

[DESCRIPTION]

[TITLE OF INVENTION]

PASSAGE DETECTION SYSTEM, PASSAGE DETECTION METHOD, PASSAGE
DETECTION DEVICE, PROGRAM, AND RECORDING MEDIUM

5 [Technical Field]

[0001]

The present invention relates to a passage detection system, a passage detection
method, a passage detection device, a program, and a recording medium. More
particularly, the present invention relates to a passage detection system, a passage
10 detection method, and a passage detection device detecting passage of a vehicle at a
predetermined position and a program causing a computer to function as the passage
detection device, and a recording medium recording the program.

Priority is claimed on Japanese Patent Application No. 2013-033201, filed
February 22, 2013, the content of which is incorporated herein by reference.

15 [Background Art]

[0002]

At present, the positions of vehicles are mainly specified by systems that use
both of a method performed with the Global Positioning System (GPS) and autonomous
navigation using gyroscopes together or the like.

20 [0003]

The GPS is a system that measures the absolute position of an object by
receiving radio waves from a plurality of GPS satellites. However, in places blocked by
buildings or in tunnels which the radio waves from the GPS satellites do not reach, it is
difficult to specify the positions of vehicles using such systems.

25 [0004]

Autonomous navigation is used in order to specify the positions of vehicles at places which radio waves do not reach. In autonomous navigation, the position of a vehicle is obtained by first deciding an initial position and subsequently calculating a movement distance and a direction from the initial position by a travel distance sensor and an azimuth sensor. As the travel distance sensor, a vehicle speed sensor measuring a travel distance from the number of rotations of tires is mainly used. As the azimuth sensor, a gyroscope detecting a rotational azimuth and amount is mainly used.

[0005]

At present, the specifying of the position of a vehicle is realized at precision of dozens of meters by using these two technologies together. In recent years, technologies for improving precision have been examined. For example, as a technology already put into practice, there is a technology called Differential GPS (DGPS). This technology realizes precision of about 10 meters by measuring an arrival state of radio waves from GPS satellites at a reference station of which an accurate position is measured in advance to comprehend an error occurring before the radio waves arrive on the ground and by transmitting differential correction radio waves indicating the error to a nearby user.

[0006]

As technologies related to such a background, various technologies are known (for example, see Patent Literature 1).

[0007]

For example, Patent Literature 1 describes a device that is mounted on a vehicle and performs charging on the vehicle according to charge rates decided in charge areas and a travel distance in a preset charge area when the vehicle travel in the charge areas.

More specifically, this device obtains vehicle position data for requesting the position of

a vehicle according to radio waves from GPS satellites. This device is supplied with charge area information indicating the position of a charge area and determines whether a vehicle approaches the charge area according to the position of the vehicle indicated by the vehicle position data and the position of the charge area indicated by the charge area information. When the vehicle is determined to be approaching the charge area, support positioning of a base station that supports positioning is activated using position correction data according to an error between the position of the base station obtained according to the radio waves from the GPS satellites and a reference point at which the base station is disposed. This device corrects the vehicle position data according to the position correction data. This device determines whether the vehicle is located in the charge area according to the vehicle position data and decides according to a travel distance and a charge rate when the vehicle is located in the charge area. This device can perform proper charging for the vehicle passing a charge area at a low cost.

[Citation List]

15 [Patent Literature]

[0008]

[Patent Literature 1]

Japanese Unexamined Patent Application, First Publication No. 2004-192349.

[Summary of Invention]

20 [Technical Problem]

[0009]

A positioning method using an on-board DGPS as in the device described in Patent Literature 1 is effective means for measuring the position of a vehicle with high precision and with efficiency. However, in specifying the position of a vehicle, the vehicle may not necessarily be said to be positioned with guaranteed precision at, for

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example, a position at which a sky visibility is not sufficiently guaranteed or a position at which it is difficult to receive the differential correction radio waves.

[0010]

5 In road pricing in which a charging process is performed when a vehicle has passed a charge point of a toll road, an on-board unit performing the charging process is needed to accurately detect whether the vehicle has passed the charge point of the toll road.

[0011]

10 However, since the vehicle may not be positioned with precision at, for example, a position at which a sky visibility may not be sufficiently guaranteed, there is a possibility of the charging process not being performed even after the vehicle has passed the charge point or the charging process being performed even though the vehicle has not passed the charge point.

[Solution to Problem]

15 [0012]

According to a first aspect of the present invention, a passage detection system detecting passage of a vehicle at a predetermined position includes: a positioning device configured to measure an own position using radio navigation and autonomous navigation; and a passage detection device configured to detect the passage of the vehicle
20 at a predetermined position. The passage detection device includes a position specifying unit configured to specify a position of the vehicle by correcting a positioning result measured by the positioning device on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result of the positioning device and on the basis of a travel state of the vehicle, and a passage
25 determination unit configured to determine whether the vehicle has passed the

predetermined position on the basis of a variation with time in the position specified by the position specifying unit.

[0013]

The passage detection device may further include a travel state specifying unit
5 configured to specify the travel state of the vehicle on the basis of the variation with time in the position specified by the position specifying unit up to a present time. The position specifying unit may specify the position of the vehicle by correcting the positioning result measured by the positioning device on the basis of the systematic error information prepared in advance regarding the system error of the positioning result
10 measured by the positioning device and the travel state of the vehicle specified by the travel state specifying unit.

[0014]

The passage detection device may further include a map matching unit configured to perform map matching on the position specified by the position specifying
15 unit, and an accidental error calculation unit configured to calculate an accidental error of the positioning result measured by the positioning device on the basis of a deviation amount between a first position specified by the position specifying unit and a second position indicated by a result obtained through the map matching by the map matching unit. The passage determination unit may determine that the vehicle has not passed the
20 predetermined position when the predetermined position is within a range of the accidental error calculated by the accidental error calculation unit.

[0015]

According to a second aspect of the present invention, a passage detection system detecting passage of a vehicle at a predetermined position includes a positioning
25 device configured to measure an own position using radio navigation and autonomous

navigation; and a passage detection device configured to detect the passage of the vehicle at a predetermined position. The passage detection device includes a map matching unit configured to perform map matching on the positioning result measured by the positioning device, an accidental error calculation unit configured to calculate an accidental error of a positioning result measured by the positioning device on the basis of a deviation amount between a first position specified by the positioning device and a second position indicated by a result obtained through the map matching by the map matching unit, and a passage determination unit configured to determine that the vehicle has not passed the predetermined position when the predetermined position is within a range of the accidental error calculated by the accidental error calculation unit.

