

Advanced Trial Application of the Interactive CDRG in UTMS

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SUMMARY

The Universal Traffic Management Society of Japan (UTMS) and the Tokyo Metropolitan Police Department have been working together to put the interactive Centrally Determined Route Guidance (CDRG) system to practical use. This system is designed to identify recommended routes based on the link travel time data provided by the traffic control system. Thus, the system is capable of offering guidance on the optimum recommended route taking the shortest possible time, even in the early stage immediately after its practical implementation when the system cannot obtain sufficient amounts of travel time data measured by in-vehicle units.

We constructed a prototype system in the central part of Tokyo in 1996 to implement field trials, and obtained satisfactory results in the previous three field trials. The third step field trial was carried out in March 1998 as the final evaluation of system performance and produced results indicating that the system provides sufficient route guidance capabilities on road networks including expressways for practical application in an actual traffic system. In February 1999, the fourth step field trial was carried out to evaluate route guidance to remote destinations and the provision of information regarding recommended lanes and intersections at fork roads with a view to further enhancing the system's capabilities.

INTRODUCTION

Traffic congestion is an everyday occurrence in large cities in Japan. Accordingly, there is increasing driver demand for utilization of traffic information that will help drivers to reach intended destinations as fast as possible. Meanwhile, car navigation systems have been developed. Recently, the National Police Agency has introduced into the traffic control system a new infrastructure: infrared beacons featuring two-way communication between the traffic control center on the ground and moving vehicles. The National Police Agency also started to provide in-vehicle units with dynamic traffic information in the spring of 1996 as a part of the Vehicle Information and Communication System (VICS).

In addition, as a means of helping relieve traffic congestion in the future, the center is to

adopt an interactive CDRG to present recommended routes for different destinations requested by moving vehicles. The CDRG serves as a sub system that may function successfully as two-way communication becomes more widespread between the control center on the ground and moving vehicles. This system returns an optimum route to every driver in response to a destination requested by the in-vehicle unit. The UTMS and the Tokyo Metropolitan Police Department have worked with each other since 1996 to conduct three field trials in the central part of Tokyo, and have demonstrated that system performance is satisfactory for practical use.

In February 1999, the fourth step field trial was carried out to evaluate route guidance to remote destinations and the provision of information regarding recommended lanes and intersections at fork roads with a view to further enhancing the system's capabilities.

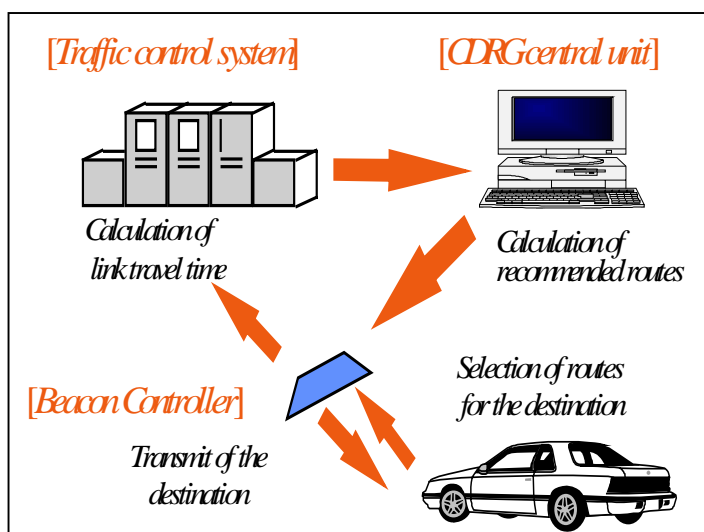


Fig.1 System Basic Configuration

SYSTEM CONFIGURATION

As shown in Fig.1, this system consists of infrared beacons, in-vehicle units, a CDRG central unit and a traffic control system. Every infrared beacon responds to data on an intended destination transmitted from an in-vehicle unit of a vehicle passing through a communication zone by immediately returning to the in-vehicle unit a recommended route and estimated travel time to the destination.

