An Arrangement of Benchmark Dataset for Model Validation in CO2 Emission Volume Estimation

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Abstract:
As global warming has become one of the major issues in recent years, reliable methodologies to estimate CO2 emission volume using traffic simulation models and emission models are highly demanded. To meet this demand, we proposed a validation framework for CO2 estimation methodologies to ensure their reliability.Then we conducted a comprehensive field data collection in an urban street in Tokyo, which can be used not only for traffic simulation model validation but also CO2 emission model validation. It recorded the number of all the passing vehicles, vehicle travel time, signal change timing, individual fuel consumption and so on. The collected data was applied to a set of models to check the validity of CO2 volume estimation.

Keywords: benchmark dataset, model validation, CO2 emission

1. Introduction

There is a growing concerns in the global warming issues all over the world. As road transportation is one of the major source of CO2 emission, it is highly demanded to establish reliable methodologies to estimate CO2 emission volume from vehicle traffic in order to make effective countermeasures. Therefore a lot of efforts have been made to develop models for CO2 emission estimation. Here, the scope of the evaluation is usually different depending on the purposes and then it is difficult to use a common model. It is generally preffered to use customised or self-developed models, and as a result, a lot of models are developed which are not compatible each other. It is very hard to determine one unified model.

Considering this situation, we are proposing a framework of evaluation which is applicable to various different models. The basic concept is not to determine a specific model but to set a common validation scheme. This paper introduces the outline of this framework and the concept of the validation process. Then, a comprehensive field data collection to arrange a benchmark dataset which plays an important role in the framework is explained. And finally, a demonstration of model validation is shown using this dataset.

2. Proposed Framework

There are already a lot of models to estimate CO2 emission volume by various developers. Each model has different characteristics such as scale, resolution, input/output variables, parameters, sensitivity, and so on. Model users also choose models from a lot of candidates to satisfy their requirements. Therefore, it would be almost impossible to select only one model which can be universally used in any types of evaluation.

On the other hand, the result of the evaluation sometimes leads to conflicts of intersets among countries/regions, so it is very important to gurantee the reliability to facilitate international discussions. If only one unified model is used for all cases of evaluation, we can easily examine the validity of the model in a obvious way. However, we have to consider a lot of models in reality, and the internal mechanisms of them are usually unknown to other users. Then it becomes a challenging issue to show the reliability of the result from different models.

To cope with this situation, we would like to propose a framework which does not specify a certain model but set a common validation scheme. Figure 1 shows the concept of this framework. Every model can be developed by different developers depending on its scope, but it has to pass the common validation process and disclose the result of the validation. Here, the common validation scheme should be determined to meet the requirements through the international discussion and agreement. Then model users can choose a set of models which is suitable for their interests based on the disclosed validation results. Through this process, the transparency of models can be guranteed to a certain extent, and we can use the results of the model as a reliability ones.

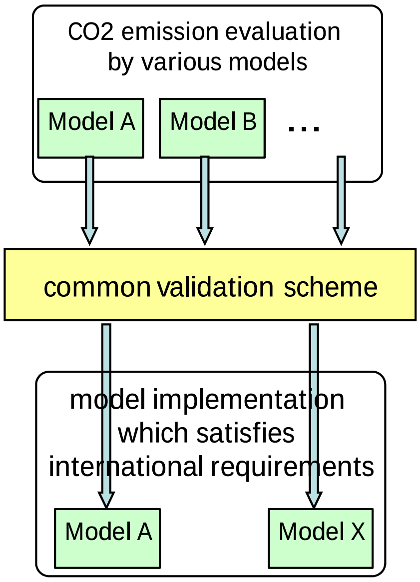

Figure 1: Framework for Model Validation

3. Data collection and Arrangement

To realize the common validation scheme, it is necessary to prepare benchmark datasets which will be commonly used to validate various models. For this purpose, we conducted a field survey and collected data comprehensively in an urban street in Tokyo.

3.1 Survey Area and Time

To set the location and time of the survey, the following things were considered.
- The data should include various stop/start patterns.
- The section should include a bottleneck intersection.
- The survey time period should include the beginning and the end of the traffic congestion
- The complete number of vehicles should be observed and counted including minor access roads and parkings.
- The data should be recorded on the second time scale.

Considering these conditions, we set the survey area in the South West of Tokyo downtown, which is densely populated. The survey section (Komazawa-dori) is 1.7 km length and there are 10 intersections along this section. There is a bottleneck intersection near the downstream end of the section. Figure 2 shows the map of the survey section. The data collection was done from 6:30 am to 10:30 am on weekday so that traffic congestion in the morning peak would be observed.

Figure 2: Survey Section

3.2 Data Collection Methods and Items

Data were collected by a couple of differnt measures in order to arrange a comprehensive dataset.

3.2.1 Video observation

Video recording was conducted to collect vehilce volume data at all the intersections along the target section. Multiple video cameras were placed depending on the number of legs of an intersection in order to cover the vehicles exiting from the intersection. Figure 3 shows an example of the alignment.

