Verification for Method of Forecasting Travel Time by Traffic Simulator

[1]Yamakoshi,M and [1]T.Kazama

[1]Kyosan Electric MFG. Co. Ltd., E-mail: m-yama@kyosan.co.jp

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EXTENDED ABSTRACT

A signal control system, outflow traffic information is exchanged between intersections, most suitable signal control parameters are determined autonomously at each intersection, is under examination. We propose a system for predicting expected forecasting travel time, by time-series outflow traffic tables created at 2 intersections at starting and ending points of a link during the process of exchanging the information, and describe the results of an accuracy verification using a traffic simulator.（MITRAM.）Figure 1 shows the principles of predicting travel times proposed herein. At each intersection, the system estimates outward traffic flows from the intersection using information on measurements from detectors, and transfers predicted data to adjacent intersections as time-series traffic flow tables. To estimate traffic outflows, the system also uses time-series traffic flow tables received from adjacent intersections and outcoming signal control parameters of the subject intersection. Travel times are estimated by comparing features that appear in time-series traffic tables created at 2 arbitrary intersections. This system provides advantages in that without requiring a dedicated infrastructure, travel times can be calculated by compiling traveling data for all vehicles, link by link, and that during the process of forecasting outflow traffic from each intersection, the effect of signal control parameters to be incorporated in the future can be added, so compared to existing travel time presumption methods, this system offers merits.

We plan on proceeding with field verification tests and to study for practical applications.

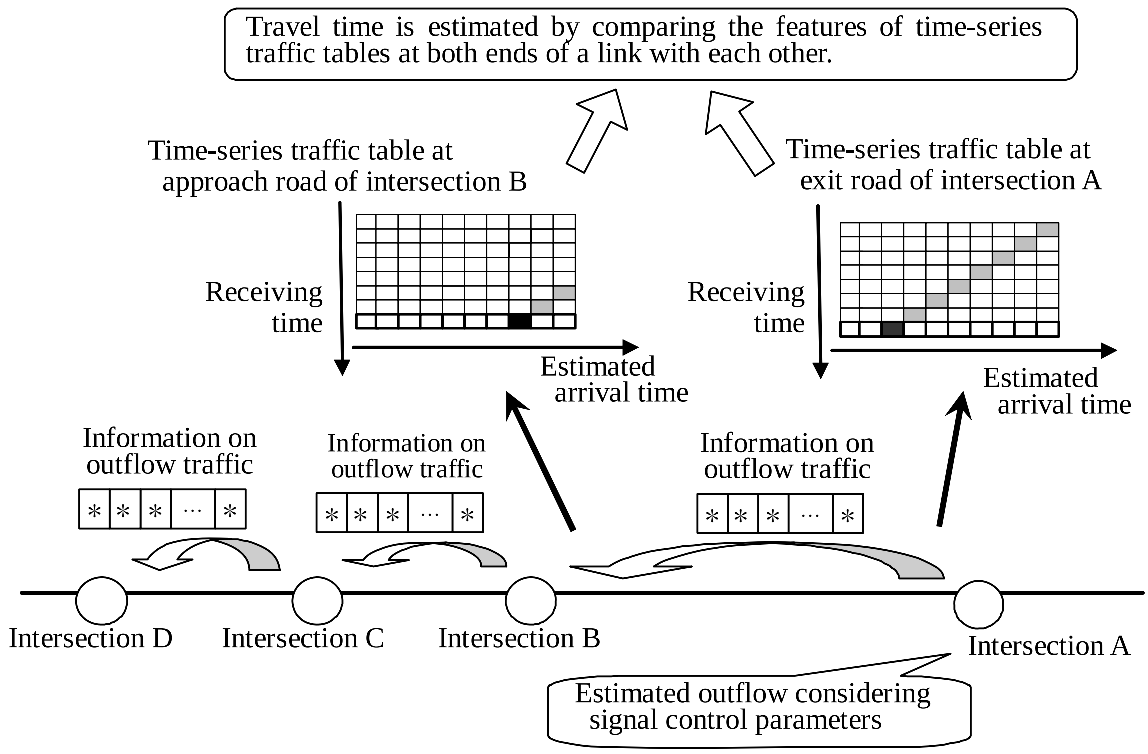

Figure 1. Principles of estimating travel time

1. INTRODUCTION

Normally, information on travel time between upstream point A and downstream point B is provided to users at the upstream point A. In a conventional method of measuring travel time, basically individual vehicle data are matched at two points. In this method, when a vehicle reaches downstream point B, a measurement of travel time is obtained as the time that the vehicle has taken since it passed upstream point A. Therefore, information on travel time, given at upstream point A does not precisely correspond to the timing for a vehicle that received the information upon actually reaching downstream point B. Consequently, if traffic conditions change, a problem occurs with the actual travel time differing from the information provided on travel time.

