Development of Dynamic Traffic Simulation System for Tokyo Metropolitan Expressways and Its Future Prospects

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【Abstract】
Tokyo Metropolitan Expressway (MEX) extends approximately 300 km and forms a large road network that carries approximately one million vehicles per day. Although traffic congestion has recently tended to be reduced as a result of the expansion of the road network, it has not completely been solved because vehicles are concentrated in certain time zones and incidents frequently occur, such as traffic accidents (at least 30 incidents per day). Travel time information with the aim of reducing traffic congestion and improving the services for drivers is provided on MEX. Currently, the instantaneous travel time on MEX calculated on the basis of real-time data is provided to drivers and its accuracy is relatively high. However, when the traffic congestion suddenly expands owing to traffic accident, the provided instantaneous travel time may become greatly different from the experienced travel time of the driver. A solution for this problem is to predict future traffic conditions. Since 2005, Metropolitan Expressway Company Limited started to develop a dynamic traffic simulation named Real Time Traffic Information by Dynamic Simulation on Urban Expressway (RISE). In 2009, the RISE was connected to the Traffic Control System (TCS) of MEX, and since then, it has been continuously operated on a trial basis. In this paper, we explain the outline of the RISE and its future prospects.

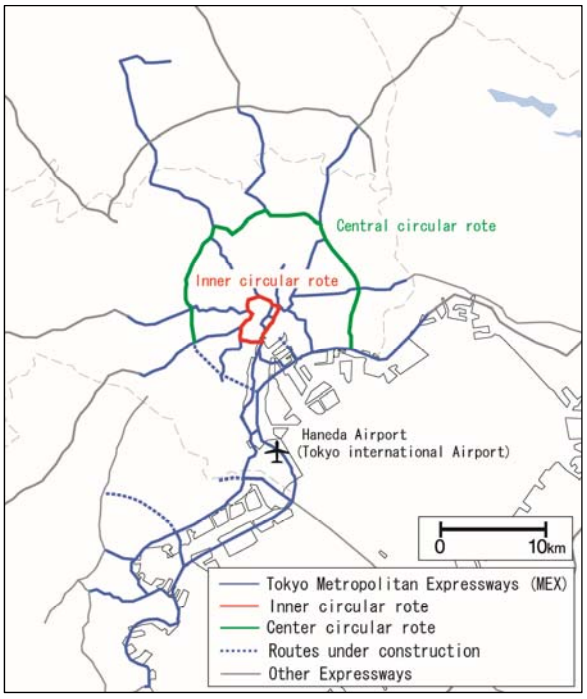

Figure. Tokyo Metropolitan Expressway Network

Firstly, the RISE outputs the traffic situation prediction results of two hours ahead at 5 minute intervals and consists of four modules. The features of the RISE are as follows.
(a) Online data from vehicle detectors densely installed on MEX (approximately 300 m intervals) is imported.
(b)The input data is prepared from a large database, including past data accumulated over a long period (those from vehicle detectors and related to accidents) and electronic toll collection origin-destination (ETC-OD) data (the rate of using ETC on MEX exceeds 90%).
(c)The incident management module is implemented to consider the effect of frequent accidents.
Here, we explain the incident management module in detail.

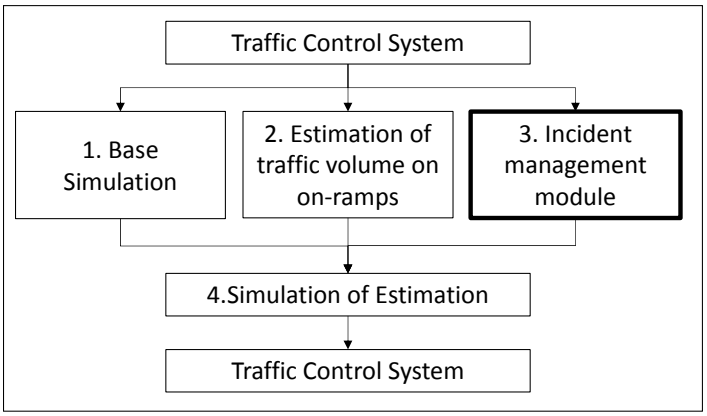

Figure. RISE flow chart

The incident management module consists of four submodules and mainly targets accidents.

The first submodule is used to estimate the period of lane closure. On the basis of accident information registered in the TCS, the period of lane closure is estimated by statistical analysis. The initial value is set to 50 min, which is the median of the period of lane closure among all accident cases, and the period of lane closure is updated in accordance with the updated accident information, such as (1) the presence of fire engines and ambulance cars, (2) the presence of emergency service vehicles, and (3) the number of vehicles involved in the accident.

The second submodule is used to estimate the traffic capacity under lane restriction. For the section with accident information registered, whether traffic congestion occurs or not is judged. When there is traffic congestion, the degraded traffic capacity is set as the traffic capacity of the link. When there is no traffic congestion, the traffic capacity of the link is set in accordance with the number of closed lanes.

The third submodule is used to estimate the variation in the on-ramp traffic volume. Here, a pattern table for the relationship between the accident point and the rate of variation in the on-ramp traffic volume is used. When an unusual on-ramp traffic volume is detected for an on-ramp that is considered to be affected by the accident, the on-ramp traffic volume in the pattern table is modified to a lower or higher value for the estimated period of lane closure.

The fourth submodule is used to estimate the diverted traffic patterns on the off-ramps. Here, a pattern table for the relationship between the accident point and the range of diverted traffic patterns on the off-ramps is used. When an unusual off-ramp traffic volume is detected for an off-ramp that is considered to be affected by the accident, the destination in the pattern table is changed into a different one.

Next, the method of analyzing the effect of the incident management module is explained. In the case of accidents, the accuracy of the RISE when each submodule is implemented and operated is estimated and compared with the accuracy when none of the four submodules are activated as the reference. The accuracy is evaluated using the travel time as the index (whether the estimated travel time is within ±10 min of the true travel time calculated using the time slice data from vehicle detectors). The results show that the accuracy is only 17% in the case without the incident management module, whereas it increases to 71% when the submodules for estimating the period of lane closure and the traffic capacity are implemented. The accuracy further increases to 83% when the submodules for estimating the variation in the on-ramp traffic volume and

the diverted traffic patterns on the off-ramps are implemented. Therefore, it is demonstrated that the incident management module is indispensable for predicting short-term future traffic conditions on MEX in real time.

Finally, we describe the future prospects of the RISE.

Addition to the accuracy improvement, for maintenance simple, automatic adjustment of the parameters is required as TCS, but solutions will not be found in a short period of time. Recently, we have examined a new method of utilizing the RISE. It is to support the improvement of efficiency in traffic control works, such as the evaluation of the effect of traffic restrictions arising from road construction, as an in-house utilization. This offline utilization highlights the advantage of the RISE of providing past data without the step for reproducing the situation of that time.

In the future, we will further improve the accuracy of the RISE and at the same time examine new methods of utilizing the system to enable early full-scale operation and utilize the predicted traffic information in a stepwise manner.

References

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