Trial Application of the Interactive CDRG in UTMS II

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SUMMARY

Universal Traffic Management Society (UTMS) and the Tokyo Metropolitan Police Department are planning to realize the interactive Centrally Determined Route Guidance (CDRG). The system selects the recommended route using link travel time data, which is gathered by the traffic control system. Therefore, even in the early stages of its adoption when it cannot obtain large quantities of travel time data measured by in-vehicle units, the system can still provide guidance relating to the shortest route in terms of time required.

We constructed a trial system on major roads in Tokyo to conduct the first-step field test in the autumn of 1996, followed by the second in the spring of 1997. In these tests, the performance of the system was estimated by actually running CDRG vehicles in the

trial area.

Based on the above results, the third-step test was carried out in March of 1998 on road networks including expressways, proving the superiority of our route guidance system again. This thesis mainly reports on the results of the third-step field test.

CDRG USED IN UTMS

Traffic congestion occurs daily in large cities in Japan. On the other hand, car navigation equipment has been developed recently and drivers have begun demanding traffic information requiring the optimum route to the driver's destination. Therefore, recently, the National Police Agency has been adding a new infrastructure equipped with two-way communication between the ground and vehicles (that is, infrared beacons) to the existing traffic control system and started to provide in-vehicle units with dynamic traffic information in the spring of 1996, in accordance with the Vehicle Information and Communication System (VICS).

We decided to adopt an interactive CDRG as a means of helping to reduce traffic congestion in the future. CDRG is one sub-system that can be realized by two-way communication between the ground and vehicles. In this system an optimum route, according to the destination of each vehicle, is recommended from a beacon. In addition, when these beacons and in-vehicle units become more widely used and can identify individual vehicles, it will be possible to implement several new traffic management measures. Additionally, using collected origin-destination (OD) information from every individual vehicle will enable more accurate prediction of traffic movement, more appropriate signal control and the providing of traffic information.

SYSTEM STRUCTURE

Fig.1 shows the system structure. This system consists of infrared beacons, in-vehicle unites, a CDRG central unit and traffic control system. A vehicle sends a destination to a beacon passing through the communication zone, then immediately the beacon returns the route information that includes the recommended route and predicated travel time to the destination to the vehicle. In order to respond to any destination within the vicinity of a beacon, it

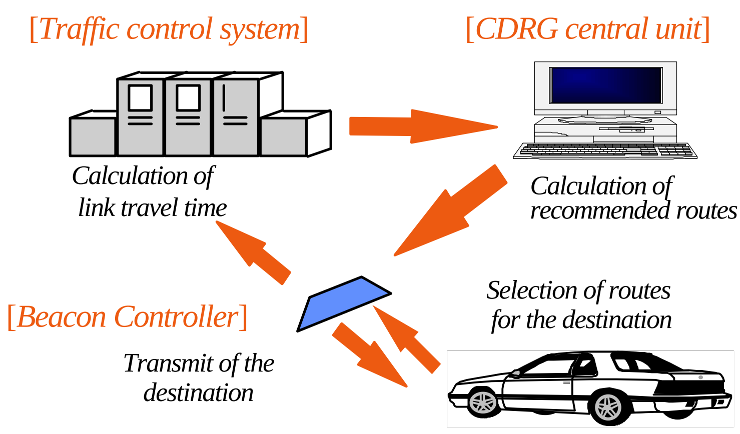

Fig.1 System Structure

accumulates the route information on all destinations in the range which is sent by a CDRG central unit every 5 minutes. The CDRG central unit calculates the route information for all relevant beacons, and transmits this information to them. The traffic control system collects vehicle detector information and creates predicted travel times of all links from it. Link predicted travel time will be obtained using travel time data measured and sent by in-vehicle units in the future when they become sufficiently widespread.