In the autonomous discrete-type signal control system now under research aiming at practical application, exchanging traffic information between adjacent intersections is examined to compute the most appropriate signal control parameters at each intersection. We propose a method of predicting travel time as traffic information to be exchanged between adjacent intersections, by comparing time-series traffic flow tables created at two points, where the time-series traffic flow table stores estimated outflow traffic from each intersection in a time series, as described below.

In conventional travel time measurements, infrastructure such as vehicle number-reading facilities must be installed to identify individual vehicles, however, according to the main future of a method, travel times can be calculated using only vehicle detectors for controlling signals.

When evaluating such a developed system, and evaluating in the real field, it is actually impossible to carry out the same conditions of exclusion and background data of a disturbance element etc., and objective evaluation is quantitatively difficult for it. Then, it evaluated this time using the traffic simulator.

The used traffic simulator (MITRAM) is a micro simulator which can express the action for every vehicles autonomously using fuzzy operation.

2. PRINCIPLES

2.1. General Description Of Travel Time Prediction

Figure 1 shows the principles of predicting travel times proposed herein. At each intersection, the system estimates outward traffic flows from the intersection using information on measurements from detectors, and transfers predicted data to adjacent intersections as time-series traffic flow tables. To estimate traffic outflows, the system also uses time-series traffic flow tables received from adjacent intersections and outcoming signal control parameters of the subject intersection. Travel times are estimated by comparing features that appear in time-series traffic tables created at 2 arbitrary intersections.

2.2. Creating Time-series Traffic Flow Tables

Time-series traffic flow tables are created in the following 3 steps at each intersection.

Step 1

The system at an intersection receives time-series traffic flow information from adjacent intersections, and estimates vehicle arrival timings for all approach roads at the intersection for up to several minutes thereafter, also using measurements from detectors at the intersection. Vehicle arrival timings are estimated for the period from the present time until several minutes later.

Step 2

Using signal control parameters that are planned to be used at the subject intersection, it is judged at each timing up to several minutes later whether or not there is a right of way. Vehicles are assumed to cause congestion at an inflow road without a right of way, and vehicles on an approach road with a right of way are processed to leave the intersection.

Step 3

As a result of judgments in Step 2, information on outflow traffic from each exit road is created and transmitted to adjacent intersections. Vehicles entering an approach road are distributed to exit roads, according to the characteristic branching ratios of the intersection.