[0016]

According to a third aspect of the present invention, a passage detection method of detecting passage of a vehicle at a predetermined position includes: a position specifying step of specifying a position of the vehicle by correcting a positioning result measured by a positioning device which measures an own position using radio navigation and autonomous navigation on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result measured by the positioning device and on the basis of a travel state of the vehicle; and a passage determination step of determining whether the vehicle has passed the predetermined position on the basis of a variation with time in the position specified in the position specifying step.

[0017]

According to a fourth aspect of the present invention, a passage detection method of detecting passage of a vehicle at a predetermined position includes: a map matching step of performing map matching on a positioning result measured by a

positioning device which measures an own position using radio navigation and autonomous navigation; an accidental error calculation step of calculating an accidental error of the positioning result measured by the positioning device on the basis of a deviation amount between a first position of the positioning result measured by the positioning device and a second position indicated by a result obtained through the map matching in the map matching step; and a passage determination step of determining that the vehicle has not passed the predetermined position when the predetermined position is within a range of the accidental error calculated in the accidental error calculation step.

[0018]

According to a fifth aspect of the present invention, a passage detection device detecting passage of a vehicle at a predetermined position includes: a position specifying unit configured to specify a position of the vehicle by correcting a positioning result measured by a positioning device which measures an own position using radio navigation and autonomous navigation on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result measured by the positioning device and on the basis of a travel state of the vehicle; and a passage determination unit configured to determine whether the vehicle has passed the predetermined position on the basis of a variation with time in the position specified in the position specifying unit.

[0019]

According to a sixth aspect of the present invention, a program causes a computer to function as a passage detection device detecting passage of a vehicle at a predetermined position. The program causes the computer to function as: a map matching unit configured to perform map matching on a positioning result measured by a positioning device which measures an own position using radio navigation and

autonomous navigation; an accidental error calculation unit configured to calculate an accidental error of the positioning result measured by the positioning device on the basis of a deviation amount between a first position of the positioning result measured by the positioning device and a second position indicated by a result obtained through the map matching in the map matching step; and a passage determination unit configured to determine that the vehicle has not passed the predetermined position when the predetermined position is within a range of the accidental error calculated in the accidental error calculation unit.

[0020]

According to a seventh aspect of the present invention, a program causes a computer to function as a passage detection device detecting passage of a vehicle at a predetermined position. The program causes the computer to function as: a position specifying unit configured to specify a position of the vehicle by correcting a positioning result measured by a positioning device which measures an own position using radio navigation and autonomous navigation on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result measured by the positioning device and on the basis of a travel state of the vehicle; and a passage determination unit configured to determine whether the vehicle has passed the predetermined position on the basis of a variation with time in the position specified in the position specifying unit.

[0021]

According to an eighth aspect of the present invention, a program causes a computer to function as a passage detection device detecting passage of a vehicle at a predetermined position. The program causes the computer to function as: a map matching unit configured to perform map matching on a positioning result measured by a

positioning device which measures an own position using radio navigation and autonomous navigation; an accidental error calculation unit configured to calculate an accidental error of the positioning result measured by the positioning device on the basis of a deviation amount between a first position of the positioning result measured by the positioning device and a second position indicated by a result obtained through the map matching in the map matching step; and a passage determination unit configured to determine that the vehicle has not passed the predetermined position when the predetermined position is within a range of the accidental error calculated in the accidental error calculation unit.

10 [0022]

According to a ninth aspect of the present invention, a recording medium recording a program causes a computer to function as a passage detection device detecting passage of a vehicle at a predetermined position. The recording medium recording the program causes the computer to function as: a position specifying unit configured to specify a position of the vehicle by correcting a positioning result measured by a positioning device which measures an own position using radio navigation and autonomous navigation on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result measured by the positioning device and on the basis of a travel state of the vehicle; and a passage determination unit configured to determine whether the vehicle has passed the predetermined position on the basis of a variation with time in the position specified in the position specifying unit.

[0023]

According to a tenth aspect of the present invention, a recording medium that records a program causes a computer to function as a passage detection device detecting

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passage of a vehicle at a predetermined position. The recording medium recording the program causes the computer to function as: a map matching unit configured to perform map matching on a positioning result measured by a positioning device which measures its position using radio navigation and autonomous navigation; an accidental error calculation unit configured to calculate an accidental error of the positioning result measured by the positioning device on the basis of a deviation amount between a first position of the positioning result measured by the positioning device and a second position indicated by a result obtained through the map matching in the map matching step; and a passage determination unit configured to determine that the vehicle has not passed the predetermined position when the predetermined position is within a range of the accidental error calculated in the accidental error calculation unit.

[0024]

In the foregoing overview of the invention, not all of the characteristics necessary for the present invention are listed.

The invention may include sub-combinations of the characteristic groups.

[Advantageous Effects of Invention]

[0025]

According to the passage detection system, the passage detection method, the passage detection device, the program, and the recording medium described above, it is possible to detect passage of a vehicle at a predetermined position without receiving an influence of an error of a positioning result obtained by a positioning device even when, for example, the vehicle is traveling on a road on which the sky visibility is not sufficiently guaranteed.

[Brief Description of Drawings]

[0026]

Fig. 1 is a diagram showing an example of a use environment of a passage detection system 100 according to an embodiment.

Fig. 2 is a diagram showing an example of the block configuration of an on-board unit 110.

5 Fig. 3 is a diagram showing an example of information stored in a systematic error information storage unit 120 in a table format.

Fig. 4 is a diagram showing an example of information stored in a charge point information storage unit 121 in a table format.

10 Fig. 5 is a diagram showing an example of an operation flow of the on-board unit 110.

Fig. 6 is a diagram showing an example of an operation flow of the on-board unit 110.

Fig. 7 is a diagram showing an example of a method of calculating an accidental error.

15 Fig. 8 is a diagram showing an example of an operation flow of the on-board unit 110.

Fig. 9 is a diagram showing an example of a hardware configuration of a computer 800 included in the on-board unit 110 according to the embodiment.