ROUTE SELECTION METHOD

The dynamic route guidance system determines recommended routes for individual drivers to reach their destinations in the shortest possible time using the Dijkstra method and/or other appropriate approaches based on link travel time data. This is referred to as the route direct calculation method. In practice, however, any slight variation in travel time data can cause significant differences in recommended routes. This may provide drivers with inconsistent recommended routes that vary moment to moment each time they pass infrared beacons as they follow the driving routes, thus confusing them. In order to solve this problem, we devised the candidate route method for offering consistent recommended routes and have proven its effectiveness in the first- and second-step field tests. With the candidate route method, several candidate routes for all destinations are predefined and the current optimum route is selected from them. In this method, however, it is not easy to respond to emergencies like closed roads, although it is not impossible.

Consequently we recently devised another route selection method capable of stabilizing recommended routes and providing easy response to emergencies. With this method, link predicted travel time is smoothed to avoid it’s random variations before calculating recommended routes using the route direct calculation method

THIRD-STEP FIELD TEST

PURPOSE

Our tests have been conducted by constructing a trial system in a practical location in Tokyo, where vehicles having an in-vehicle unit actually ran.

In the first- and second- step field tests that were conducted in the autumn of 1996 and the spring of 1997, respectively, the performance of the system with the candidate route method was verified to be sufficiently high for practical use on general road networks.

Based on the above test results and improvements mentioned in the previous section, the third-step field test was conducted from March 24 through 26, 1998. The purposes of this test with respect to system performance were as follows:

- Evaluation of new route selection method capable of responding to an emergency.

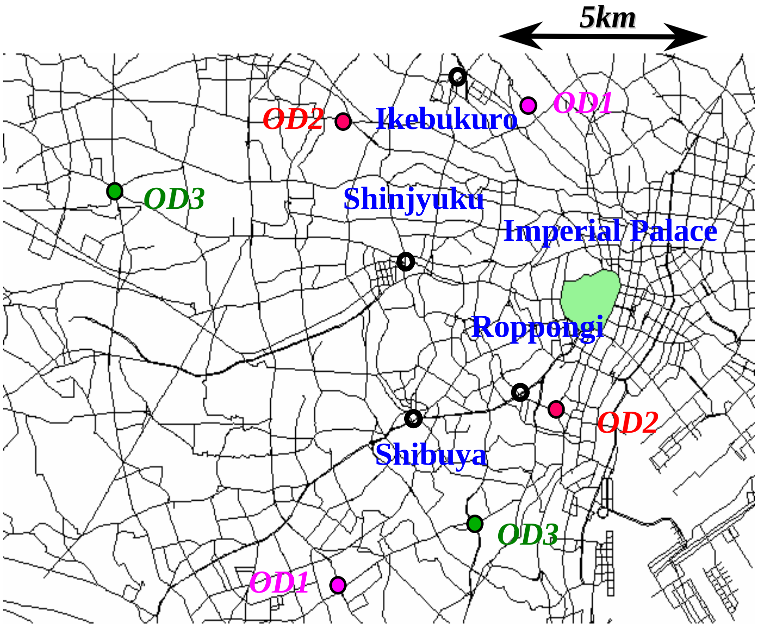

Fig.2 Trial Area

-Comparison of several route guidance methods on road networks including expressways.

CONSTRUCTION OF TRIAL SYSTEM

Fig. 2 shows the trial area extending for 20 km from east to west and 15 km from north to south in the central to western area of Tokyo, where a DRGS function was added to approximately 200 infrared beacons that had already been installed on general roads. Within this area, six pairs of ODs were set for testing as shown in Table 1.

Roads applicable to route guidance were general main roads on which vehicle detector information was collected and the Tokyo Metropolitan Expressway on which link travel time information was provided by the Tokyo Metropolitan Expressway Public Corporation.

