TRAFFIC MODELLING AND EVALUATION ON URBAN NETWORKS

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Traffic modelling and management on urban networks has attracted much attention recently due to its importance in reducing traffic congestion, increasing transport system efficiency and transport safety control. Compared to motorways, there has not been much research conducted on urban street traffic due to the complexity of urban traffic dynamics and lack of relevant data. With the advancement of technology, new detection facilities are used in the transport system such as the Global Positioning System (GPS), on-road Inductive Loop Detectors (ILDs), probe vehicles and Automatic Number Plate Recognition (ANPR) system which provides us more support for traffic modelling on urban networks. The objective of this paper is to investigate how different traffic models perform in traffic modelling on urban networks such as travel time estimation and thereby in further traffic evaluation and prediction on urban networks.

Different kinds of traffic models including both macroscopic and microscopic ones have been developed for traffic evaluation. In this study, macroscopic models Deterministic Queuing Model (DQM) and Cell Transmission Model (CTM) are applied in traffic modelling and evaluation. Specifically, Deterministic Queuing Model (DQM) is a point-queue model while Cell Transmission Model (CTM) is a physical-queue model. Deterministic Queuing

Model decomposed travel time into free-flow travel time and delays at intersections and is applied under the situation where the traffic demand is given. In Cell Transmission Model, a link is discretised into many cells numbered i (0, 1, …. , n) from upstream to downstream and every cell has many parameters, inflow, outflow, density, speed and so on. Under light traffic condition, the inflow is the traffic demand for every time step and the outflow depends on the inflow; under heavy traffic condition, given the time step t, cell traffic demand is determined by outflow from upstream cell rather than inflow. This paper compared DQM and CTM in various aspects, including the underlying theory, data requirement and parameter calibration.

To test the performances of DQM and CTM in the real world, a case study is conducted on Tottenham Court Road in central London with Split Cycle Offset Optimisation Technique (SCOOT) data and Automatic Number Plate Recognition (ANPR) data. Until now, there are around 3,000 intersections operating under the Split Cycle Offset Optimisation Technique (SCOOT) system in central London and about 500 cameras for enforcing various transport policies like congestion charging and low emission zones. In this case study, travel time estimation is used as the main evaluation metric. When applying DQM and CTM on this network, we use the real-time signal timing and cycle traffic demand in the models to estimate travel time and most of parameters are calibrated from the same database. We also coordinate the free-flow speed to minimise the gap between model estimation and records from LCAP system. It is concluded that the average speed on the arterial changes with traffic flow volumes instead of fixing at the free-flow speed. Therefore, DQM and CTM take advantage of the detection data to the full.

Through theoretical analysis and empirical study, it is found that CTM and DQM give the same estimation under light traffic circumstance and CTM is more precise in heavy traffic estimation. In addition, the pattern estimated using individual vehicle simulation is consistent with that estimated by average delay. Lastly, DQM is more efficient in model implementation than CTM. In conclusion, DQM and CTM should be combined to give the best performance with the lowest cost. Different from other relevant studies, this paper uses real-time traffic demand profiles and real-time signal timing as the data inputs and uses ANPR travel time as the benchmark, which provides insights into the actual situation.

In terms of applications, travel time estimation has many functions, not only in traffic evaluation, but also in new transport services such as Intelligent Transport System. Intelligent Transport System (ITS) is developing very rapidly over the last decade and travel time estimation is required to support many of the existing and potential ITS services. In addition, travel time estimation is an important indicator of road network performance. So travel time estimation is widely used by both network operators and the travelling public. Furthermore, the applications of DQM and CTM are not restricted to travel time estimation. Reserve capacity is an indicator used to evaluate the capacity of the road network. It is found that the reserve capacity of Tottenham Court Road is 1.2~1.3. As we all know, sometimes one section of the road network is closed for some period of time due to incident and it will influence the normal movement of traffic on the network. Therefore, quantifying the influence of the incident is very important in the traffic evaluation and corresponding management. It is found that even the closure of one lane on one section of Tottenham Court Road will lead to significant delays after the incidents happen. Following the framework in this study, DQM and CTM can be applied in different network configurations for traffic modelling and evaluation. The various applications discussed in this study could deal with many problems regarding congestion on urban networks.

Due to some limitations of this study, in the future work, the calibration of some parameters such as saturation flow and jam density should be improved using field data. In addition, the future work will focus on the model testing on more complicated networks in central London and the testing of other traffic models.