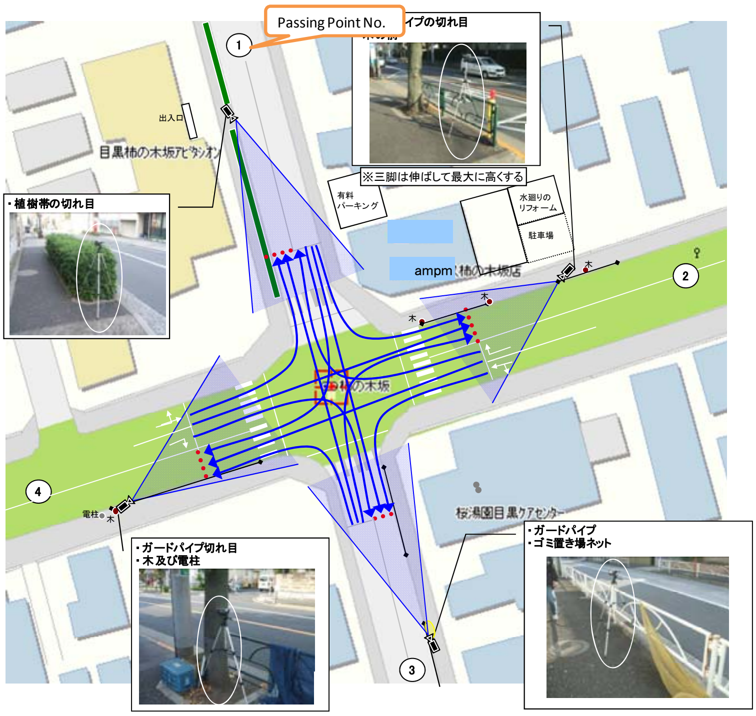

Figure 3: Example of video camera alignment

After the survey, recorded video images were processed and the following data items were extracted from them.

- Traffic volume (by direction, by vehicle type) at each intersection
- Signal change timing at each intersection

3.2.2 Probe vehicle run

To obtain the traffic condition along the section, 13 probe vehicles were prepared including a large truck. They ran through the section in a specified route repeatedly so that they could pass the section every 5 minutes. They were equipped with a logger to record GPS data, vehicle speed and fuel consumption. After processing the recorded data, the following data items were obtained.

- Position of each vehicle at every second
- Speed, acceleration/deceleration of each vehicle at every second
- Average link/section speed
- Average section travel time

3.2.3 Manual recoding

In addition to the above, some other types of data were collected by manual recording as follows.

- Incoming traffic from minor paths (time of enterance)
- Outgoing traffic to minor paths (time of exit)
- Incoming traffic from roadside facilities (time of enterance)
- Outgoing traffic to roadside facilities (time of enterance)
- On-street parking vehicles (time of beginning/end of parking)

- Bus stopping at a bus stop (time of beginning/end of stopping)

3.3 Arrangement as a Benchmark Dataset

The collected data items were processed to eliminate data errors and outliers. Then they were arranged into one package as a dataset together with explanatory documents. As it was supposed to be used as a standard in order to validate newly developed models, it was uploaded to the International Traffic Database (ITDb) to be shared among other model developers. Registered users of ITDb can browse the uploaded datasets through the data repository, and can download them from it. Figure 4 shows how it is stored in the ITDb.

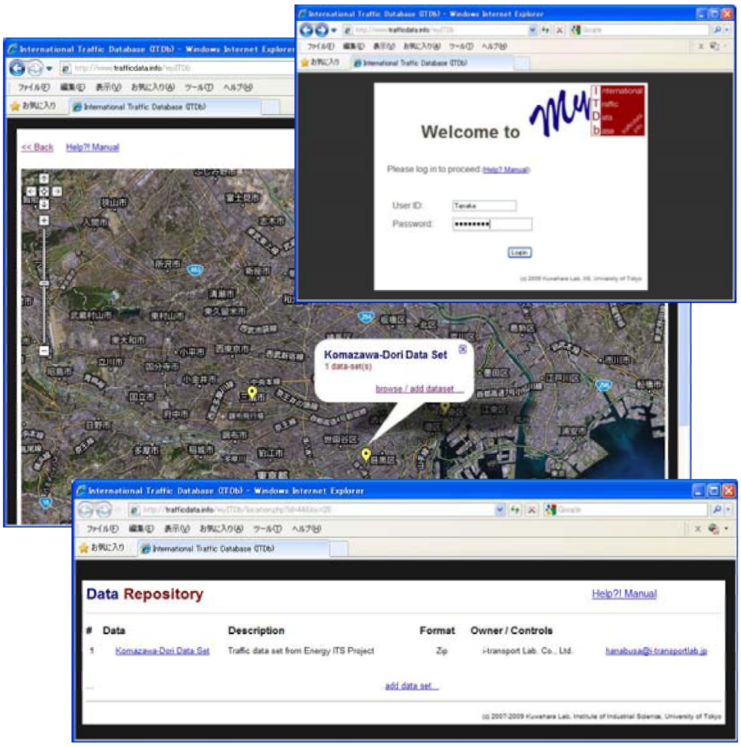

Figure 4: Stored dataset on ITDb

4. Model validation

Using the arranged benchmark dataset, a model validation trial was conducted in order to confirm the feasibility of the proposed validation scheme and process. Here, we examined a set of traffic simulation model and CO2 emission model we developed.