Individual infrared beacons receive route information from the CDRG central unit every five minutes for data storage to enable them to respond to inquiries about any destination in their own coverage (a radius of about 20 km or more even in zones with the heaviest traffic) by providing a recommended route to the destination. The CDRG central unit determines the route information for all infrared beacons under its control

based on expected travel time data for each link received from the traffic control system. It then transmits this route information to the individual infrared beacons. The length of the communication zone between an infrared beacon and the in-vehicle unit was approximately 3.7 m

Table 1 Infrared beacon specifications

Item	Specification
Emitting wave length	850 nm
Modulation method	Pulse amplitude Modulation
Transmission method	Two-way communication
Transmission Uplink	64K bps
Speed Downlink	1M bps
Data Capacity Uplink	256 byte
Downlink	10K byte
Communication zone	3.5m x 3.7m
Vehicle max. speed	70 Km/h

ahead of the vehicle. Table 1 shows the detailed infrared beacon specifications.

This system offers the features listed below:

- The information transmitted to an in-vehicle unit contains only route data, and thus the amount of information is limited to the required minimum. This allows route guidance for distant destinations as far as 20 km away.
- An infrared beacon is designed to pick up only the information appropriate for a requested destination among the previously optimized route information, thus allowing quick response to an in-vehicle unit.
- Every recommended route is determined based on link travel time data obtained from the traffic control system, and thus the possible shortest route in terms of time is available even in the early stage immediately after practical implementation of the system when large quantities of travel time data measured by in-vehicle units cannot be obtained.

At present, the traffic control system is designed to collect information from detectors installed on present vehicles and then estimate the expected travel time for individual links. In the future, however, when in-vehicle units become widespread enough to allow the traffic control system to collect sufficient amounts of travel time data measured by the in-vehicle units, the measured travel time data will be used to determine the expected travel time.

FIRST THROUGH THIRD STEP FIELD TRIALS

We set up a trial system in 1996 in the central part of Tokyo and obtained satisfactory results in the two field trials carried out on general road networks up to 1997. In addition, in March 1998, the third step field trial was carried out on expanded test road networks including the Tokyo Metropolitan Expressway as the final evaluation of system performance. In the third step field trial, a comparison was made of average travel times to specified destinations. The results indicated that the time taken by the vehicles following the recommended routes provided by the system was shorter by 3.7% and 11.2% respectively compared with taxis and ordinary vehicles. This demonstrates the superiority of the route guidance capabilities of the system. In addition, the estimated travel time to different destinations provided by the infrared beacons to the in-vehicle units on the way to the destinations was found to be nearly the same as the actual required time in most cases. Furthermore, route guidance for detouring any temporarily closed ramps on the Tokyo Metropolitan Expressway enabled the system to respond properly to any unexpected event, thereby proving that system performance is satisfactory for practical application.

FOURTH STEP FIELD TRIAL

We aim to provide a system offering the basic capabilities evaluated in previous field trials as the initial practical system. However, soon after the start of practical operation, we intend to make the system even more convenient for drivers by incorporating additional capabilities such as route guidance for remote destinations and provision of supplementary information such as recommended lanes. To verify the capabilities, the fourth step field trial was carried out in February this year.

Route Guidance for Remote Destinations

This system provides detailed information for a series of route links to any destination in the short range (20 km or less) from individual infrared beacons. When a driver wants to go to a distant destination outside the short destination range, the Locally Determined Route Guidance (LDRG) system in an in-vehicle unit may be used for route guidance in the zones beyond the short destination range. However, we have investigated another system which offers route guidance information under the control of the traffic center for the purpose of reducing the burden on in-vehicle units.

