GPS-based Mobile Information Board System

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Abstract: In recent years, the Global Positioning System (GPS), which makes it possible to specify the latitude and longitude of ground positions, has begun to find wider application in fields such as car navigation and geodetic surveying. GPS is used in a wide range of applications for the road traffic industry, and car navigation systems are quickly becoming popular as digital maps become increasingly precise and terminals more affordable. Systems using GPS are becoming especially popular among consumers. For public infrastructure projects, resources such as Intelligent Transport Systems (ITS) that support safer driving and provide traffic information remain under development. These circumstances have led the authors to develop a GPS-based system that provides traffic information via mobile devices. The system is installed in a vehicle to provide successive motorists with traffic information on a virtual message board. Using a general-purpose car navigation device, the system derives information such as the current location, distance to passing zones (road areas where passing is permitted) or other landmarks, and possible routes between the current location and the destination. The system then processes the data for use in various traffic and safety advisories. Ultimately, the information is relayed by traffic information signs and sent to following vehicles. This information is intended to keep motorists from driving in a manner that endangers others under certain traffic conditions. This paper presents our analysis of data from a field trial in which we obtained GPS data (including latitude and longitude) and projections of current location based on map-matching to determine the current location along a route.

Keywords: *GPS, ITS, traffic information signs, map-matching*

1. INTRODUCTION

In recent years, the Global Positioning System (GPS), which provides the latitude and longitude of specific points on the ground, has seen increasingly wider use in applications such as car navigation. GPS is especially widespread in the road traffic industry. Car navigation systems have surged in popularity as digital maps become more precise and terminals more affordable. Systems incorporating GPS are becoming especially popular among consumers. For public infrastructure projects, GPS devices have come to be regarded as a potential valuable asset for application in Intelligent Transport Systems (ITS), supporting safer driving and providing traffic information.

These circumstances have led the authors to develop a system that provides information to increase traffic safety. A GPS unit and electronic traffic information sign are installed on a service vehicle, such as a snowplow, operating in a special environment. While the equipment constantly calculates the distance between the current location and a predetermined target site, it displays information on the Message Sign, such as distance between following drivers and the next turnout or passing zone.

Figure 1 illustrates the system concept.

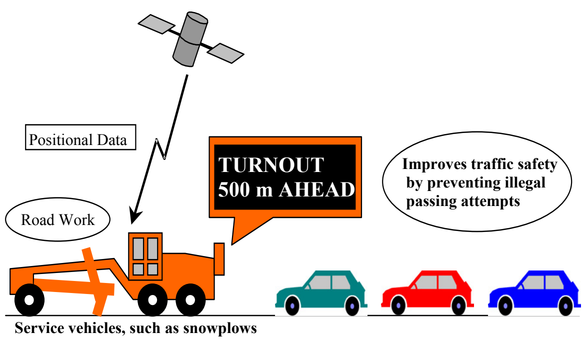


Figure 1. System Concept

2. SYSTEM OVERVIEW

This system comprises equipment installed on a vehicle as well as a central host computer, located elsewhere, for processing data related to the driving route. It consists of the following hardware and software. Figure 2 shows the system configuration.

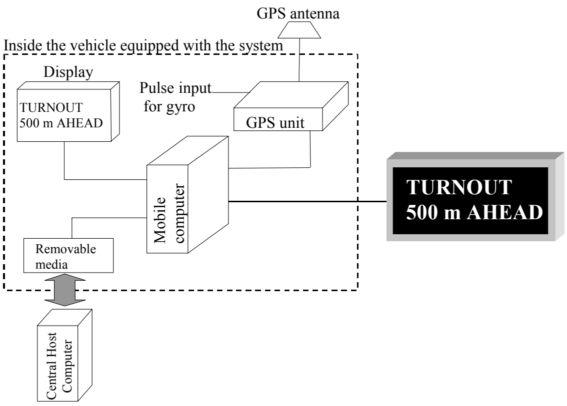


Figure 2. System Configuration

2.1 Hardware

2.1.1 GPS Unit

A general-purpose GPS unit is used to determine latitude and longitude. The standard functions are given below:

- Determination of current location when two or more GPS satellites are accessible
- Gyro function (Note 1)

2.1.2 Central Host Computer

The central host computer is a general-purpose personal computer to be used by the system administrator. This computer will presumably be located in an office in the area of service and be used to manage the system. Following software installation, the computer is used to run the Managed Navigation System, an application that incorporates digital maps.