[Description of Embodiments]

20 [0027]

Hereinafter, the invention will be described according to embodiments. The following embodiments do not limit the invention described in the claims. All of the specific combinations to be described in the embodiments may not be said to be essential for solutions of the invention.

25 [0028]

Fig. 1 is a diagram showing an example of a use environment of a passage detection system 100 according to an embodiment. The passage detection system 100 is a system detecting passage of a charge point by the vehicle. Here, the charge point refers to a position at which a charging process is performed in road pricing. The charge point may be an example of a “predetermined position” in the present invention.

[0029]

The passage detection system 100 includes an on-board unit 110, a GPS reception unit 130, and a display 150. The on-board unit 110 may be an example of a “passage detection device” according to the present invention. The GPS reception unit 130 may be an example of a “positioning device” according to the present invention.

[0030]

The GPS reception unit 130 is a device that measures its own position using radio navigation and autonomous navigation. More specifically, the GPS reception unit 130 includes a GPS antenna, an accelerometer, and an angular velocity meter. Here, the GPS antenna is an antenna that receives radio waves from GPS satellites. The accelerometer is a measurement unit that measures a change in acceleration when a vehicle is moving. The angular velocity meter is a measurement unit that measures a change in an angular velocity when the vehicle is moving. For example, the GPS reception unit 130 is installed at a position at which the GPS antenna is not obstructed, such as a dashboard D of the vehicle. The GPS reception unit 130 is connected electrically to the on-board unit 110. The GPS reception unit 130 measures its position using the radio navigation with the GPS and the autonomous navigation using the accelerometer and the angular velocity meter. The GPS reception unit 130 outputs data indicating a result of the positioning to the on-board unit 110.

[0031]

The on-board unit 110 is a device that detects passage of a charge point by the vehicle.

More specifically, for example, the on-board unit 110 is installed at a position which the hands of a driver reach without interruption of driving, such as a side surface of a center console C of the vehicle. The on-board unit 110 is connected electrically to the GPS reception unit 130 and the display 150. An integrated circuit (IC) card is inserted into a card slot I of the on-board unit 110. Here, inside the IC card, for example, information regarding a user of the passage detection system 100, a non-volatile memory storing charging information or the like including a use history, and application data for realizing a security function are mounted. The on-board unit 110 determines whether the vehicle has passed the charge point when an input of data output from the GPS reception unit 130 is received. The on-board unit 110 performs a charging process when the on-board unit 110 determines that the vehicle has passed the charge point. The on-board unit 110 outputs data indicating a result of the charging process to the display 150.

[0032]

The display 150 is a device that displays text or figures. More specifically, for example, the display 150 is installed at a position which the driver can view, such as the center console C of the vehicle. The display 150 is connected electrically to the on-board unit 110. The display 150 displays the result of the charging process indicated by the data when an input of the data output from the on-board unit 110 is received.

[0033]

In the embodiment, the configuration of the passage detection system 100 including one GPS reception unit 130 and one display 150 will be described. However, the passage detection system 100 may include a plurality of the GPS reception units 130

and a plurality of the displays 150.

[0034]

Fig. 2 is a diagram showing an example of the block configuration of an on-board unit 110. The on-board unit 110 includes a positioning result data input reception unit 111, a position specifying unit 112, a map matching unit 113, a travel state specifying unit 114, an accidental error calculation unit 115, a passage determination unit 116, a charging process unit 117, a data output unit 118, a map data storage unit 119, a systematic error information storage unit 120, and a charge point information storage unit 121. In the following description, the functions and operations of the constituent elements will be described in detail.

[0035]

The positioning result data input reception unit 111 receives an input of data which is output from the GPS reception unit 130 and indicates a positioning result.

[0036]

The position specifying unit 112 specifies the position of the vehicle by correcting the positioning result measured by the GPS reception unit 130 on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result by the GPS reception unit 130 and on the basis of a travel state of the vehicle. More specifically, the position specifying unit 112 specifies the position of the vehicle by correcting the positioning result by the GPS reception unit 130 on the basis of the systematic error information prepared in advance regarding the systematic error of the positioning result by the GPS reception unit 130 and on the basis of the travel state of the vehicle specified by the travel state specifying unit 114. Here, the travel states of the vehicle are broadly classified into travel states indicating that the vehicle is traveling or travel states indicating that the vehicle is stopped. The travel states indicating that

the vehicle is traveling include a travel state that the vehicle goes straight, a travel state that the vehicle travels while turning right, and a travel state that the vehicle travels while turning left. The systematic error is assumed to refer to an error measured at the same position when position coordinates of the positioning result by the GPS reception unit 130 systematically deviate from genuine position coordinates of the position of the vehicle as long as the position is measured in the same travel state. Here, the genuine position coordinates refer to, for example, position coordinates on a map.

[0037]

The map matching unit 113 performs map matching of a position specified by the position specifying unit 112. Here, the map matching is a process of forcibly matching a position specified by the position specifying unit 112 to the inside of a road on a map when the position is outside the road on the map on the basis of the assumption that the vehicle is traveling on the road.

[0038]

The travel state specifying unit 114 specifies the travel state of the vehicle on the basis of a variation with time in the position specified by the position specifying unit 112 up to the present time.

[0039]

The accidental error calculation unit 115 calculates an accidental error of the positioning result by the GPS reception unit 130 on the basis of a deviation amount between a first position specified by the position specifying unit 112 and a second position indicated by the result of the map matching by the map matching unit 113. Here, the accidental error is assumed to refer to an error varying for each positioning even when the vehicle is positioned in the same travel state and at the same position.

[0040]

The passage determination unit 116 determines whether the vehicle has passed a charge point on the basis of a variation with time in the position specified by the position specifying unit 112. More specifically, the passage determination unit 116 determines that the vehicle has not passed the charge point when the charge point is within a range of
5 the accidental error calculated by the accidental error calculation unit 115.

[0041]

The charging process unit 117 performs the charging process when the vehicle has passed the charge point.

[0042]

10 The data output unit 118 outputs data indicating the result of the charging process to the display 150.

[0043]

The map data storage unit 119 stores data of a digital map. Here, the digital map is a map which is digitized and can be processed by a computer.