Figure 2 illustrates the concept of the system. Multiple remote destination zones are predetermined to allow an in-vehicle unit to select any of them as a destination beyond the short destination range. The remote destination zones are set up to have gradually

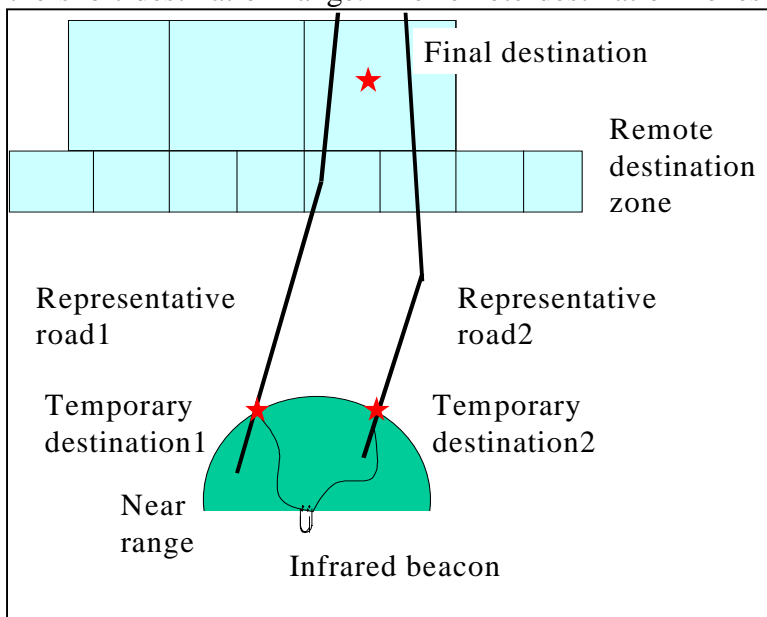


Fig.2 Route Guidance to Remote Destination

increasing coverage areas (for example, a radius of several kilometers and then a radius of tens of kilometers) the farther they are from the installation location of an infrared beacon. For every pair consisting of the location of an infrared beacon and a remote destination zone, the system determines several temporary destinations in the vicinity of the boundary of the short destination range, names of representative roads connecting the temporary

destinations and the final remote destinations, and the statistically calculated travel time. The system determines this information in the form of semi-fixed data. These items of information composed of remote destination zones, temporary destinations, names of representative roads, and the statistically calculated travel time are stored in the infrared beacons. Every infrared beacon responds to a selected remote destination transmitted from an in-vehicle unit by returning to the in-vehicle unit the data on a series of detail route links, names of representative roads connecting relevant temporary destinations and the final remote destination, and estimated travel time from the infrared beacon to the final remote destination. In practice, the information regarding the zones from temporary destinations to the final remote destination does not reflect dynamic traffic conditions that vary from time to time. However, temporary destinations are sequentially updated as a vehicle gets closer to the final destination, and then the vehicle can obtain the latest traffic information from other infrared beacons. This means that 'remoteness' of the current destination zone viewed from the last short destination range decreases, thus leading to increased reliability of route information.

Construction of Trial System

The trials of route guidance to remote destinations involved varying the zone areas between the front and back of the short destination range covered by each infrared beacon to provide required information. Then two trials were carried out; Trial A with the final destination set at a distant point of 20 km or more away, and Trial B with the final destination set at a near point of 5 to 20 km away. For the trials of route guidance to remote destinations, about fifty infrared beacons were selected among those installed on general roads in a range extending 20 km to the east and west and 15 km to the north

Table 2 Trial A and B of ODs

Trial	Origin	Destination	Distance
A	Koujimachi police station	Sunagawa 6-ban	30Km
B	Miyake-zaka	Seishoukou-mae	8Km

and south in the central to western parts of Tokyo for a trial area with the addition of the DRGS function. Table 2 shows combinations of origin-destination (OD) points, and Fig.3 shows the configuration of the trial area.



Fig.3 Trial area

Trial Method

The trials were conducted based on reports submitted by the drivers operating the vehicles equipped with the in-vehicle units. The reports included evaluations of whether or not the drivers felt any incongruity regarding the route information provided by the infrared beacons. In the trials, the test vehicles followed the routes in accordance with the information provided by the infrared beacons, and they stopped moving when they received detailed route information to the final destination without actually reaching the final destination. The vehicles stopped moving on the way to the final destination because the availability of detailed route information from an infrared beacon means that the final destination is located within the short destination range from the infrared beacon and also because driving in the short destination range was already investigated

in the third step field trial (1) carried out last year which showed that the system is effective. For these reasons, the vehicles stopped moving after they entered the short destination range.