2.1.3 Mobile Computer

The mobile computer is a weather-resistant computer installed in a vehicle in which a mobile information system is installed. A shock- and cold-resistant computer is used to ensure normal operations inside snowplows or other vehicles used in extreme environments. The computer runs the Windows operating system from ROM, as well as communications software to access the Message Sign.

2.1.4 Compact Text Message Sign

The system also includes a compact, LED-type text Message Sign capable of displaying two lines of text of four double-byte characters per line. Before system installation, various text messages (for example, TURNOUT 500 m AHEAD") as shown in the figure are stored in the memory of the Message Sign. These elements can be combined in various combinations to form various messages displayed on the Message Sign. Users contact the central host computer to set which messages are to be displayed via the mobile computer's serial port.

Note 1: Even when the vehicle is in tunnels or other locations blocked from satellite communications, the system is capable of estimating the current position by detecting angular velocity with a sensor and calculating relative angles to determine by how many degrees the driver has deviated from the last confirmed heading.

2.2 Software

2.2.1 Managed Navigation System Software

Managed Navigation System Software (MNSS) is installed and used on the central host computer. This application is based on the Geographic Information Systems (GIS).

It provides the following software functions.

- Includes digital maps (scale: 1:25,000)
- Road settings (10 routes).
- Turnout settings (200 turnouts)
- A screen plot of the route based on travel log

Figure 3 shows an illustration of the basic screen displayed after startup.

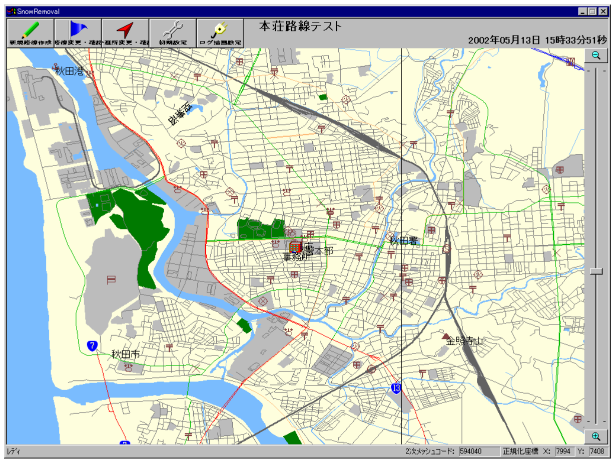


Figure 3. MNSS screen

Digital maps, shown at a scale of 1:25,000, are drawn from the nationwide digital map database. Lines representing the following roadways are stored in a database of vector data.

- Expressways
- National highways
- Prefectural roads
- Other roads 3 m or more in width

Using the MNSS, the system administrator can specify various route settings. Up to twenty turnouts or passing zones can be assigned to each route.

Routes are created by selecting a series of national highways, expressways, or other roads from the digital map data for one zone after another. The settings for each route are stored as vector data.

Figure 4 shows a sample screen for a route assigned 11 hypothetical turnouts or passing zones in one zone for a round-trip itinerary on Route 7 in Akita, Japan.

After the settings for this route are saved, the data is transferred via removable media and saved to the mobile computer as the route for the vehicle equipped with this system.

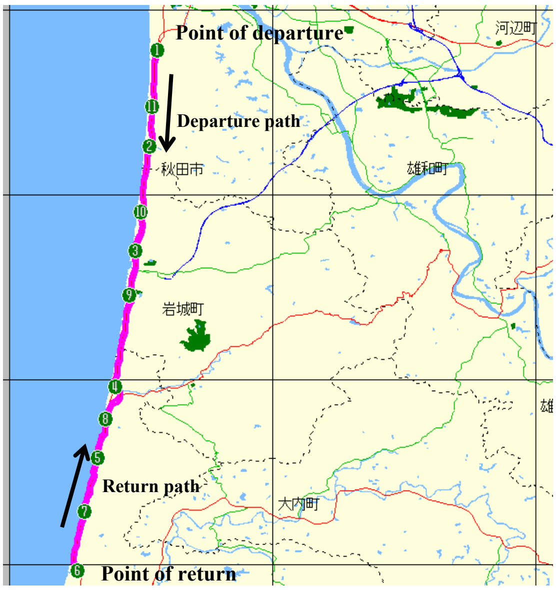


Figure 4. Sample Screen for Route Settings

2.2.2 Mobile Software for Supplying Information

Software used to provide information to motorists is installed on the mobile computer. This application provides the following functions:

- Controls the Message Sign
- Calculates the distance between the current location and turnouts

(a) Controlling the Message Sign

Implemented via the serial port, these functions are used to manage the information displayed on the mounted Message Sign. Before use, information is stored in the memory of the Message Sign. To determine the information displayed on the Message Sign, users transmit a signal to the central host computer (hereafter, this signal will be referred to as a "display command").

