博士論文（要約）

Route Guidance System for Reducing Travelling Time by Personalized Rerouting of Vehicles in Urban Road Traffic Network

（走行ルートの動的な車両別変更によって都市道路交通網における車両走行時間の短縮を図るルート案内システム）

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Urban road traffic congestion has been a severe problem for years. This research proposes a novel preventive RGS with personalized rerouting to tackle the problem of traffic congestion in urban areas. The mechanism of the proposed RGS is to provide route guidance to drivers when traffic congestion is predicted, and differentiate the route guidance that is given to vehicles to prevent triggering secondary congestion on detour routes.

Three major technical issues, i.e., short-term traffic amount prediction, average speed estimation, and vehicle ranking, were addressed in this research in order to achieve the final goal of reducing average travel time. Two urban traffic amount prediction models and one average speed estimation model were firstly proposed based on microscopic modeling approaches, which are suitable for the studies in urban traffic network and distinctly differ from existing models that are based on macroscopic modeling approaches. Real traffic data are used to evaluate the prediction or estimation accuracy of the proposed models by comparing them with existing models. The results demonstrated that both of the proposed traffic amount prediction models significantly reduce prediction error by up to 52% and 30% in the best cases. The first model works better when guidance update interval is not long, while the second one demonstrated opposite feature. Therefore, the former is more suitable for the proposed RGS and thus is used in the implementation of the proposed RGS afterwards. With respect to the travel speed estimation model, it consistently led to lower errors than the widely used Greenshields' Model (GM). By properly selecting the tuning parameter, the proposed model successfully reduces estimation error by more than 50% in the studied urban traffic network. On the other hand, the proposed model also satisfies the practical requirement of speed estimation, as its relative errors are constantly lower than 20%. Furthermore, it was also noticed that GM had the tendency of overestimation, especially when traffic amount on a link was high. The overestimation of speed could give a distorted picture of the traffic conditions. The proposed speed estimation model was used in the implementation of the proposed RGS, while the GM model was used by the existing RGS that is taken as the baseline for comparison.

In order to effectively realize the personalized rerouting, the vehicles that needed to be rerouted should be ranked according to their potential contribution to the reduction in average travel time. The vehicles with higher ranking would be rerouted first and thus have the chance to enjoy better alternative routes. Six ranking criteria were proposed based on three categories of rationalities. The proposed RGS is constructed with the proposed traffic amount prediction model, the average speed estimation model, and a ranking criterion implemented in corresponding module in the system. The evaluation of the vehicle ranking was conducted in line with the performance of the proposed RGS on the system level, as the measures on the effectiveness of the ranking criteria are also the measures of the systematic performance of the whole RGS. Traffic simulations were conducted in a small proportion of London traffic network with traffic demand of approximately a thousand vehicles.

The effect of tuning parameters, including congestion threshold, selection level, and guidance update interval, were firstly investigated to decide the proper values for these parameters. The results show that {0.7, 3, 60s} is a set of proper values for the parameters in the studied scenario, as they not only leads to satisfactory performance of the proposed RGS in terms of reducing travel time, but also offer good trade off among other potential benefit, such as travel distance and rerouting frequency. It is also noticed that ranking vehicles according to their distance to the destination generally yields good outcome in all cases.

With the above values of parameters and the ranking criterion, the performance of the proposed RGS is then compared to an existing one on both macroscopic and microscopic level. On the macroscopic level, the proposed RGS not only successfully reduces the average travel time by 22%, but also leads to shorter average travel length. Besides, 40% less vehicles are involved in rerouting in the proposed RGS, and the average number of rerouting for each rerouted vehicles is reduced from 6.8 times in the existing RGS to only 1.6 times in the proposed one. Performance analysis on microscopic level further indicates that the advantages of the proposed RGS over the existing one may primarily come from the vehicles that are rerouted in both RGS and the vehicles that are rerouted in the existing RGS but not in the proposed one, which in total takes up 77% of all the vehicles. It is also found that most of the rerouted vehicles are benefited from the personalized rerouting in the proposed RGS, especially if they would also have been rerouted in the existing RGS. Some of the non-rerouted vehicles in the proposed RGS are also benefited from the rerouting of other vehicles, especially if they would have been rerouted in the existing RGS.

The travel time of each individual vehicle in the proposed RGS is also compared to that of the same vehicle if no route guidance is given. The results show that 77% of the vehicles save travel time when they follow the personalized route guidance, and in total 66% of the vehicles save more than half of their travel time. In other words, among all the vehicles that save travel time, 85% of them in fact save more than half of their travel time. The personalized route guidance also has strong impact on the distribution of travel time of all vehicles in the traffic network. Compared to the distribution of travel time in the case where no guidance is given, the distribution of travel time in the proposed RGS is more centered to the left, which means that if a driver follows the personalized route guidance received, there is high probability of spending less time traveling and arriving earlier to the destination. This benefit may give incentive to drivers to comply with the personalized guidance that they received from the proposed RGS.