Provision of Information about Intersections at Fork Roads

For the trials, recommended driving lanes for individual exit lanes at different entrance links to intersections and estimated distances to the intersections from infrared beacons were previously stored in the infrared beacons in the form of static information.

The infrared beacons select from the above-mentioned static information appropriate driving lanes for entrance lanes to the downstream intersections on recommended routes as well as recommended routes and transmit the selected data to the in-vehicle units. Also, given that a vehicle may not be able to change lanes on a recommended route if there is insufficient distance to a downstream intersection, the infrared beacons inform the in-vehicle unit of the estimated distance to the downstream intersection to allow the in-vehicle unit to determine if the recommended route should be shown to the driver.

Construction of Trial System

The trial of provision of information on intersections at fork roads was carried out in a trial area having a radius of about 5 km in the central part of Tokyo with about 50 infrared beacons selected among those installed on general roads for additional capabilities. Figure 4 shows the trial area.



Fig.4 Trial area

Trial Method

The trial was carried out based on reports submitted by drivers operating the vehicles equipped with the in-vehicle units. The reports included evaluations of whether or not the drivers felt any incongruity regarding the information provided by the infrared beacons. In the trial of provision of information about intersections at fork roads, the test vehicles ran freely between any locations in the trial area without selecting any specific combination of origin and destination points. Then, while the test vehicles were running in accordance with the recommended route information, information about fork road intersections provided while the

vehicles were moving was evaluated for convenience.

Result of Trial

Both trials were carried out over the full month of February 1999 with four vehicles used for route guidance to remote destinations and three vehicles used for the provision of information about fork road intersections. The evaluation results are as shown below.

Route Guidance to Remote Destinations

-The provided recommended routes were reported not to generate any sense of incongruity in drivers and were thus appropriate.

-Temporary destinations were sequentially updated without any problem as the test vehicles approached the final destination.

-Updating of temporary destinations seems not to be recognized by the actual in-vehicle units and thus no problem may be involved.

Drivers using navigation systems are normally unaware of route changes made to distant points outside the display screen because they are looking at the current vehicle position displayed on a large-scaled map while they are driving their cars.

-Temporary destinations should be dynamically updated in response to different traffic conditions.

-In some cases, the provided travel time was found to vary considerably when detailed routes to the final destination were obtained after the vehicles entered the short destination range.

In the present trials, the provided estimated travel time to remote destinations was based on the static travel time from beacon points to the final destinations when there is no congestion. This caused considerably lower travel time values than those calculated dynamically to reflect the actual traffic conditions.

Provision of Information about Fork Road Intersections

-This information is effective for supporting safe driving.

-Lanes and provided routes were approximately consistent with each other.

-Added convenience will be obtained if the information about directions of fork roads is available corresponding to recommended routes.

This information has been defined in the system specifications, though it was not available in the trials.

-The information about fork road intersections should also contain additional information regarding several intersections at further points ahead and not only downstream intersections.

CONCLUSION AND FURTHER CONSIDERATIONS

The trials were carried out with a combination of two route guidance methods: route guidance to remote destinations newly adopted in this year's trials and route guidance in the short destination range, the superiority of which was already demonstrated in last year's trials. The route guidance methods were proved to be satisfactory for practical

use in the existing traffic system. In addition, the information about fork road intersections was also found to be very effective as supporting information for drivers when used in combination with the route guidance information.

For practical application of the system in the future, the following possible problems were raised:

- Estimated travel time to remote destinations may vary considerably on the way to the final destinations.

- Information for several fork road intersections is required.

- So long as available information about temporary destinations is limited to only one point, provision of recommended routes may fail if any accident occurs in the recommended routes.

- Routes to remote destinations are unidentifiable.

The system specifications will be reviewed this year to seek solutions to the above problems. There are also other problems relating to commercial operation of the system after it is put to practical use, including proper management of information about road networks and intersections. Thus we must make constant effort in further investigations with the aim of constructing the best possible system.

Reference

(1) Shinji Makino, "Trial Application of the Interactive CDRG in UTMS", 5th World Congress on ITS, Oct. 1999