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Intersection signal control multi-objective optimization based on genetic algorithm

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Abstract: A signal control intersection increases not only vehicle delay, but also vehicle emissions and fuel consumption in that area. Because more and more fuel and air pollution problems arise recently, an intersection signal control optimization method which aims at reducing vehicle emissions, fuel consumption and vehicle delay is required heavily. This paper proposed a signal control multi-object optimization method to reduce vehicle emissions, fuel consumption and vehicle delay simultaneously at an intersection. The optimization method combined the Paramics microscopic traffic simulation software, Comprehensive Modal Emissions Model (CMEM), and genetic algorithm. An intersection in Haizhu District, Guangzhou, was taken for a case study. The result of the case study shows the optimal timing scheme obtained from this method is better than the Webster timing scheme.

Key words: intersection traffic signal control; multi-object optimization; genetic algorithm; microscopic traffic simulation; CMEM

1 Introduction

Signal control intersection is one of the most important elements of the urban transportation network. Its timing plan would influence traffic efficiency in that area. Thus, many scholars have been interested in studying the traffic signal timing for years.

Tradition signal timing method is the Webster model, which is based on minimizing traffic delay to calculate the timing plan (Dion and Hellinga 2002). With the growth of automobile, the Webster model cannot satisfy actual situation. So, Lots of researchers developed various signal timing methods to meet the demands (Ceylan and Bell 2004; Chen et al. 1997; Yang et al. 2001). Recently, an increasing number of fuel and air pollution problems in transportation draw many scholars' attention. Therefore, more and more scholars attempt to optimize the timing plan to reduce the fuel consumption and emission of traffic flow in the area. Kwak et al. (2012) used fuel consumption and emission of vehicles as criteria to assess timing plan of intersection and optimize the timing plans of four intersections on a major road. Zhang et al. (2010) combined urban microscopic traffic simu-

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lation model and IVE model to analyze the efficiency of the intersection and vehicle emission. Although these studies have tried to optimize the timing scheme for diverse objects, there are few researches which could combine different objects to optimize timing scheme.

In this paper, an genetic algorithm based intersection signal control multi-objective optimization is proposed. This method can search for a timing scheme which reduces vehicle emissions, fuel consumption and vehicle delay simultaneously at an intersection. To reach this goal, this method integrates the Paramics microscopic traffic simulation software, Comprehensive Modal Emissions Model (CMEM), and genetic algorithm. Additionally, an intersection economic evaluation model is established to evaluate the timing scheme of intersection.

This paper is organized as follows: firstly, the methodology of the multi-objective optimization is introduced. Secondly, the intersection used for the case study and the case study results are illustrated. Finally, the conclusions of this study are presented.

2 Methodology

The intersection signal control multi-objective optimization contains three parts: part 1, vehicle emission and fuel consumption simulation; part 2, intersection economic evaluation model; part 3, genetic algorithm optimization. The relationship between these three parts is illustrated in Fig. 1. Vehicle emission and fuel consumption simulation and intersection economic evaluation model are referred to simulation and evaluation model for short respectively.

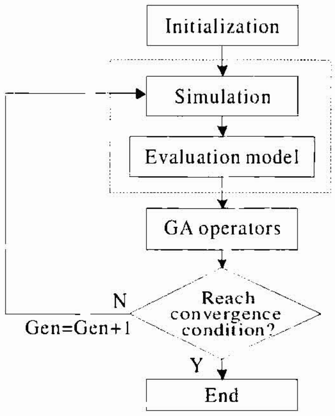

Fig. 1 Structure of multi-objective optimization

In Fig. 1, the optimization method is established on a genetic algorithm framework. Part 3, the genetic algorithm optimization, is the main structure of this method. Part 1 and part 2 are embedded into the genetic algorithm framework to evaluate candidate timing schemes.

2.1 Vehicle emission and fuel consumption simulation

The simulation of vehicle emission and fuel consumption is used to obtain vehicle emission, fuel consumption and vehicle delay at intersection.

This part is established by combining Paramics microscopic traffic simulation software and CMEM microscopic emission model. When Paramics simulates the traffic running status at an intersection, CMEM model could calculate the vehicle emission and fuel consumption in the whole network at the same time.

The way to integrate Paramics and CMEM is to write a Paramics plug-in program of CMEM model and call it during the traffic simulation process. Moreover, because Paramics classifies vehicles according to the sizes of actual traffic flow, while CMEM further subdivides them according to their emission standards, the use of catalyst and other emission related attributions. Obviously, their vehicle categories are not the same. In order to find the corresponding CMEM calculation module for each vehicle in the Paramics network, the mapping relationship between the vehicle types in Paramics and CMEM should be established. So, the optimization method here subdivides the vehicle types of Paramics according to the classification criteria of CMEM and then resets the vehicle categories in Paramics software to build the mapping relationship.

After finishing the procedures above, the simulation of vehicle emission and fuel consumption is established. When the traffic simulation of the signalized intersection is over, this part would output vehicle emission, fuel consumption and vehicle delay of intersection.

2.2 Intersection economic evaluation model

The intersection economic evaluation model utilizes comprehensive economic cost to evaluate signal tim-