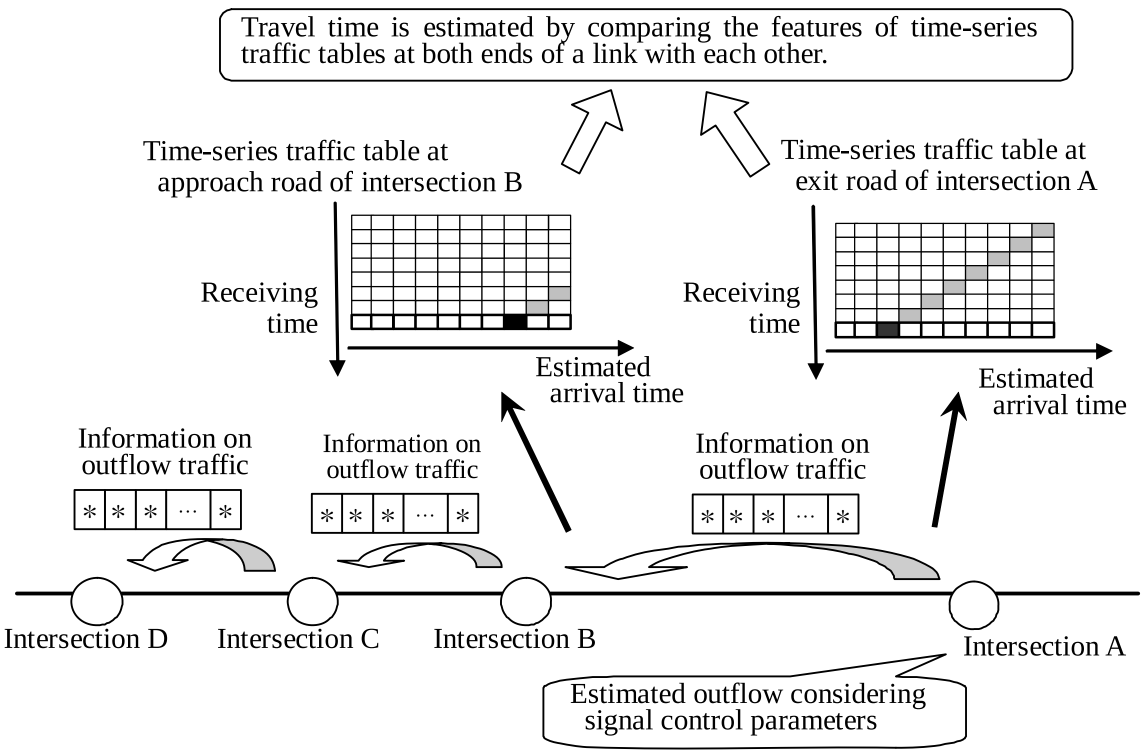

Figure 1. Principles of estimating travel time

2.3. Estimating Travel Times By Comparing Time-series Traffic Flow Tables At 2 Points

A characteristic point in a respective time-series traffic flow table, created at start and end points of a section for which travel times are to be calculated, is defined as the point where traffic volume suddenly increases, and is extracted. As shown in Figure 2, the difference between two characteristic points on the time-series table can be defined as the travel time between the points. The rationale of this definition is that the distribution of traffic flows at an intersection of a trunk road can be represented by a waveform with a peak at the green signal beginning at either intersection, and even after the distribution shifts in the traffic space over time, the original waveform is essentially maintained.

Time-series traffic flow tables created at intersections store the number of vehicles planned to pass from the present time until several minutes later, so the coming movement of vehicle fleets between intersections can be predicted.

	10s	20s	30s	40s	50s	60s	70s	80s	90s	100s
Outflow from intersection A	0	6	10	9	10	7	4	3	0	0
Inflow into intersection B	0	0	0	0	7	9	10	10	6	3

Estimated travel time (30s)

Figure 2. Comparison of characteristic points in time-series traffic tables

2.4. Effects From Signal Awaiting Queues

If an intersection is included in a section subject to travel time prediction, the effects of signal awaiting queues must be added. In a time-series traffic flow table, the leading end of a vehicle fleet appears as a characteristic point. However, if a signal-awaiting queue emerges at the intermediate intersection, the leading-end vehicle before the queue might not always take the leading-end position after the queue. This phenomenon is shown in Figure 3; in the case of signal waiting, a vehicle group arriving at the intermediate intersection is absorbed into the trailing end of the waiting queue. After a signal-awaiting time, vehicles subjected to travel time prediction pass the intersection later than the vehicle group.

The time delay from the leading end of a vehicle group in a signal awaiting queue is proportional to the number of vehicles that have collected at the intersection. Because the saturated traffic flow per lane is 1 vehicle/2 seconds, the time delay due to signal waiting is given by

Time delay due to signal waiting = Number of stopping vehicles × 2 (s)/number of lanes.