15 [0044]

Fig. 3 is a diagram showing an example of information stored in the systematic error information storage unit 120 in a table format. The systematic error information storage unit 120 stores information regarding the genuine position coordinates (longitude and latitude), information regarding the travel state of the vehicle, and information
20 regarding position coordinates (longitude and latitude) of the positioning result in association therewith. The information stored in the systematic error information storage unit 120 may be an example of “systematic error information” according to the present invention.

[0045]

25 The information regarding “the genuine position coordinates (longitude and

latitude)” is information indicating the longitude and the latitude on a digital map.

Specifically, the information regarding “the genuine position coordinates (longitude and latitude)” indicates the longitude and latitude of a position on the digital map at which the systematic error occurs in the positioning result of the GPS reception unit 130 in the periphery of the charge point.

[0046]

The information regarding “the travel state of the vehicle” is information indicating the travel state of the vehicle at the position indicated by the information regarding “the genuine position coordinates (longitude and latitude).”

10 [0047]

The information regarding “the position coordinates (longitude and latitude) of the positioning result” is information indicating the positioning result of the GPS reception unit 130 when the travel state of the vehicle is a state indicated by the information regarding “the travel state of the vehicle” at the position indicated by the information regarding “the genuine position coordinates (longitude and latitude).”

15 More specifically, a deviation amount between the position coordinates indicated by the information regarding “the genuine position coordinates (longitude and latitude)” and the position coordinates indicated by the information regarding “the position coordinates (longitude and latitude) of the positioning result” is a systematic error when the travel state of the vehicle is a state indicated by the information regarding “the travel state of the vehicle” at the position indicated by the information regarding “the genuine position coordinates (longitude and latitude).”

20 [0048]

That is, in the case of the example shown in Fig. 3, for example, when the position coordinates of the positioning result by the GPS reception unit 130 are “(Eb,

Nb)” and the travel state of the vehicle at that time is “going straight,” it is indicated that the genuine position coordinates at which the vehicle is present are “(Ea, Na).” Further, when the position coordinates of the positioning result by the GPS reception unit 130 are “(Eb, Nb)” and the travel state of the vehicle at that time is “stopped,” it is indicated that the genuine position coordinates at which the vehicle is present are “(Ed, Nd).”

Furthermore, when the genuine position coordinates are “(Ea, Na)” and the travel state of the vehicle at the position is “traveling while turning right,” it is indicated that the positioning result by the GPS reception unit 130 is “(Ec, Nc).”

[0049]

Fig. 4 is a diagram showing an example of information stored in the charge point information storage unit 121 in a table format. The charge point information storage unit 121 stores information regarding a charge point ID (identifier), information regarding position coordinates (longitude and latitude), and information regarding a fee (yen) in association therewith.

[0050]

The information regarding “the charge point ID” is an identification sign which uniquely identifies each charge point among a plurality of charge points.

[0051]

The information regarding “the position coordinates (longitude and latitude)” is information indicating the longitude and latitude of a charge point on the digital map, which is indicated by the information regarding “the charge point ID.”

[0052]

The information regarding “the fee (yen)” is information indicating an amount of a fee to be paid in the charging process when the vehicle passes the charge point indicated by the information regarding “the charge point ID.”

[0053]

In the case of the example shown in Fig. 4, for example, a charge point present at the position of position coordinates “(Ef, Nf)” indicates a charge point at which “200 (yen)” is paid.

5 [0054]

Fig. 5 is a diagram showing an example of an operation flow of the on-board unit 110. In the description of the operation flow, a map matching process for the position of the vehicle will be described in detail. In the description of the operation flow, all of Figs. 1 to 4 are referred to.

10 [0055]

The GPS reception unit 130 measures its own position using the radio navigation by GPS and the autonomous navigation using both of the accelerometer and the angular velocity meter together at predetermined intervals. The GPS reception unit 130 sequentially outputs data indicating the positioning results to the on-board unit 110.

15 [0056]

When the positioning result data input reception unit 111 of the on-board unit 110 receives an input of the data indicating the positioning results output from the GPS reception unit 130 (S101), the data is transmitted to the position specifying unit 112.

[0057]

20

When the data transmitted from the positioning result data input reception unit 111 is received, the position specifying unit 112 of the on-board unit 110 specifies the position of the vehicle by correcting the positioning results indicated by the data received from the positioning result data input reception unit 111 on the basis of the information stored in the systematic error information storage unit 120 and the travel state of the vehicle indicated by the data received from the travel state specifying unit 114 (S102).

25

[0058]

For example, when the position coordinates indicated by the data received from the positioning result data input reception unit 111 are “(Ea, Na)” and the travel state of the vehicle indicated by the latest data received from the travel state specifying unit 114 is “going straight,” the position specifying unit 112 reads the information “(Eb, Nb)” regarding “the genuine position coordinates (longitude and latitude)” stored in association with “(Ea, Na),” which is the information regarding “the position coordinates (longitude and latitude)” of the positioning result and “going straight” which is the information regarding the “travel state of the vehicle” among the information stored in the systematic error information storage unit 120. The position specifying unit 112 specifies the position coordinates (Ea, Na) as the position of the vehicle after the correction.

[0059]

Here, when the same position coordinates as the positioning result indicated by the data transmitted from the positioning result data input reception unit 111 is not stored as the information regarding “the position coordinates (longitude and latitude) of the positioning result” of the systematic error information storage unit 120, the position specifying unit 112 specifies the position coordinates of the positioning result indicated by the data received from the positioning result data input reception unit 111 as the position of the vehicle without change. This is because no systematic error occurs at the position when the corresponding information is not stored in the systematic error information storage unit 120.

[0060]

The position specifying unit 112 transmits the data indicating the position coordinates of the vehicle specified in this way to the map matching unit 113, the travel

state specifying unit 114, and the accidental error calculation unit 115.

[0061]

When the data transmitted from the position specifying unit 112 is received, the map matching unit 113 of the on-board unit 110 performs map matching on the position coordinates indicated by the data (S103). For example, the map matching unit 113 performs the map matching on the position coordinates indicated by the data transmitted from the position specifying unit 112 using a road shape on the digital map, a travel pattern history of the vehicle, and the like as data according to a heuristic algorithm. The map matching unit 113 transmits data indicating the position coordinates after the map matching to the travel state specifying unit 114, the accidental error calculation unit 115, and the passage determination unit 116.