Table 1 Six pairs of ODs in the trial area

OD No.	Origin	Destination
1-A	Sengoku 1-chome	Kakinoki-zaka rikkyo
1-B	Kakinoki-zaka rikkyo	Sengoku 1-chome
2-A	Ochiai 1-chome	onarimon
2-B	onarimon	Ochiai 1-chome
3-A	Shimendou	Seishoukou-mae
3-B	Seishoukou-mae	Shimendou

The Tokyo Metropolitan Expressway is a toll road network extending for approximately 300 km around the central part of Tokyo with a flat rate tariff. On the expressway, radio beacons were installed instead of infrared beacons, which serve VICS information such as link travel time and congestion, not CDRG route information though. Ramp closure often, but randomly, occurs on the expressway, for reducing traffic jams there by closing upstream entrances (ramps) and restricting traffic inflow to congested sections. So this system is designed to use plan information of ramp closure when calculating recommended routes in order to avoid the ramp if it is estimated to be closed by the time the vehicle arrives there.

A vehicle was provided with two routes, namely, the shortest time route both with and without the expressway, and predicted travel times on those routes to the destination at a starting point and en route only on general roads, running along its recommended route. The length of the communication zone between an infrared beacon and the in-vehicle unit was approximately 3.7 m ahead of the vehicle. Table 2 shows the detailed infrared beacon specifications. The beacon was designed to hold recommended routes and predicted travel times to all destinations within a radius of 20 km from its installed position.

Table 2 Infrared beacon specifications

Item		Specification
Emitting wave length		850 nm
Modulation method		Pulse Amplitude modulation
Transmission method		Two-way communication
Transmission speed	Uplink	64 Kbps
	Downlink	1 Mbps
Data capacity	Uplink	256 Byte
	Downlink	10 Kbyte
Communication zone		3.5m x 3.7m
Vehicle speed		70Km/h

The CDRG central unit updated the recommended routes and predicted travel times on each infrared beacon every five minutes. In addition, it was connected to the traffic control system via a LAN from which it obtained such data as link predicted travel time and plan information of ramp closure every five minutes.

TESTING METHOD

In the field test, six groups were formed each consisting of the following three types of vehicles.

- CDRG vehicle : driving under guidance with CDRG system.
- Taxis: driving in accordance with an experienced taxi driver's judgement.
- Ordinary vehicles: driving under human judgement with congestion information or guidance of the autonomous in-vehicle unit with shortest distance route selecting method.

Each group started at the same time and data on travel time between O and D were collected. Every type of vehicle was to choose a route either with or without expressways, with the driver surmising of predicted travel time for each route in the case of the vehicle other than a CDRG vehicle. As a result of a pre-conducted travel examination, running on the Metropolitan Expressway rather than on general roads had been found to be extremely advantageous for some ODs. In order to overcome this, we statistically obtained the travel time difference (handicap) between routes with and without expressways beforehand and had each vehicle select either route after adding the handicap to the routes using expressways.

The CDRG vehicles ran only on main general roads where route guidance was available and on expressways, while other vehicles ran on all but the narrowest general roads.

For all vehicles running on the expressway, a handicap was also added to the actual travel time for evaluation purposes.

TEST RESULT

Each OD pair ran six times a day for three days, totaling 108 runs. Part of the data collected was inappropriate for system evaluation since such errors as failures of a CDRG vehicle's driver to follow the recommended route were included. Two indexes were obtained from data on 84 runs excluding the above cases.

Travel Time per Vehicle Type

Table 3 Average and increase of travel time per vehicle type

Vehicle type	Average travel time (Sec)	Increase rate(%)
CDRG	3397.8	0.0
Taxi	3525.2	3.7
Ordinary	3820.1	12.4

Table 3 shows the average and increased travel time compared with the CDRG vehicles for each type of vehicle. The travel time increase rate (%) is defined as follows:

$$TIR = (TTO - TTC) / TTC \times 100$$

Here, TIR refers to travel time increase rate, TTO to travel time for other than CDRG vehicles and TTC to travel time for CDRG vehicles.

The results show that the CDRG vehicles arrived at their destinations fastest on average, followed by taxis (later by 3.7%) and ordinary vehicles (later by 12.4%).