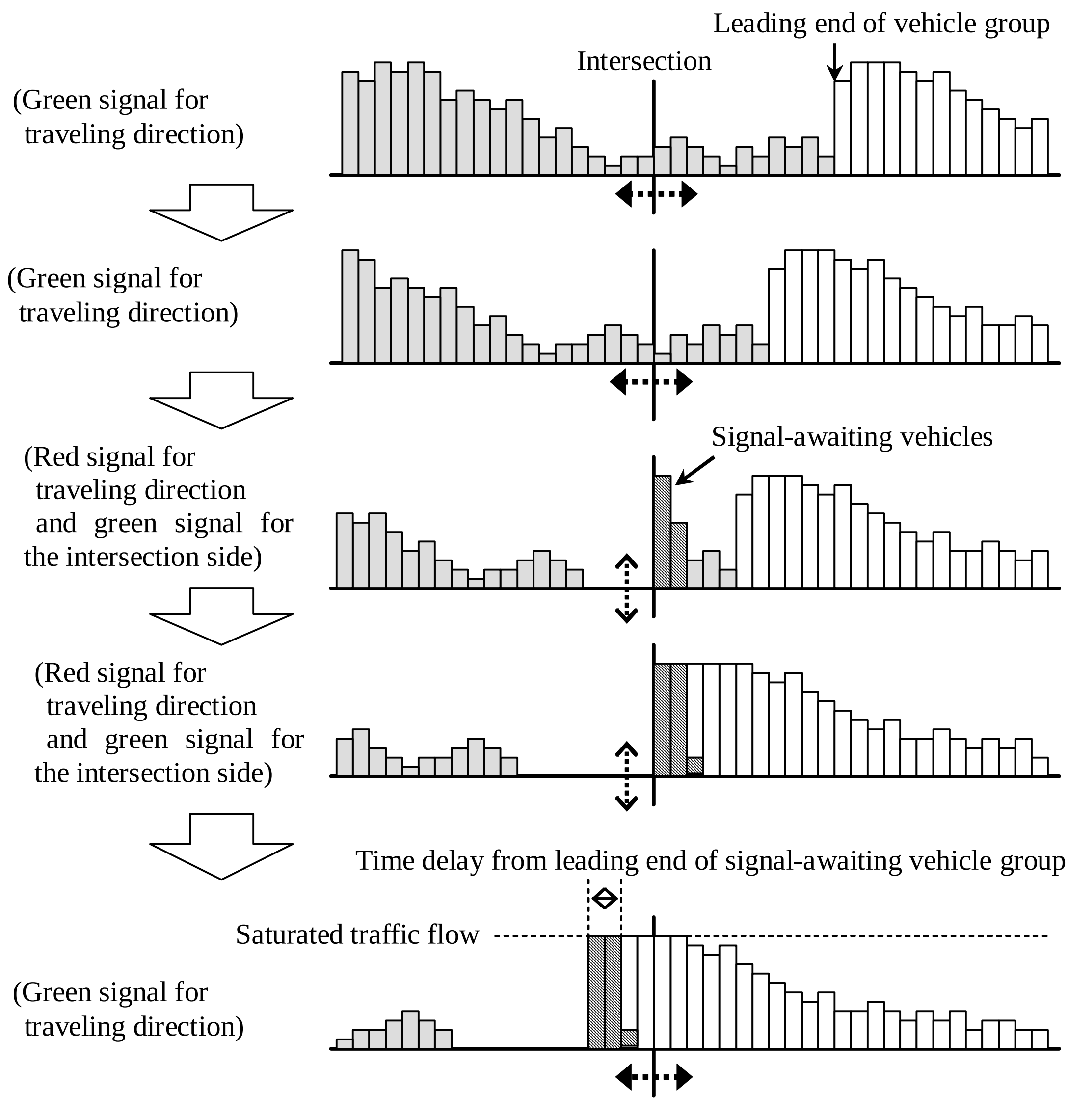

Figure 3. Formation of vehicle group at signal-awaiting queue

3. METHOD OF EXPERIMENT

3.1. Model Line

The model line is shown in Figure 4.
The total length is 2,270m with 7 intersections.

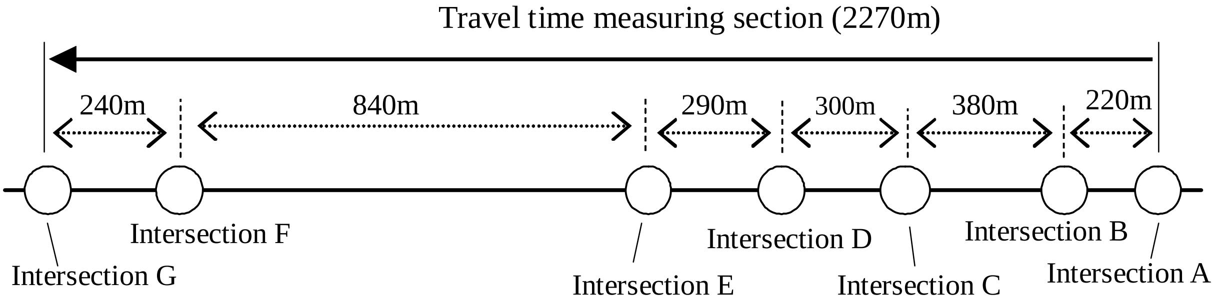

Figure 4. Model line

3.2. Experimental System

The experimental system is shown in Figure 5.
Time-series traffic flow tables were exchanged in the computer between intersections, based on data from the detectors for 6:30 ~ 7:50 on May 13, 2003 on the model line. The time-series traffic flow tables of intersections A, C, E, and G were compared, and travel times for 3 sections were summed up as predicted travel times. The predicted travel time was calculated every 10 seconds, and the mean time for one minute was defined as an estimation.

