

{DESCRIPTION}

{Title of Invention}

APPARATUS FOR VEHICLE AND POSITION CORRECTING METHOD THEREFOR

{Technical Field}

{0001}

The present invention relates to an apparatus for vehicle and a position correcting method therefor.

{Background Art}

{0002}

In the related art, as a function of a car navigation system, etc., there is known technology called map matching, in which a traveling route is identified by using position information obtained by using GPS, etc. and map information prepared in advance (e.g., see Patent Literature 1).

Map matching is also being utilized in road pricing. For example, map matching is being used to detect that a predetermined charging position has been passed through and to then execute charging processing.

{Citation List}

{Patent Literature}

{0003}

{PTL 1}

Japanese Unexamined Patent Application, Publication No.
2006-266986

{Summary of Invention}

{Technical Problem}

{0004}

Recently, in road pricing, there is a demand for immediately notifying the driver when the driver has passed through a predetermined charging position.

With the conventional map matching, however, an error occurs between a traveling position on a map and an actual traveling position due to an error in position detection by means of GPS. Thus, there are cases where it is difficult to instantly recognize that a predetermined charging position has been passed through, and it is difficult to immediately notify the driver that he or she has passed through the charging position.

{0005}

An object of the present invention is to improve the accuracy of position detection after an intersection is passed through.

{Solution to Problem}

{0006}

A first aspect of the present invention is an apparatus for vehicle including a position-information obtaining means for obtaining position information of a moving object; an intersection-information storage means for storing intersection information in which, for at least one intersection, the coordinates of intersection positions are

registered in association with combinations of a direction of entry into and a turning direction at the intersection; a detecting means for detecting, as a reference detection position, the position of the moving object at the time when an angle made by an advancing direction at a first predetermined time before and a current advancing direction has reached a first predetermined angle in an intersection region set for each intersection; an intersection-position obtaining means for obtaining, from the intersection information, the coordinates of a relevant intersection position based on a direction of entry of the moving object into the intersection region and a turning direction of the moving object in the intersection region; and a correcting means for correcting the position information of the moving object obtained by the position-information obtaining means by using (i) the position coordinates of the intersection position obtained by the intersection-position obtaining means and (ii) the reference detection position detected by the detecting means.

{0007}

According to this aspect, for each intersection, the coordinates of intersection positions that serve as references are registered in association with directions of entry into the intersection and turning directions at the intersection. When the moving object passes through an intersection, the

position information is corrected by using the coordinates of an appropriate intersection position based on the direction of entry into and turning direction at the intersection. Thus, for example, compared with the case where the same intersection position is registered irrespective of the direction of entry and turning direction, it is possible to improve the accuracy of position-information correction after passing through the intersection. Accordingly, for example, in the case where a charging position is set ahead of the exit of the intersection, it is possible to quickly detect that the charging position has been passed through. This makes it possible to immediately notify the driver that the charging position has been passed through.

{0008}

In the above apparatus for vehicle, in a case where the angle made by an advancing direction at a second predetermined time before and a current advancing direction, the second predetermined time being longer than the first predetermined time, has reached a second predetermined angle, the second predetermined angle being greater than the first predetermined angle, the detecting means may detect, as a reference position, the position of the moving object where the moving object is at the first predetermined angle relative to the advancing direction at the second predetermined time before based on a traveling history from the second predetermined

time before to a current time.

{0009}

This makes it possible to reliably detect that the moving object has turned at the intersection, while excluding the case where the moving object has passed straight through the intersection in a meandering fashion, etc.

{0010}

The above apparatus for vehicle may further include an angular-velocity sensor, and the detecting means may detect a traveling angle by using an integral value of values measured by the angular-velocity sensor.

{0011}

By detecting the traveling angle by using the angular-velocity sensor, it becomes possible to readily detect the traveling angle while maintaining the desired accuracy.

{0012}

In the above apparatus for vehicle, the correcting means may include a correcting-amount calculating means for calculating an offset vector for making the reference detection position detected by the detecting means coincide with the coordinates of the intersection position obtained by the intersection-position obtaining means; and a position correcting means for correcting, by using the offset vector, the position information of the moving object obtained by the position-information obtaining means.

{0013}

Since the position information is corrected by using the offset vector, in the case where a uniform offset is included in the position information obtained by the position-information obtaining means, it is possible to effectively remove this offset error.

{0014}

In the above apparatus for vehicle, the position correcting means may correct the offset vector by multiplying the offset vector by a weighting coefficient that gradually decreases to zero as time passes, and the position correcting means may correct the position information of the moving object by adding the corrected offset vector to the position information of the moving object obtained by the position-information obtaining means.

{0015}

Since the offset vector is gradually decreased to zero, it is possible to gradually shift to position information detection by the position-information obtaining means.

{0016}

In the above apparatus for vehicle, the position-information obtaining means may include a GPS unit and a dead reckoning means, the correcting means may execute correction for making the reference detection position coincide with the position coordinates of the intersection position, and in a

case where the correcting means has corrected the reference detection position, the position-information obtaining means may adopt a position detected by the dead reckoning means with reference to the intersection position as the position information of the moving object and then switch to adopt a position detected by the GPS unit.