Sample display patterns are shown below.

Table 1. Sample types of information for the message available for display on the Message Sign

Pattern No.	Content Displayed
1	TURNOUT 100 m AHEAD
2	TURNOUT 200 m AHEAD
□ □ □	□ □ □
9	TURNOUT 900 m AHEAD
10	TURNOUT 1 km AHEAD
11	TURNOUT 2 km AHEAD
12	SHOVELING AHEAD
13	AVOID REAR IMPACT
14	TURNOUT AHEAD

(b) Calculating the Distance Between the Current Location and Turnout

During travel, this function calculates the distance to turnouts along the route using GPS data. Route and turnout data specified beforehand with the MNSS is transferred via removable media and loaded into the mobile information software.

When the distance remaining matches the distance indicated by GPS data, the mobile information software issues a command to display this distance on the Message Sign. When the value for remaining distance reaches zero meters, the system switches to begin calculating the distance to the next turnout.

It is also possible to set the system to display standard messages, such as SHOVELING AHEAD, in alternation with the two distance remaining display commands.

Figure 5 shows the processing steps in program flow for the distance remaining display command sent to the Message Sign by the mobile information software.

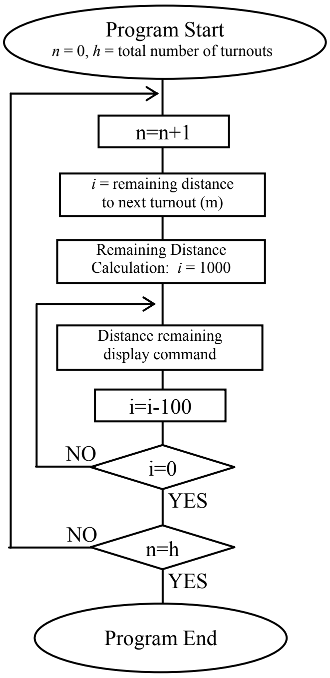


Figure 5. Program flow for Message Sign communication software

3. CALCULATING THE DISTANCE BETWEEN THE CURRENT LOCATION AND THE NEXT TURNOUT

The system software can calculate the distance from the current location to the next turnout or passing zone.

Figure 6 shows how distance is calculated. Steps 2-4 comprise the map-matching portion of the procedure.

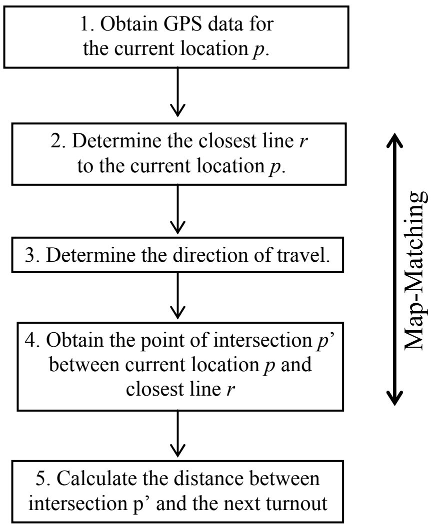


Figure 6. Steps in calculating distance

3.1 Obtaining GPS Data

Data from the GPS unit ("GPS data") consists of data on latitude, longitude, altitude, and gyro reliability measured once every second. The table below shows a partial record of GPS data collected during travel.

Table 2. GPS Data

Sec	Location Measurement Method	Gyro Reliability	Latitude	Longitude	Altitude
1	3D Location Measurement	Reliable	039□ 30'09"	140□ 21'15"	23
2	3D Location Measurement	Reliable	039□ 30'10"	140□ 21'15"	23
3	3D Location Measurement	Reliable	039□ 30'10"	140□ 21'14"	22
4	3D Location Measurement	Reliable	039□ 30'11"	140□ 21'14"	22

If the location cannot be measured or the gyro data is unreliable, the data is deleted and processing aborted.

3.2 Map-Matching

Map-matching overrides erroneous GPS positional data by plotting the closest location on the specified route.