In the present experiment, data from detectors were collected from the traffic simulator, which was configured with the model line. The traffic simulator used is a micro-simulator of a tracking type, in which the behavior of a vehicle can be represented in terms of speeding up, slowing down, etc. (1) (2) Intersections in the traffic simulator were operated with signal control parameters that were identical to those at the site. The traffic simulator was validated to be capable of simulating traffic conditions that were essentially the same as those at the site.

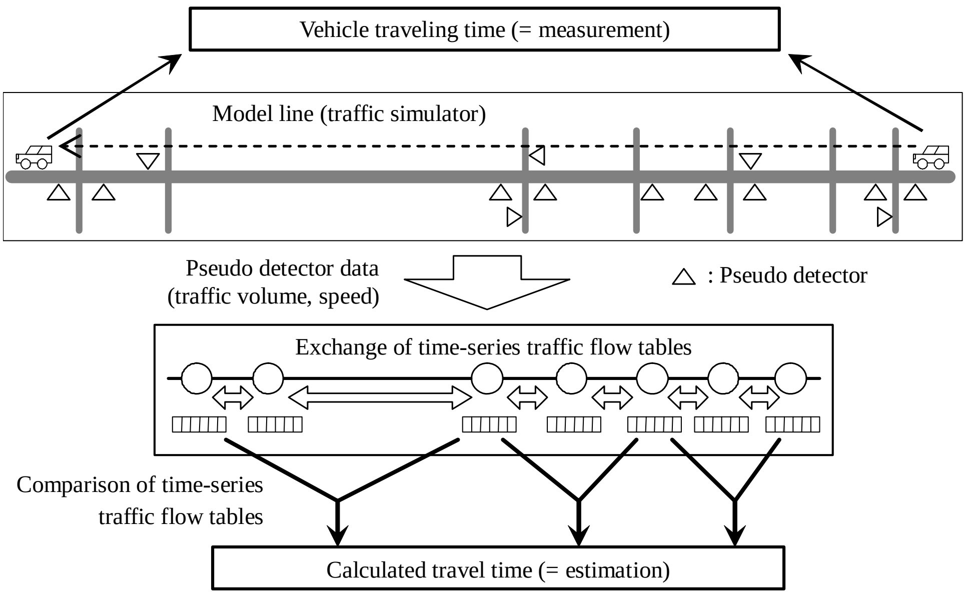

Figure 5. Experimental system

3.3. Results Of Experiment

Figure 6 shows time trends of estimations and measurements of travel time. For measurements, 5-minute mean values were used to avoid variations of travel times among vehicles. Times on the abscissa in Figure 6 were counted from the time a vehicle passed the upstream point.

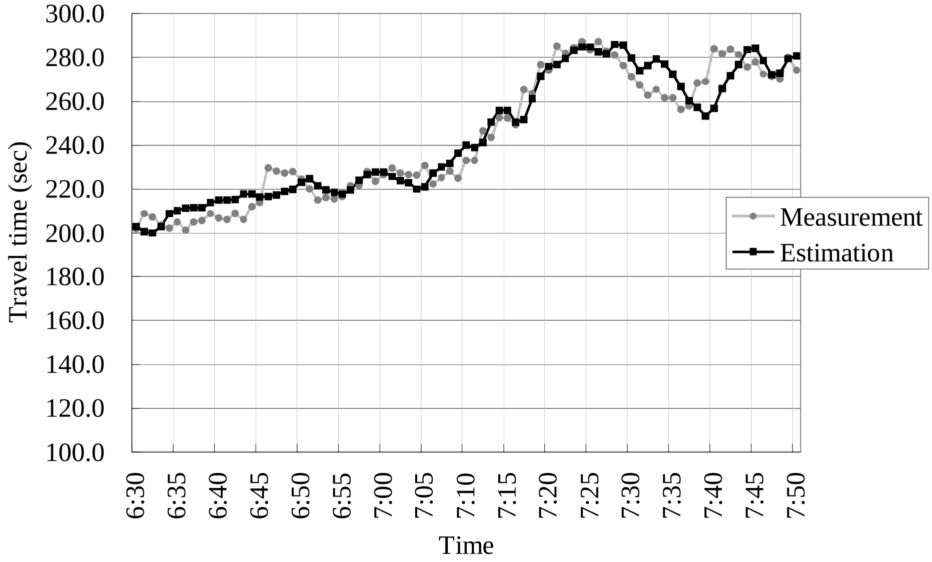

Figure 6. Time trends of travel time

Object times of an evaluation can be classified into three modes depending on traffic conditions. Mode 6:30 ~ 7:00 represents a light traffic state, 7:00 ~ 7:20 a transition (light traffic >>> congestion), and 7:20 ~ 7:50 a congested state. Although measurements differ slightly from estimations in the congested state, estimations might agree quite well with measurements. Table 1 shows error ratios between estimations and measurements.