{0017}

Since the GPS unit and the dead reckoning means are used, and the dead reckoning means is used during periods in which higher accuracy is attained with the result of detection by the dead reckoning means while switching to the GPS unit during periods in which a large error is involved in the position detection by the dead reckoning means, it is possible to execute position detection by using an optimal position detecting means in accordance with the period. This makes it possible to improve the accuracy of position-information detection.

{0018}

In the above apparatus for vehicle, the position-information obtaining means the position-information obtaining means may include a GPS unit and a dead reckoning means and may obtain the position information of the moving object by calculating a weighted average of the position information obtained by the dead reckoning means and the position information obtained by the GPS unit, and in a case where the

correcting means has corrected the reference detection position, a large weight may be used for the dead reckoning means immediately after the correction, and a weight for the GPS unit may be gradually increased as time passes.

{0019}

Accordingly, it becomes possible to execute position detection by using an optimal position detecting means in accordance with the period and to gradually shift from the position detection by the dead reckoning means to the position detection by the GPS unit. This makes it possible to maintain the continuity of detected positions.

{0020}

In the above apparatus for vehicle, information obtained by the GPS unit may be used regarding velocity information when the dead reckoning means obtains position information.

{0021}

This makes it possible to overcome the disadvantage of error accumulation with the dead reckoning means.

{0022}

The above apparatus for vehicle may further include an output means for outputting the position information of the moving object obtained by the position-information obtaining means and for outputting corrected position information of the moving object during a period in which the position information of the moving object is being corrected by the

correcting means; and a map matching means for identifying a position of the moving object on a map by using the position information of the moving object output from the output means, the map matching means having map information in which roads are configured of multiple links and each of the links has unique identification information and position information assigned thereto.

{0023}

With this configuration, it becomes possible to improve the accuracy of map matching.

{0024}

In the above apparatus for vehicle, together with the coordinates of each intersection position in the intersection information, the identification information of a link that exists ahead of a turn at the relevant intersection may be registered, and the output means may output the identification information of the link together with the position information of the moving object.

{0025}

By outputting the link ID of a link that the moving object, having passed through an intersection, enters next, as described above, it becomes possible for the map matching means to uniquely identify the link.

{0026}

A second aspect of the present invention is a position

correcting method for an apparatus for vehicle, wherein intersection information is prepared in advance, in which, for at least one intersection, the coordinates of intersection positions are registered in association with combinations of a direction of entry into and a turning direction at the intersection, the position correcting method including a position-information obtaining step of obtaining position information of a moving object; a detecting step of detecting, as a reference detection position, the position of the moving object at the time when an angle made by an advancing direction at a first predetermined time before and a current advancing direction reached a first predetermined angle in an intersection region set for each intersection; an intersection-position obtaining step of obtaining, from the intersection information, the coordinates of a relevant intersection position based on a direction of entry of the moving object into the intersection region and a turning direction of the moving object in the intersection region; and a correcting step of correcting the position information of the moving object obtained in the position-information obtaining step by using the position coordinates of the intersection position obtained in the intersection-position obtaining step and the reference detection position detected in the detecting step.

{0027}

A third aspect of the present invention is a position correcting program for an apparatus for vehicle, wherein intersection information is stored in advance, in which, for at least one intersection, the coordinates of intersection positions are registered in association with combinations of a direction of entry into and a turning direction at the intersection, the position correcting program causing a computer to execute position-information obtaining processing for obtaining position information of a moving object; detection processing for detecting, as a reference detection position, the position of the moving object at the time when an angle made by an advancing direction at a first predetermined time before and a current advancing direction reached a first predetermined angle in an intersection region set for each intersection; intersection-position obtaining processing for obtaining, from the intersection information, the coordinates of a relevant intersection position based on a direction of entry of the moving object into the intersection region and a turning direction of the moving object in the intersection region; and correction processing for correcting the position information of the moving object obtained in the position-information obtaining processing by using the position coordinates of the intersection position obtained in the intersection-position obtaining processing and the reference detection position detected in the detection

processing.

{Advantageous Effects of Invention}

{0028}

According to the present invention, an advantage is afforded in that, in the case where a charging position has been set at a position ahead of an intersection, it is possible to reduce a time delay involved in a notification of passage through the charging position.

{Brief Description of Drawings}

{0029}

{Fig. 1}

Fig. 1 is a diagram showing a functional block diagram of an apparatus for vehicle according to an embodiment of the present invention.

{Fig. 2}

Fig. 2 is a diagram for explaining map information according to the embodiment of the present invention.

{Fig. 3}

Fig. 3 is a diagram for explaining intersection positions that are registered in intersection information.

{Fig. 4}

Fig. 4 is a diagram for explaining the detection of a turn at an intersection by a detecting unit.

{Fig. 5}

Fig. 5 is a diagram for explaining an intersection

region.

