM

Webster model is a method to calculate signal timing with the objective of minimizing vehicle delay time, so its core content is the calculation of vehicle delay and optimal cycle time. And the cycle time here is based on the calculation of vehicle delay, which is a more commonly used calculation method in traffic signal control.

Linear regression is a kind of linear model which uses the linear combination of attributes to predict. Its purpose is to find a straight line or a plane or a higher-dimensional hyperplane, so as to minimize the error between the predicted value and the real value.

Given data set $D = \{(x_i, y_i)\}_{i=1}^{m}$, where $x_i = (x_{i1}, x_{i2}, \ldots, x_{id})$, $y_i \in R$ (the output space of linear regression is the whole real space). M is the number of samples and D is the attribute dimension.

Linear regression tries to learn: $f(x_i) = w^T x_i + b$, (1), so that $f(x_i) \simeq y_i$ for discussion, $b = w_0 \cdot x_0$, where x0 = 1. Then w becomes $w = (w_0, w_1, \ldots, w_d)$, X becomes $x_i = (1, x_{i1}, \ldots, x_{id})$, and the expected function is:

$$f(x_i) = w^T x_i \qquad (1)$$

There must be a difference between the predicted value and the real value $\varepsilon$. for each sample:

$$y_i = w^T x_i + \varepsilon_i \qquad (2)$$

It is assumed that the error $\varepsilon_i$ is independent and identically distributed, and obeys the Gaussian distribution. Namely:

$$p(\varepsilon_i) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{{\varepsilon_i}^2}{2\sigma^2}\right) \qquad (3)$$

By substituting (2) into (3), we get the conditional probability that the predicted value is Yi when the parameter W and data wi are known.

$$p\left(y_i \mid x_i; w\right) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{\left(y_i - w^T x_i\right)^2}{2\sigma^2}\right) \quad (4)$$

Multiply (4) to obtain the conditional probability of Y in the case of known parameter W and data X. This conditional probability is numerically equal to, likelihood (w|x, y), that is, under the condition of known existing data, W is the probability of real parameter, that is, likelihood function (5):

$$L(w) = \prod_{i=1}^{m} p\left(y_i \mid x_i; w\right) = \prod_{i=1}^{m} \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{\left(y_i - w^T x_i\right)^2}{2\sigma^2}\right) \quad (5)$$

The optimal period C0 output by the above algorithm is only a theoretical value. In the actual intersection, in order to ensure the minimum delay, the period can be varied within the range of 0.75C0~1.5C0. Use the "linear regression algorithm" in machine learning to fit the linear formula between the actual period length C and C0.

## III.EXPERIMENT

Ptv-vissim is a microscopic traffic simulation modeling tool based on time interval and driving behavior. It can analyze the operation status of urban road network traffic under various traffic conditions (such as traffic signals, bus stops, etc.) and effectively evaluate traffic schemes [1]. VISSIM can not only generate online traffic conditions, but also offline statistics of various data, such as travel time, queue length, etc. [2]. Therefore, the experiment was simulated using VISSIM software in this experiment. Get different data by setting different traffic flows. The value of C0 is calculated by the above Webster algorithm, and then the fixed traffic volume is changed within the range of 0.75C0~1.5C0, and the C value when the intersection pass rate is the highest is C true. Through the engineering calculation software Octave, the linear regression algorithm of the above data set is calculated to fit the linear function between C actual and C0.

## IV.RESULTS AND ANALYSIS

This paper mainly analyzes the queue length and travel time results in VISSIM simulation. In the simulation software, the traffic rule is set as right traffic, the simulation time is 3600s, and the saturated traffic flow of each entrance in the intersection is set as 1500vehicle / h. In order to verify the effectiveness of the dynamic timing scheme in this paper, the evaluation results of the dynamic timing scheme are compared with the results of the traditional static timing scheme.

In this experiment, a common intersection was established using VISSIM software, and the average travel time and average queue length of the static timing scheme and the dynamic timing scheme under different traffic flows were compared.

In the traditional static timing scheme, the signal period is 100s, the East-West signal is 48S green, the yellow is 4S, the red is 48S, the North-South signal is 48S red, the yellow is 4S, the green is 48S. In this scheme, the average queue length and average travel time of vehicles at the intersection are shown in the figure, which is the comparison object of the effect of dynamic timing scheme.

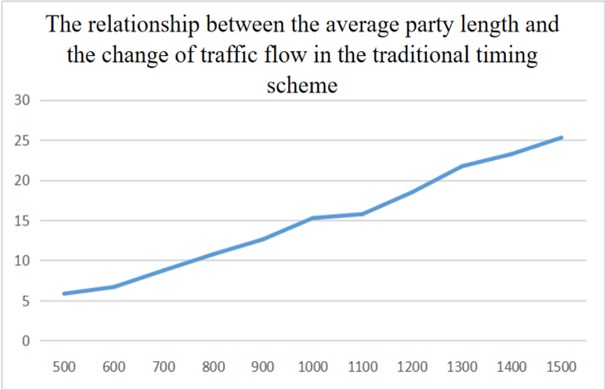


Figure 1 Diagram of average queue length under traditional static time allocation scheme

In the traditional timing scheme, the relationship between the average travel time and the traffic flow is not obvious.

In the dynamic time allocation scheme, the average queue length also increases with the increase of traffic flow, but in the case of low traffic flow, the starting value is low and the increase is slow, and this is in the case of C0 only taking the default parameters. Under the condition that C0 automatically calculates the best value according to the traffic flow, the increase of the traffic flow can be slowed down obviously.