Map-matching is used to calculate the distance from the compensated current location to specified turnouts or passing zones along the route.

4. RUNNING TEST

To verify the functions of the MNSS and Mobile Information Software, a trial run was conducted under the following conditions:

- Dates: December 18–19, 2001
- Location: Akita Expressway
- Weather Conditions: Snowfall
- Road Conditions: Snow Removed
- Average Speed: Approx. 80 km/h

4.1 Running Test Environment

A regular passenger car was used to carry the mobile information system. For the test, the car was equipped with a notebook computer combining the functions of the central host computer, mobile computer, and display component (Figure 2). The computer was connected to the GPS unit, and MNSS and mobile information software applications were installed.

For the test route, we selected Akita Expressway, since this roadway features a series of tunnels. The driving route as well as turnouts and passing zones were specified in advance. The car was driven along the route while all data types were gathered.

4.2 Test Details

4.2.1 Tests Involving Reception of GPS Data

Trial runs were carried out to determine whether GPS data could be obtained at the normal rate of once per second under conditions of inclement weather. The tests also sought to determine whether GPS data can be obtained in tunnels (while the gyro operates) over long distances without losing track of the current location. GPS data was recorded for the travel log.

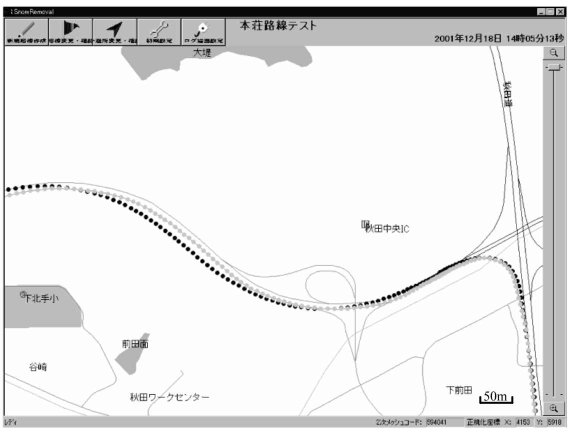
4.2.2 Test Involving Calculation of the Distance between Current Location and Turnout

Trial runs were conducted to determine whether the remaining distance to turnouts would be calculated correctly (while also applying map-matching) and whether this could be displayed on the computer. The compensated current location data was recorded for the travel log.

4.3 Results of Running Tests

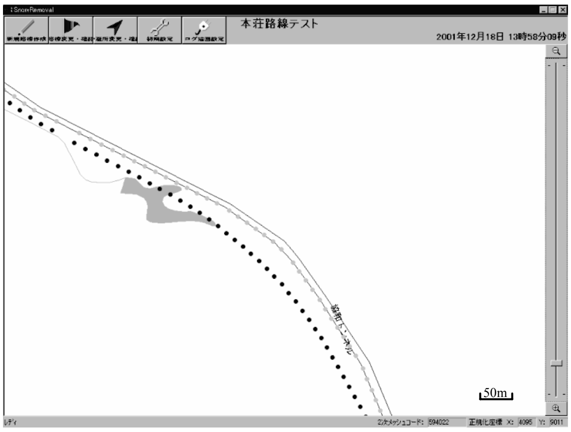
Based on the travel log data collected, the travel log data screen plotting function of the MNSS was used to compare the GPS data with the compensated current location data.

Figure 7 shows the results from the travel log for driving under normal conditions. Figure 8 shows the results from the travel log for driving in tunnels.



•••• Plot of GPS Current Location Data
•••• Plot of Compensated Current Location Data

Figure 7. Travel Results for Normal Driving Conditions



•••• Plot of GPS Current Location Data
•••• Plot of Compensated Current Location Data

Figure 8. Travel Results for Driving in Tunnels

5. CONCLUSION

Trial run results indicate that accurate projections of the current location were made, even after driving several kilometers through tunnels. The system accomplished this by reconciling data obtained from GPS and the compensated current location along the route. The maximum discrepancy between the actual current location and the compensated current location was found to be 15 m under normal driving conditions and 30 m when driving through tunnels, a condition that prevents GPS data reception.

Thus, errors of the present system, which supplies information to drivers in following vehicles in increments of 100 meters, are within an acceptable range.

Work is currently underway to make it possible for GPS-based systems for Traffic Message Signs to be realized in mobile devices such as portable phones. Also under development are systems that will guide service vehicles from control stations.

6. ACKNOWLEDGEMENT

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7. REFERENCES

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