[0062]

When the data transmitted from the position specifying unit 112 and the map matching unit 113 is received, the travel state specifying unit 114 of the on-board unit 110 specifies the travel state of the vehicle on the basis of a variation with time in the position coordinates indicated by the data (S104).

[0063]

First, the travel state specifying unit 114 specifies whether the vehicle is traveling or stopped on the basis of the variation with time in the position coordinates indicated by the data received from the position specifying unit 112. For example, when the variation with time in the position coordinates indicated by the plurality of pieces of data received within a predetermined time from the position specifying unit 112 is less than a predetermined value, the travel state specifying unit 114 specifies that the vehicle is stopped. Further, when the variation with time in the position coordinates indicated by the plurality of pieces of data received within the predetermined time from

the position specifying unit 112 is equal to or greater than the predetermined value, the travel state specifying unit 114 specifies that the vehicle is traveling.

[0064]

When the travel state specifying unit 114 specifies that the vehicle is traveling,
5 the travel state specifying unit 114 specifies whether the vehicle is going straight, is traveling while turning right, or is traveling while turning left on the basis of the variation with time in the position coordinates indicated by the data received from the map matching unit 113. For example, when the variation with time in the position
10 coordinates indicated by the plurality of pieces of data received within a predetermined time from the map matching unit 113 is linear, the travel state specifying unit 114 specifies that the vehicle is going straight. Further, when the variation with time in the position coordinates indicated by the plurality of pieces of data received within the
predetermined time from the map matching unit 113 is a change from north to east or a change from south to west, the travel state specifying unit 114 specifies that the vehicle is
15 traveling while turning right. Furthermore, when the variation with time in the position coordinates indicated by the plurality of pieces of data received within the predetermined time from the map matching unit 113 is a change from north to west change or a change from south to east change, the travel state specifying unit 114 specifies that the vehicle is traveling while turning left.

20 [0065]

The travel state specifying unit 114 transmits data indicating the specified travel state of the vehicle to the position specifying unit 112.

[0066]

When the data transmitted from the positioning result data input reception unit
25 111 is received, the position specifying unit 112 specifies the position of the vehicle by

correcting the positioning result indicated by the data received from the positioning result data input reception unit 111 on the basis of the information stored in the systematic error information storage unit 120 and the travel state of the vehicle indicated by the data received from the travel state specifying unit 114 (S102).

5 [0067]

When an input of the data output from the GPS reception unit 130 is received, the on-board unit 110 performs map matching on the position of the vehicle by repeating the processes of steps S101 to S104.

[0068]

10 Fig. 6 is a diagram showing an example of an operation flow of the on-board unit 110. In the description of the operation flow, a process of calculating the range of an accidental error in the current position of the vehicle will be described in detail. In the description of the operation flow, all of Figs. 1, 5, and 7 are referred to. Fig. 7 is a diagram showing an example of a method of calculating the range of an accidental error.

15 Of the steps of the operation flow shown in Fig. 6, the steps with the same reference numerals as the operation flow shown in Fig. 5 indicate the same operations.

[0069]

The position specifying unit 112 transmits data indicating the position coordinates to the accidental error calculation unit 115 whenever the position specifying unit 112 specifies the position coordinates of the vehicle. The map matching unit 113 transmits data indicating the position coordinates after the map matching to the accidental error calculation unit 115 whenever the map matching unit 113 performs the map matching.

[0070]

25 When the data transmitted from the position specifying unit 112 and the map

matching unit 113 is received, the accidental error calculation unit 115 of the on-board unit 110 sequentially calculates ranges of the accidental error of the positioning result by the GPS reception unit 130 on the basis of a deviation amount between the position coordinates indicated by the data received from the position specifying unit 112 and the position coordinates indicated by the data received from the map matching unit 113 (S105). Here, the position coordinates indicated by the data received from the position specifying unit 112 may be an example of a “first position” according to the present invention. The position coordinates indicated by the data received from the map matching unit 113 may be an example of a “second position” according to the present invention.

[0071]

For example, as shown in Fig. 7, when the accidental error calculation unit 115 calculates a range E_c of the accidental error at a position P71 specified by the position specifying unit 112, the accidental error calculation unit 115 calculates a root mean square Err of deviation amounts $E1$ to E_n between the position coordinates of positions P1 to Pn specified by the position specifying unit 112 within a predetermined time until the vehicle reaches the position P71 and the position coordinates of positions M1 to Mn of the results obtained through the map matching on the positions P1 to Pn by the map matching unit 113 (Expression (1)).

[0072]

[Math 1]

$$Err = \sqrt{\frac{E1^2 + E2^2 + E3^2 + \dots + En^2}{n}} \quad \cdot \cdot \cdot \quad (1)$$

[0073]

The accidental error calculation unit 115 calculates the range of the accidental error by multiplying the value of the root mean square Err by N (N is an integer). The range of the accidental error is broadened as the value of N is larger. The accidental error calculation unit 115 transmits data indicating the calculated range of the accidental error to the passage determination unit 116.

[0074]

The on-board unit 110 can perform a process with reference to the range of the accidental error at the current position of the vehicle.

10 [0075]

Fig. 8 is a diagram showing an example of an operation flow of the on-board unit 110. In the description of the operation flow, a process of detecting passage of the charge point by the vehicle will be described in detail. In the description of the operation flow, all of Figs. 1 to 7 are referred to. In the operation flow shown in Fig. 8, the steps with the same reference numerals as the operation flow shown in Figs. 5 and 6 indicate the same operations.

[0076]

The map matching unit 113 transmits the data indicating the position coordinates after the map matching to the passage determination unit 116 whenever the map matching unit 113 performs the map matching. The accidental error calculation unit 115 transmits the data indicating the range of the accidental error to the passage determination unit 116 whenever the range of the accidental error is calculated.