The average travel time under the above timing scheme is shown in the figure below.

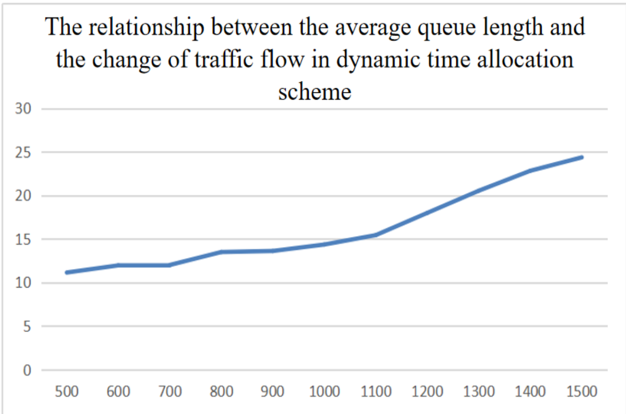


Figure 2 Schematic diagram of average travel time under dynamic timing scheme

Similar to the queue length, it can also maintain significantly lower average travel time at a lower traffic volume. In order to verify the effectiveness of the dynamic time allocation scheme in this paper, the following figure shows the difference between the traditional static time allocation scheme and the dynamic time allocation scheme in terms of average queue length and average travel time under the same traffic flow.

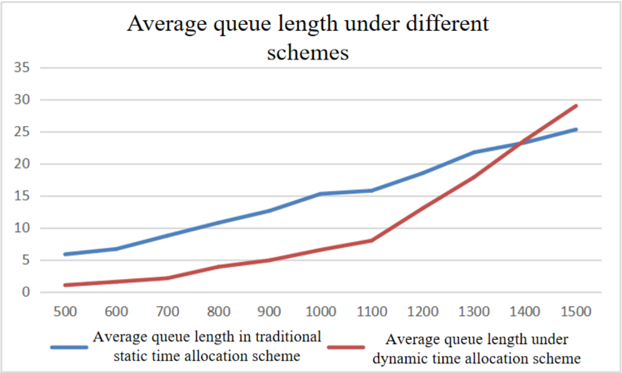


Figure 3 The diagram of the average queue length under the traditional static time assignment and the dynamic time assignment scheme in this paper

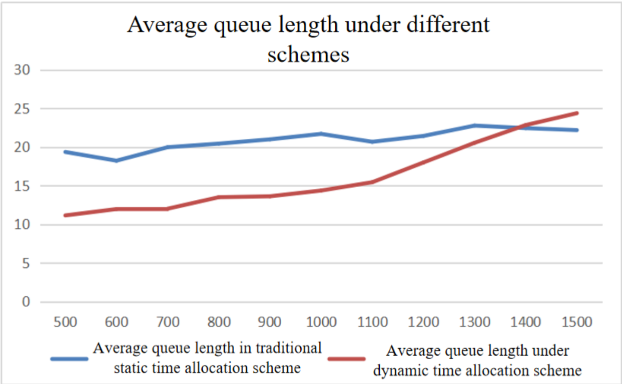


Figure 4 The diagram of the traditional static timing and the average travel time under the dynamic timing scheme in this paper

It can be clearly seen that the average queue length and the average travel time in the dynamic scheme are significantly lower than that in the traditional static scheme.

If the average queue length is set to be no more than 10 when the road is unblocked and no more than 15 when it is relatively unblocked, the average travel time is no more than 15 when it is unblocked and no more than 20 when it is relatively unblocked.

It can be seen from Fig. 3 and Fig. 4 that in terms of queue length index, the traditional static timing scheme can only keep the road unblocked when the traffic volume is about 700, and keep the road unblocked when the traffic volume is about 1000. The dynamic timing scheme in this paper can keep the road smooth when the traffic volume is about 1200. If the average travel time index is observed, the traditional static timing scheme can not keep the road unblocked even when the traffic flow is low, and can only keep the road unblocked when the traffic flow is not more than 700. In this paper, the dynamic timing scheme can keep the roads unblocked when the traffic volume is less than 1100. The traffic is kept clear when the traffic volume is less than 1300, which is obviously superior to the traditional static timing scheme. If the two indicators are combined, the roads will be smooth or smooth when both indicators are in a smooth or smoother standard. It can be concluded that in the traditional static timing scheme, even if the traffic volume is small, the road cannot be kept clear, and the road can be kept smooth even when the traffic volume is not more than 700. The dynamic timing scheme described in this paper can keep the road in a smooth state when the traffic volume is less than 1100. It can be seen that the dynamic timing scheme in this paper has obvious effects on improving road traffic capacity and relieving congestion.

From the actual optimal period C of the above output and the actual green time of the 1, 2 phase, the yellow time can be obtained as follows:

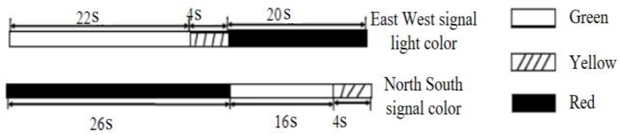


Figure 5.The above figure is an example of signal timing diagram

The period of traffic lights is generally 25s ~ 120s, and the signal setting period is too short, which is not conducive to driving safety. The setting period is too long, and the delay time of vehicles is too long. On the contrary, it will lead to traffic congestion on the road.

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