We prepared the same road network as the surveyed area, including 23 zones of origin and destination. OD demand table was given in the unit of 5 minutes and two vehicle types (passenger car and truck) were set. The siganl parameters were also set same as the observed value.

4.1 Traffic Simulation Model

Figure 5 shows a comparison of simulated and measured values of traffic flow in the target section. They are plotted more or less around 45 degree line. Figure 6 shows the transition of the section travel time. Here, measured travel time is obtained from the probe data. Both results shows good correspondences, which means the traffic simulation model can reproduce the traffic condition accurately enough.

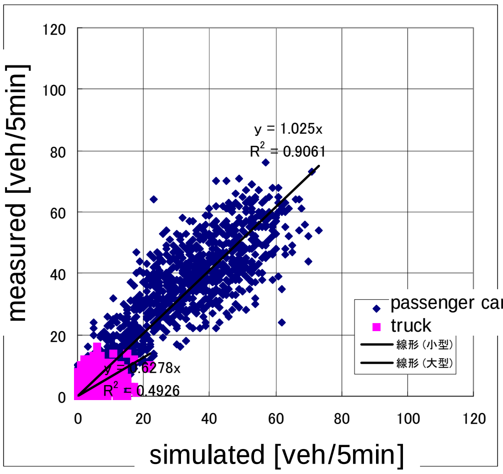

Figure 5: Comparison of the traffic flow

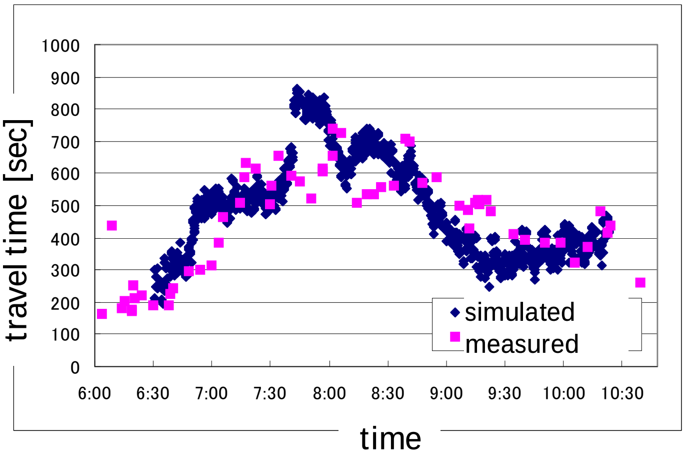

Figure 6: Transition of the section travel time

4.2 CO2 Emission Model

Figure 7 shows the estimated CO2 emission volume from individual vehicles using the results of traffic simulation model. The measured values are obtained from the fuel consumption of the probe vehicles. Note that the number of “measured” plots is less because the vehicle category has to be more finely classified in calculating CO2 emission and then the number of corresponding probe vehicles becomes also limited. Nevertheless, the simulated and the measured values are in the same range, meaning that the CO2 emission model provides reasonable results.

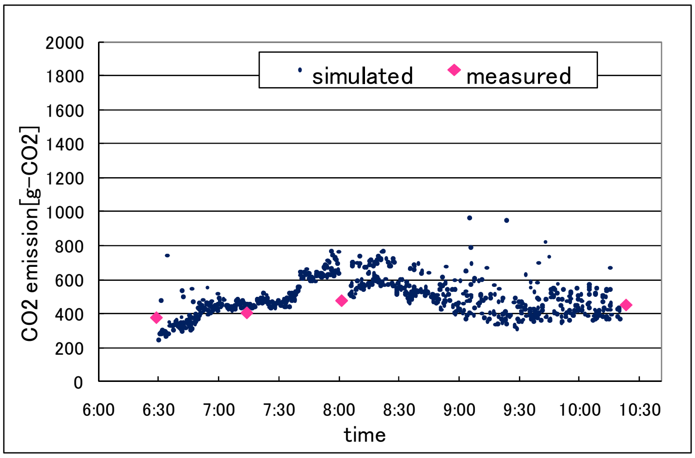

Figure 7: Estimated CO2 emission volume from individual vehicles

5. Conclusion

This paper proposed a common validation framework which can be applied to different combinations of traffic simulation models and CO2 emission models that are used to estimate CO2 emission volume. Then a comprehensive data collection activity to arrange a benchmark dataset and a validation trial using this dataset are shown.

Estimation of CO2 emission is becoming more and more important for policy making, project evaluation and international discussion, therefore we have to establish reliable methodologies for it. Here, validation framework plays a very important role to gurantee mutual trust. And data collection, storage and sharing are essential to support the framework. We have been working on this activity collaborating with other international partners, and would like to expand the framework over the world.

References:

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