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主 論 文 の 要 旨

論文題目　**Short-term Link Travel Time Prediction and Intersection Priority Control for Urban Traffic Control and Management System**
(都市交通制御および管理システムのためのリンク所要時間の短期予測と交差点優先順位制御に関する研究)

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論 文 内 容 の 要 旨

Traffic congestion has bothered people for a long time since motorization and urbanization took place in many cities around the world. Traffic congestion results from the imbalance between traffic demand and supply, so many governments used to construct more roads to meet the increasing traffic demand. However, it turned out to stimulate more congestion on the road. With the rapid development of computer and sensor technologies, decision-makers are trying to control and manage the traffic based on the intelligent transportation system (ITS) which shows great potential in reducing the congestion. To handle more and more complicated traffic conditions, many researchers devoted their efforts to expand traffic control and management from the real-time into the future and from highways to urban networks.

This study contributed to an ITS-based traffic control and management strategy which dynamically controls the priority at the intersection and employs short-term urban link travel time prediction so that it can catch up with the frequent change in the urban traffic condition. As an important component in modern traffic control and management systems, short-term travel time prediction models are widely studied using probe vehicle data, but the low penetration rate of probe vehicles limits their real-world applications in highways and urban arterials. Therefore, this study proposed non-parametric models to enhance the coverage rate of the prediction under the low data penetration rate and expand the prediction horizon so that they can be applied on the whole urban network in the real world. When the study site changes from the highway to the urban network, the traffic condition becomes more complex. It is more doable to solve the congestion problem over a small scale where the traffic condition has a similar characteristic instead of reducing the congestion on the whole network. Therefore, the intersection which is the main potential bottleneck of the urban network attracts our attention. This study proposed a strategy to dynamically determine the priority of each incoming link at the intersection to reduce the congestion. Three main sections were employed to explain the details of this study.

Firstly, this study aimed to relieve the limitation of study sites caused by the low data penetration rate when predicting short-term travel time at urban networks. It was realized through a non-parametric model which is based on Bayes' theorem under a "prediction-resampling" structure. To predict the travel time for a link, most previous approaches used data only from vehicles on the target link. In contrast, the proposed model in this study considered data from vehicles in the crossing direction. With the data from both directions, the coverage rate of an application using the proposed model can be expanded, especially when the data penetration rate is low. Besides, the signal pattern was estimated through the utilization of relationships between vehicles in both directions. The proposed model was evaluated in a computer simulation to test its robustness and reliability under different data penetration rates. The results implied that the proposed model has a high coverage rate and stable and acceptable performance at different penetration rates.

Secondly, this study further expanded the prediction horizon of the proposed model mentioned above, which can only make predictions within a signal cycle due to its short time interval and expensive computational cost. To make multistep predictions into a longer future, most research chose to aggregate probe data to obtain useful samples when the penetration rate is low. However, the aggregation of probe data can only provide a general description of the travel time, which cannot capture changes in travel time during a short time interval. To overcome this limitation, a non-parametric model using disaggregate probe data based on dynamic time warping was developed. Besides, instead of estimating the signal pattern, data from the target link were separated into different signal phases by the data from the crossing direction. A classical k-nearest neighbor model and a naïve model were compared with the proposed model. The models were tested using the same computer simulation data. Moreover, data from two real-world cases in Nagoya, Japan were also used to evaluate the models. The results showed that the proposed model outperforms the other two models under different data penetration rates because its utilization of vehicle data is more efficient.

Lastly, to find out a practical method which can reduce congestion on the urban network in the real world, attention is concentrated on small but easy-congested locations such as the intersection. This study combined the link transmission model and a local linear programming formulation to dynamically determine the priority of each incoming link at each intersection on the urban network. This model provided a local optimum solution for the traffic congestion so it can be added to other approaches that have different global objectives. The proposed model and models using other intersection priority strategies are tested by simulation data. Results showed that the congestion level in the proposed model was lower than other models, while the travel cost remained similar.