[0077]

When the data transmitted from each of the map matching unit 113 and the accidental error calculation unit 115 is received, the passage determination unit 116 of

the on-board unit 110 sequentially determines whether the vehicle has passed the charge point on the basis of the information indicated by the data (S106). For example, the passage determination unit 116 compares the position coordinates after the map matching indicated by the data received from the map matching unit 113 to the position coordinates indicated by the information regarding “the position coordinates (longitude and latitude)” stored in the charge point information storage unit 121. When the position coordinates after the map matching are within a threshold value of the position coordinates indicated by one piece of information regarding “the position coordinates (longitude and latitude)”, the passage determination unit 116 starts passage determination with the charge point at the position coordinates indicated by the information regarding “the position coordinates (longitude and latitude)” as a target. For example, while the position coordinates of the charge point of a passage determination target are within the range of the accidental error which centers on the position coordinates after the map matching and are indicated by the data received from the accidental error calculation unit 115, the passage determination unit 116 determines that the vehicle has not passed the charge point (No in S106). When the position coordinates of the charge point of the passage determination target deviate from the range of the accidental error which centers on the position coordinates after the map matching, the passage determination unit 116 determines that the vehicle has passed the charge point (Yes in S106). When the passage determination unit 116 determines that the vehicle has passed the charge point, the data indicating the information regarding “the charge point ID” of the charge point is transmitted to the charging process unit 117.

[0078]

When the data transmitted from the passage determination unit 116 is received, the charging process unit 117 of the on-board unit 110 reads the information regarding

“the fee (yen)” stored in association with the information regarding “the charge point ID” indicated by the data received from the passage determination unit 116 among the information regarding “the fee (yen)” stored in the charge point information storage unit 121. The charging process unit 117 charges a passage fee by subtracting an amount of electronic money corresponding to the fee indicated by the information from the IC card inserted into the card slot I of the on-board unit 110 (S107). The charging process unit 117 transmits data indicating the result of the charging process to the data output unit 118.

[0079]

When the data transmitted from the charging process unit 117 is received, the data output unit 118 of the on-board unit 110 outputs data for displaying the result of the charging process indicated by the data to the display 150 (S108).

[0080]

The result of the charging process is displayed on the display 150.

[0081]

The passage detection system 100 may include a speaker instead of the display 150 or along with the display 150. In this case, the data output unit 118 of the on-board unit outputs data for outputting the result of the charging process as audio to the speaker.

[0082]

As described above, the passage detection system 100 includes the GPS reception unit 130 that measures its own position using the radio navigation and the autonomous navigation. The passage detection system 100 includes the on-board unit 110 detecting a charge point that a vehicle has passed. The on-board unit 110 specifies the position of the vehicle by correcting a positioning result measured by a positioning device on the basis of systematic error information prepared in advance regarding a

systematic error of the positioning result by the GPS reception unit 130 and on the basis of a travel state of the vehicle. The on-board unit 110 determines whether the vehicle has passed the charge point on the basis of the variation with time in the specified position.

5 [0083]

In the passage detection system 100, for example, it is possible to detect passage of the charge point by the vehicle without receiving an influence of the systematic error of the positioning result by the GPS reception unit 130, for example, even when the vehicle is traveling on a road on which a sky visibility is not sufficiently guaranteed.

10 [0084]

The on-board unit 110 specifies the travel state of the vehicle on the basis of the variation with time in the position of the vehicle specified up to the present time. The on-board unit 110 specifies the position of the vehicle by correcting the positioning result by the GPS reception unit 130 on the basis of the systematic error information prepared in advance regarding the systematic error of the positioning result by the GPS reception unit 130 and the specified travel state of the vehicle.

[0085]

In the passage detection system 100, it is possible to specify the travel state of the vehicle whenever the position of the vehicle is specified.

20 [0086]

The on-board unit 110 performs the map matching on the specified position of the vehicle. The on-board unit 110 calculates the accidental error of the positioning result by the GPS reception unit 130 on the basis of the deviation amount between the specified position of the vehicle and the position indicated by the result obtained through the map matching. When the charge point is within the range of the calculated

25

accidental error, the on-board unit 110 determines that the vehicle has not passed the charge point.

[0087]

In the passage detection system 100, it is possible to prevent erroneous
5 determination that the vehicle has passed the charge point because of influence of the accidental error when the vehicle has not passed the charge point.

[0088]

In the above-described embodiment, the example in which the on-board unit 110 calculates the accidental error of the positioning result by the GPS reception unit 130 on
10 the basis of the deviation amount between the specified first position of the vehicle and the second position indicated by the result obtained by performing the map matching on the first position by correcting the positioning result by the GPS reception unit 130 on the basis of the systematic error information prepared in advance regarding the systematic error of the positioning result by the GPS reception unit 130 and the travel state of the
15 vehicle has been described. However, the on-board unit 110 can calculate the accidental error of the positioning result by the GPS reception unit 130 according to another method. For example, the on-board unit 110 may calculate the accidental error of the positioning result by the GPS reception unit 130 on the basis of the deviation amount between the first position of the positioning result by the GPS reception unit 130 and the second
20 position indicated by the result obtained by performing the map matching on the positioning result by the GPS reception unit 130.

[0089]

Fig. 9 is a diagram showing an example of a hardware configuration of a computer 800 included in the on-board unit 110 according to the embodiment. The
25 computer 800 according to the embodiment includes a central processing unit (CPU) 802,

a random access memory (RAM) 803, a graphic controller 804, and a CPU peripheral unit including a display 805 connected to each other by a host controller 801, an input/output unit including a communication interface 807, a hard disk drive 808, and a compact disk read-only memory (CD-ROM) drive 809 connected to each other by an input/output controller 806, and a legacy input/output unit including a read-only memory (ROM) 810, a flexible disk drive 811, and an input/output chip 812 connected to the input/output controller 806.

[0090]

The host controller 801 connects the RAM 803 to the CPU 802 and the graphic controller 804 accessing the RAM 803 at a high transmission rate. The CPU 802 operates on the basis of programs stored in the ROM 810 and the RAM 803 to control each unit. The graphic controller 804 acquires image data generated on a frame buffer provided inside the RAM 803 by the CPU 802 or the like and displays the image data on the display 805. Instead of this, the graphic controller 804 may include a frame buffer storing image data generated by the CPU 802 or the like therein.

