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A coordinated signal control method for arterial road of adjacent intersections based on the improved genetic algorithm☆

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ABSTRACT

To reduce the vehicle delay effectively, a coordinated signal control method for arterial road of adjacent intersections has been proposed, which is based on the genetic algorithm improved. The method takes the signal coordinated control system for arterial road of adjacent intersections as the research object, by analyzing the signal states encountered by the head and tail of fleet before the crossing of the arterial road, and adopting the minimum total delay of waiting queue team as the performance index, to establish the coordinate control system optimization model for arterial road, in which a cycle length, signal timing and phase difference are optimization parameters. And the method introduce minimum spanning tree clustering idea to improve the defects of the standard genetic algorithm (Standard Genetic Algorithms, SGA), and then optimizes the aforementioned the coordinate control system optimization model for arterial road. The experiment shows that the results obtained by the improved genetic algorithm are better than the ones obtained by standard genetic algorithm and traditional algebraic method respectively.

1. Introduction

The traffic jam in cities is increasing, and the signal control of intersection is particularly important, especially for the main roads with larger vehicle flux. So the traffic jam can be effectively alleviated by the reasonable coordination and control of traffic signal. There are two traditional methods for road intersection signal control, graphic method and numerical method [1], which both regard the maximum width of green as the goal to solve and control. The numerical method has been wildly use in some road system design [2,3] as a most-used method of numerical calculation, but in the calculation process, factors considered were too little, and signal of solution obtained cannot get good effects in control; although the graphical method is simple and intuitive, it is quite limited. It is usually used in the case of two or less than two decision parameters.

Aiming at the problems of the traditional methods for trunk road coordination control, many scholars have studied and proposed various models and intelligent control algorithm. Wang Jin [4] and Liu Guangping et al. [5] respectively proposed

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their own calculation model and verified the accuracy of the model, however, they did not establish a perfect model of traffic control. Although Lu Kai [6] and Gu Yuanli [7] established the control model, the optimization method has to be improved.

In this paper, the method of coordinated control for the main roads in the adjacent intersections is established with the total delay as the performance index, and which adopts the improved genetic algorithm as the optimization algorithm. At the same time, this method regards the period length, signal timing and phase difference as parameters to optimize and solve. Finally the results obtained by the optimization algorithm are compared with the ones obtained by a simple genetic algorithm, which verified that the model of the arterial coordination control established in this thesis and the improved genetic algorithm used to optimize are effective and reasonable.

2. The model of trunk road coordination control

2.1. Model hypothesis

In view of the common two phase (straight line phase) design method, a traffic control model is established for the main road coordination control system of adjacent intersections.

Assume that: the phase transition does not take into account the signal loss time; without considering the vehicle condition, the vehicle arrival rate is a fixed value, and the vehicle arrival time is guaranteed; the factors such as drivers and pedestrians are not considered.

2.2. Establish the mathematical model

In this section, a mathematical model is set up for the adjacent intersection system which is shown in Fig. 1, then we analysis and calculate the delay time from crossing A to crossing B. Assume that the moment when the first green lights at the first phase of the cross A is the 0 moments, in accordance with the signal state which the head and tail of the release team from the upstream intersection A reach the downstream intersection B, as well as the lower reaches of the B in the release period whether to reach the equilibrium point, the blocked situations of down fleet are divided into 14 cases.

When the head of the team to reach the intersection B encountered the first red light (regard the moment that the green lights at the intersection A as 0 moments, the first red light is the state that signal lamp is red for the first time on the corresponding phase after 0 moments at the intersection B) and the tail of the team to arrive at the junction B encountered second red light (the state that signal lamp is red for the second time on the corresponding phase after 0 moments at the intersection B), the vehicle team reaches the balance point during the released period of junction B green light (reach the vehicle and release the vehicle to reach equilibrium, vehicles can be directly through the intersection). The moment that the head of team reach to the intersection of B and the tail of team reach to the intersection of B and the time interval of green lighting and reaching balance point meet the following conditions. The moment that the head of team reach to the intersection of B:

$$t_1 = \frac{L - L_{chu}}{vl} \in [T - r_B, T]. \tag{1}$$

The moment that the tail of team reach to the intersection of B:

$$t_2 = t_1 + \frac{N_{AB}}{q_0} \in [T + g_B, T + C]. \tag{2}$$

Time interval of green lighting and reaching balance point:

$$x = t - T = \frac{n_1 + q_0 * (T - t_1)}{s_d - q_0} < g_B. \tag{3}$$

Among that, L is the distance between two intersections. L_{chu} is initial queue length that the team reach to the downstream intersection of B. vl is the free-flow speed of vehicles. N_{AB} is the total vehicle number which release from the intersection of A, and $N_{AB} = s_d * g_A$, s_d is saturation volume rate (release rate). q_0 is vehicle arrival rate. g_A is green time on the upstream intersection of A. g_B is green time on the downstream intersection of B. r_B is red time on the downstream intersection of B.

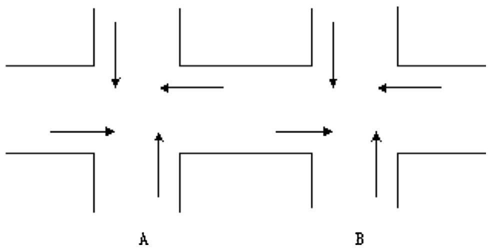

Fig. 1. The adjacent intersection diagram.