Winning Rate of CDRG Vehicle

Table 4 Winning rate per vehicle type

Vehicle type	OD						
	1A	1B	2A	2B	3A	3B	Total
CDRG	46.2	61.5	41.7	50.0	64.3	37.5	50.0
Taxi	46.2	30.8	58.3	31.3	14.3	43.8	36.9
Ordinary	7.7	7.7	0.0	18.8	21.4	18.8	13.1

Table 4 shows another index, namely, the winning rate. This value is calculated by dividing the number of times a particular vehicle reached the destination fastest by the total number of runs. The winning rate for CDRG vehicles was the highest of all ODs except OD2A and 3B, occupying half, or 50.0%, of all ODs. For the remaining two ODs, the winning rate for taxis was the highest. This was probably due to the fact that drivers of CDRG and ordinary vehicles stayed in a certain lane while experienced taxi drivers knew when to change lanes, resulting in a difference in travel time even when both used the same route. The average travel time difference between CDRG vehicles and taxis, however, was not significantly large. This indicates that the system is capable of consistently providing close-to-optimum routes even when the optimum routes cannot be obtained for some reason or other.

Accuracy of Predicted Travel Time

Fig. 3 shows the comparison between the predicted travel time to the destination provided by infrared beacons during CDRG vehicle runs and the actual time. It was verified travel time information provided by this system is sufficiently reliable for practical use.

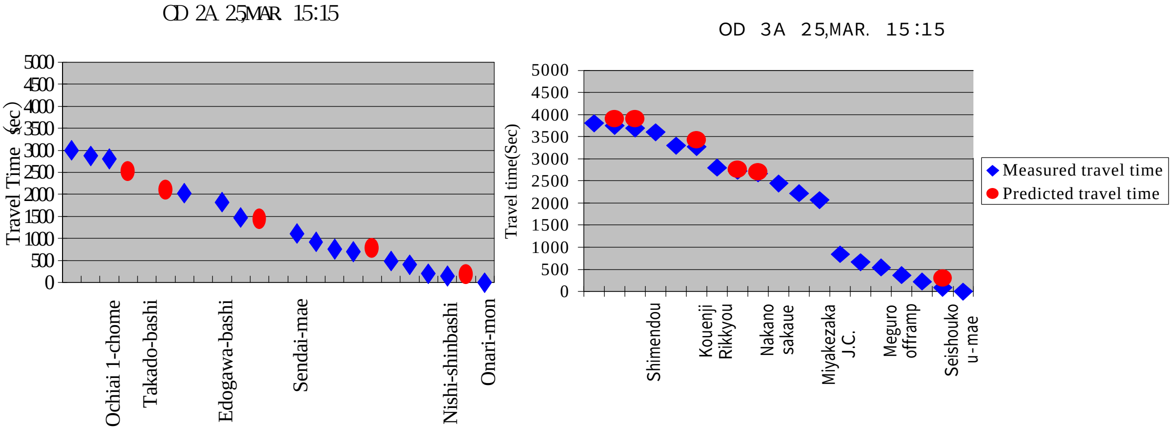

Fig.3 Predicted and measured travel time

Stability of Recommended Route

In this test, the stability of the recommended routes was approximately the same as in the last test which adopted the candidate route selection method. Although route information supplied by the infrared beacons changed during traveling according to varied traffic information, the number of such changes was one to three times per travel at most, thus causing no confusion to the drivers.

Response to Emergency

For this test, ramp closure on the expressway was an anticipated emergency. No CDRG vehicle was encountered ramp closure during the actual running, although 0 to 10 ramps were closed when testing the same as under normal conditions. This indicates that the system is capable of successfully recommending another route when a ramp is closed.

CONCLUSION

In this test, we adopted a method for selecting recommended routes using pre-smoothed predicted travel time. As the above field test results show, the CDRG vehicles using the route guidance information provided by this system arrived at their destinations in the shortest time on average, confirming that it is more efficient than depending on experienced taxi drivers, thereby proving its practicality. It is also confirmed that this route selection method is as capable of providing consistent routes as the candidate route method and responding to an emergency like ramp closure on expressways.

We will conduct the fourth-step field test in 1999 aimed at putting the system to practical use in the near future. This test is intended to evaluate whether it is capable of providing effective route guidance to the final destination as a whole when a distant designation further than 20 km from a starting point is specified.

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