[0091]

The input/output controller 806 connects the host controller 801 to the hard disk drive 808, the CD-ROM drive 809, and the communication interface 807 serving as a relatively high-speed input/output device. The hard disk drive 808 stores programs and data to be used by the CPU 802 inside the computer 800. The CD-ROM drive 809 reads a program or data from the CD-ROM 892 and provides the program or the data to the hard disk drive 808 via the RAM 803.

[0092]

The ROM 810, the flexible disk driver 811, and a relatively low-speed input/output device of the input/output chip 812 are connected to the input/output

controller 806. The ROM 810 stores, for example, a boot program executed at the time of activation by the computer 800 and/or a program dependent on hardware of the computer 800. The flexible disk driver 811 reads a program or data from the flexible disk 893 and provides the program or the data to the hard disk drive 808 via the RAM 803. The input/output chip 812 connects the flexible disk driver 811 to the input/output controller 806 and connects various input/output devices to the input/output controller 806 via, for example, a parallel port, a serial port, a keyboard port, and a mouse port.

[0093]

A program provided to the hard disk drive 808 via the RAM 803 is stored in the flexible disk 893, the CD-ROM 892, or a recording medium such as an integrated circuit (IC) card to be provided by a user. The program read from the recording medium, is installed on the hard disk drive 808 inside the computer 800 via the RAM 803, and is executed by the CPU 802.

[0094]

A program that is installed on the computer 800 and causes the computer 800 to function as the on-board unit 110 causes the computer 800 to function as: the position specifying unit 112 that specifies the position of the vehicle by correcting the positioning result by the GPS reception unit 130 on the basis of the systematic error information prepared in advance regarding the systematic error of the positioning result by the GPS reception unit 130 and the travel state of the vehicle in step S102; and the passage determination unit 116 that determines that the vehicle has passed a charge point in step S106 on the basis of the variation with time in the position specified by the position specifying unit 112.

[0095]

The program may further cause the computer 800 to function as: the travel state

specifying unit 114 that specifies the travel state of the vehicle in step S104 on the basis of the variation with time in the position specified by the position specifying unit 112 up to the present time; and the position specifying unit 112 that specifies the position of the vehicle by correcting the positioning result by the GPS reception unit 130 in step S102
5 on the basis of the systematic error information prepared in advance regarding the systematic error of the positioning result by the GPS reception unit 130 and the travel state of the vehicle specified by the travel state specifying unit 114.

[0096]

The program may further cause the computer 800 to function as: the map
10 matching unit 113 that performs the map matching in step S103 on the position specified by the position specifying unit 112; the accidental error calculation unit 115 that calculates the accidental error of the positioning result by the GPS reception unit 130 in step S105 on the basis of the deviation amount between the position specified by the position specifying unit 112 and the position indicated by the result obtained through the
15 map matching by the map matching unit 113; and the passage determination unit 116 that determines that the vehicle has not passed the charge point in step S106 when the charge point is within the range of the accidental error calculated by the accidental error calculation unit 115.

[0097]

20 The information processing described in the program is read to the computer 800, which functions as the positioning result data input reception unit 111, the position specifying unit 112, the map matching unit 113, the travel state specifying unit 114, the accidental error calculation unit 115, the passage determination unit 116, the charging process unit 117, the data output unit 118, the map data storage unit 119, the systematic
25 error information storage unit 120, and the charge point information storage unit 121

which are specific cooperative means of software and the various hardware resources described above. When such specific means realize the calculation or processing of information according to a use purpose of the computer 800 according to the embodiment, the specific on-board unit 110 according to the use purpose is constructed.

5 [0098]

For example, when communication is performed between the computer 800 and an external device, the CPU 802 executes a communication program loaded on the RAM 803 and instructs the communication interface 807 to perform a communication process on the basis of processing content described in the communication program. Under the control of the CPU 802, the communication interface 807 reads the transmission data stored in a transmission buffer region or the like provided on a storage device such as the RAM 803, the hard disk drive 808, the flexible disk 893, or the CD-ROM 892 and transmits the transmission data via a network, or writes received data received from a network on a reception buffer region or the like provided on the storage device. Thus, the communication interface 807 may transmit transmission and reception data to and from the storage device in conformity with a direct memory access scheme. Instead of this, the transmission and reception data may be transmitted when the CPU 802 reads data from a storage device of a transmission source or from the communication interface 807 and writes the data on the communication interface 807 of a transmission destination or the storage device.

[0099]

The CPU 802 performs various processes on data on the RAM 803 by reading necessary portions or all portions from among files or databases stored in an external storage device such as the hard disk drive 808, the CD-ROM 892, or the flexible disk 893 to the RAM 803 through direct memory access transmission. The CPU 802 rewrites the

processed data on the external storage device through the direct memory access transmission or the like.

[0100]

In such processes, the RAM 803 can be considered to temporarily retain content of the external storage device. Therefore, in the embodiment, the RAM 803, the external storage device, and the like are collectively referred to as a memory, a storage unit, a storage device, or the like. Various kinds of information such as various programs, data, tables, and databases in the embodiment are stored in such a storage device and are information processing targets. The CPU 802 can also maintain a part of the RAM 803 as a cache storage device to perform reading and writing on the cache storage device. In the embodiment, since the cache storage device performs some of the functions of the RAM 803, the cache storage device is also included in the RAM 803, the memory, and/or the storage device unless the cache storage device is separately indicated.

[0101]

The CPU 802 performs various processes including various kinds of calculation, information processing, condition determination, information retrieval, and substitution designated by a command string of a program and described in the embodiment on the data read from the RAM 803 and rewrites the data to the RAM 803. For example, when the condition determination is performed, the CPU 802 determines whether a condition is satisfied, for example, whether various variables indicated in the embodiment are greater than, less than, equal to or greater than, equal to or less than, or equal to other variables or integers. The command string is branched into another command string or a sub-routine is called according to whether or not the condition is satisfied.

[0102]

The CPU 802 can retrieve information stored in files, databases, or the like in the storage device. For example, when a plurality of entries in which each attribute value of a first attribute is associated with an attribute value of a second attribute are stored in the storage device, the CPU 802 retrieves an entry matching a condition by which the attribute value of the first attribute is designated among the plurality of entries stored in the storage device and reads the attribute value of the second attribute stored in this entry. Thus, it is possible to obtain the attribute value of the second attribute associated with the first attribute satisfying a predetermined condition.