The results were satisfactory because in any traffic state, mean error ratios of travel times are not more than 3%. Even in varying traffic state, travel time estimations obtained have satisfactorily high accuracy, for example, during periods with stable traffic conditions.

However, as shown in Figure 6, estimations deviate from measurements during congestion. This might come from a traffic status that could not be predicted from time-series traffic flow tables, because of an unexpected outcome such as the closing of a lane caused by a right turn.

Figure 7 is a scatter diagram showing measured travel times and predicted travel times. The correlation coefficient is 0.96.

Table 1. Prediction accuracies

Time period	Traffic condition	Mean error ratio (%)	Max error ratio (%)
6:30 - 7:00	Light traffic	2.7	5.7
7:00 - 7:20	Light traffic >>> Congestion	2.2	5.2
7:20 - 7:50	Congestion	2.9	9.6

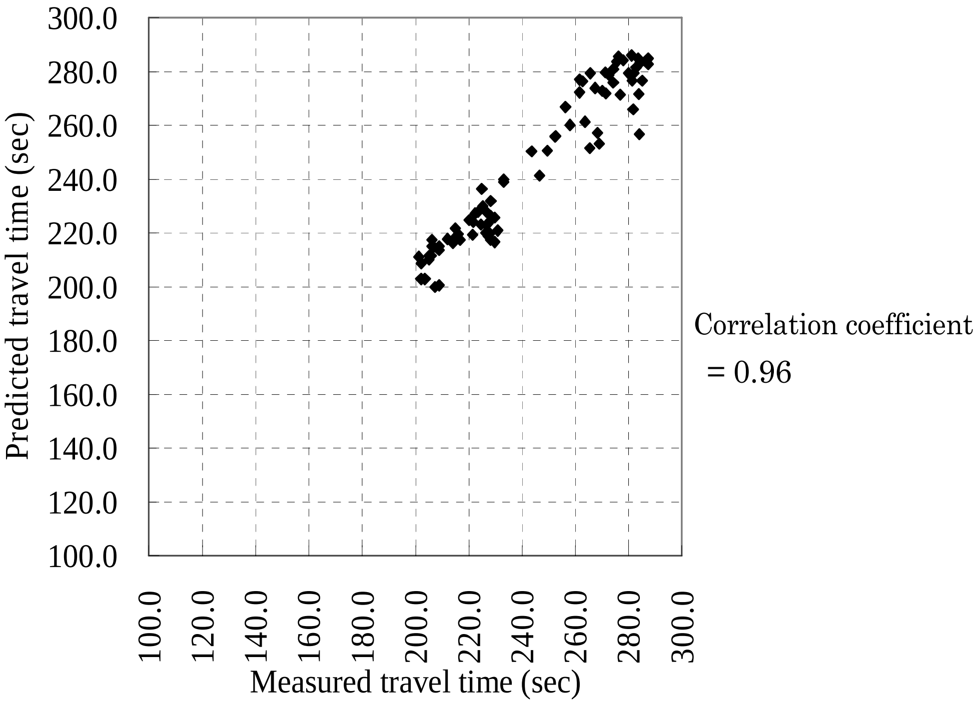

Figure 7. Correlation between measurements and estimations

4. CONCLUSION

We could confirm the effect of estimating travel times by exchanging time-series traffic tables between intersections using traffic simulator.

In particular, even if traffic conditions changed, highly accurate travel time estimations were obtained.

This system provides advantages in that without requiring a dedicated infrastructure, travel times can be calculated by compiling traveling data for all vehicles, link by link, and that during the process of forecasting outflow traffic from each intersection, the effect of signal control parameters to be incorporated in the future can be added, so compared to existing travel time presumption methods, this system offers merits. We plan on proceeding with field verification tests and to study for practical applications.

5. REFERENCES

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