[0103]

The program described above or a module may be stored in an external storage medium. As the storage medium, for example, an optical recording medium such as a digital versatile disc (DVD) or a compact disc (CD), a magneto-optical recording medium such as a magneto-optical disc (MO), a tape medium, or a semiconductor memory can be used in addition to the flexible disk 893 or the CD-ROM 892. A storage medium such as a hard disk or a RAM provided in a server system connected to a dedicated communication network or the Internet may be used as the recording medium and a program may be supplied to the computer 800 via a network.

[0104]

Embodiments of the present invention have been described above, but the technical scope of the present invention is not limited to ranges of the foregoing embodiments. It should be apparent to those skilled in the art that various modifications or improvements of the foregoing embodiments can be made. It should be apparent from the description of the claims that the modifications or improvements are also included in the technical scope of the present invention.

[Industrial Applicability]

[0105]

According to the passage detection system, the passage detection method, the passage detection device, the program, and the recording medium described above, it is possible to detect a predetermined position that a vehicle has passed without receiving an influence of an error of a positioning result obtained by a positioning device, for example, even when the vehicle is traveling on a road on which a sky visibility is not sufficiently guaranteed.

[Reference Signs List]

[0106]

- 10 100 Passage detection system
 - 110 On-board unit
 - 111 Positioning result data input reception unit
 - 112 Position specifying unit
 - 113 Map matching unit
 - 15 114 Travel state specifying unit
 - 115 Accidental error calculation unit
 - 116 Passage determination unit
 - 117 Charging process unit
 - 118 Data output unit
 - 20 119 Map data storage unit
 - 120 Systematic error information storage unit
 - 121 Charge point information storage unit
 - 130 GPS reception unit
 - 150 Display
 - 25 800 Computer

	801 Host controller
	802 CPU
	803 RAM
	804 Graphic controller
5	805 Display
	806 Input/output controller
	807 Communication interface
	808 Hard disk drive
	809 CD-ROM drive
10	810 ROM
	811 Flexible disk driver
	812 Input/output chip
	891 Network communication device
	892 CD-ROM
15	893 Flexible disk
	C Center console
	D Dashboard
	I Card slot

CLAIMS

[Claim 1]

A passage detection system detecting passage of a vehicle at a predetermined position, the passage detection system comprising:

a positioning device configured to measure an own position using radio navigation and autonomous navigation; and

a passage detection device configured to detect the passage of the vehicle at the predetermined position;

wherein the passage detection device includes:

a position specifying unit configured to specify a position of the vehicle by correcting a positioning result measured by the positioning device on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result of the positioning device and on the basis of a travel state of the vehicle, the systematic error is assumed to be an error, which exhibits a consistent trend, measured when position coordinates of the positioning result systematically deviate from genuine position coordinates of the position of the vehicle when the position is measured at the same position and in the same travel state; and

a passage determination unit configured to determine whether the vehicle has passed the predetermined position on the basis of a variation with time in the position specified by the position specifying unit.

[Claim 2]

The passage detection system according to claim 1,

wherein the passage detection device further includes a travel state specifying unit configured to specify the travel state of the vehicle on the basis of the variation with time in the position specified by the position specifying unit up to a present time; and

wherein the position specifying unit specifies the position of the vehicle by correcting the positioning result measured by the positioning device on the basis of the systematic error information prepared in advance regarding the system error of the positioning result measured by the positioning device and on the basis of the travel state of the vehicle specified by the travel state specifying unit.

[Claim 3]

A passage detection method of detecting passage of a vehicle at a predetermined position, the method comprising:

a position specifying step of specifying a position of the vehicle by correcting a positioning result measured by a positioning device which measures an own position using radio navigation and autonomous navigation on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result measured by the positioning device and on the basis of a travel state of the vehicle, the systematic error is assumed to be an error, which exhibits a consistent trend, measured when position coordinates of the positioning result systematically deviate from genuine position coordinates of the position of the vehicle when the position is measured at the same position and in the same travel state; and

a passage determination step of determining whether the vehicle has passed the predetermined position on the basis of a variation with time in the position specified in the position specifying step.

[Claim 4]

A passage detection device detecting passage of a vehicle at a predetermined position, the passage detection device comprising:

a position specifying unit configured to specify a position of the vehicle by correcting a positioning result measured by a positioning device which measures an own position using radio navigation and autonomous navigation on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result measured by the positioning device and on the basis of a travel state of the vehicle, the systematic error is assumed to be an error, which exhibits a consistent trend, measured when position coordinates of the positioning result systematically deviate from genuine position coordinates of the position of the vehicle when the position is measured at the same position and in the same travel state; and

a passage determination unit configured to determine whether the vehicle has passed the predetermined position on the basis of a variation with time in the position specified in the position specifying unit.

[Claim 5]

A program causing a computer to function as a passage detection device detecting passage of a vehicle at a predetermined position, the program causing the computer to function as:

a position specifying unit configured to specify a position of the vehicle by correcting a positioning result measured by a positioning device which measures an own position using radio navigation and autonomous navigation on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result measured by the positioning device and on the basis of a travel state of the vehicle, the systematic error is assumed to be an error, which exhibits a consistent trend, measured when position coordinates of the positioning result systematically deviate from genuine position coordinates of the position of the vehicle when the position is measured at the same position and in the same travel state; and

a passage determination unit configured to determine whether the vehicle has passed the predetermined position on the basis of a variation with time in the position specified in the position specifying unit.

[Claim 6]

A recording medium that records a program causing a computer to function as a passage detection device detecting passage of a vehicle at a predetermined position, the recording medium recording the program causing the computer to function as:

a position specifying unit configured to specify a position of the vehicle by correcting a positioning result measured by a positioning device which measures an own position using radio navigation and autonomous navigation on the basis of systematic error information prepared in advance regarding a systematic error of the positioning result measured by the positioning device and on the basis of a travel state of the vehicle, the systematic error is assumed to be an error, which exhibits a consistent trend, measured when position coordinates of the positioning result systematically deviate from genuine position coordinates of the position of the vehicle when the position is measured at the same position and in the same travel state; and

a passage determination unit configured to determine whether the vehicle has passed the predetermined position on the basis of a variation with time in the position specified in the position specifying unit.