{Fig. 6}

Fig. 6 is a graph for explaining a method of detecting a turn and a method of detecting a reference detection position according to a second method of the detecting unit, showing an example of a history of angular-velocity integral values in the case of a right turn.

{Fig. 7}

Fig. 7 is a graph for explaining a method of detecting a turn and a method of detecting a reference detection position according to the second method of the detecting unit, showing an example of a history of angular-velocity integral values in the case of a left turn.

{Fig. 8}

Fig. 8 is a graph for explaining a method of detecting a reference detection position according to a third method of the detecting unit, showing an example of a history of angular-velocity integral values in the case of a right turn.

{Fig. 9}

Fig. 9 is a graph for explaining a method of detecting a reference detection position according to the third method of the detecting unit, showing an example of a history of angular-velocity integral values in the case of a left turn.

{Fig. 10}

Fig. 10 is a diagram for explaining a direction of entry

of a moving object into an intersection region and a turning direction of the moving object in the intersection region.

{Fig. 11}

Fig. 11 is a diagram for explaining a direction of entry of the moving object into an intersection region and a turning direction of the moving object in the intersection region.

{Fig. 12}

Fig. 12 is a diagram for explaining a direction of entry of the moving object into an intersection region and a turning direction of the moving object in the intersection region.

{Fig. 13}

Fig. 13 is a diagram for explaining a direction of entry of the moving object into an intersection region and a turning direction of the moving object in the intersection region.

{Fig. 14}

Fig. 14 is a diagram for explaining position-information correction.

{Fig. 15}

Fig. 15 is a graph showing an example of a weighting coefficient function.

{Fig. 16}

Fig. 16 is a diagram for explaining another example of position-information correction.

{Fig. 17}

Fig. 17 is a graph showing an example of a weighting

coefficient function.

{Fig. 18}

Fig. 18 is a diagram for explaining another example of position-information correction.

{Description of Embodiments}

{0030}

An embodiment of an apparatus for vehicle and a position correcting method therefor according to the present invention will be described below with reference to the drawings.

The apparatus for vehicle according to this embodiment is widely used for road pricing. For example, the apparatus for vehicle is applied to a pricing scheme in which a fixed toll is charged when a toll road has been passed through, a pricing scheme in which a toll corresponding to the distance travelled in a predetermined charging area is charged, etc. The apparatus for vehicle can be applied to both the case where a toll to be collected is determined or charged upon entry into a charging area or a toll road and the case where a toll to be collected is determined or charged upon exit from a charging area or a toll road.

{0031}

Fig. 1 is a diagram showing a functional block diagram of an apparatus for vehicle 1 according to an embodiment of the present invention. For example, the apparatus for vehicle 1 has a computer installed therein, and the functions of the

individual components described below are realized by hardware corresponding to the functions or by a computational processing unit executing programs (a position correcting program, etc.) recorded on a computer-readable recording medium.

As shown in Fig. 1, the apparatus for vehicle 1 includes a positioning unit 10 that outputs position information of a moving object, a map matching unit 30, and a charging processing unit 40.

{0032}

The positioning unit 10 includes, as its main components, a position-information obtaining unit 11, an intersection-information storage unit 12, a detecting unit 13, an intersection-position obtaining unit 14, a correcting unit 15, and an output unit 16.

The position-information obtaining unit 11 obtains position information of the moving object. The position-information obtaining unit 11 includes a GPS unit 111 and a dead reckoning unit 112. The dead reckoning unit 112 identifies the advancing direction of and the distance travelled by the moving object by using values measured by on-board sensors and thereby detects the current position. Examples of the on-board sensors include a gyro, an acceleration sensor, and a velocity sensor.

{0033}

The position-information obtaining unit 11 obtains position information of the moving object, for example, by executing processing for combining (e.g., calculating a weighted average of) a position output from the GPS unit 111 and a position output from the dead reckoning unit 112. For example, the position-information obtaining unit 11 obtains position information of the moving object by using equation (1) given below.

{0034}

$$\text{Position information of the moving object} = w \times \text{Position output from the GPS unit} + (1 - w) \times \text{Position output from the dead reckoning unit} \quad (1)$$

{0035}

In equation (1), w denotes a weighting coefficient that varies dynamically within a range from 0 to 1.0. For example, in a place where it is possible to obtain a position by means of the GPS unit 111, the weighting coefficient w is set to be a relatively large value. On the other hand, in a place where it is impossible or difficult to obtain a position by means of the GPS unit 111, for example, in a tunnel or between tall buildings, the weighting coefficient w is set to be zero or a value close to zero. More specifically, the GPS unit 111 outputs, together with the positioning result at a certain time, the standard deviation s of the error thereof. The standard deviation s takes on a relatively small value in a

place where the reception conditions of the GPS unit 111 are good. On the other hand, the standard deviation s takes on a relatively large value in a place where the reception conditions are poor. For example, the position-information obtaining unit 11 is provided in advance with a formula (e.g., $w = 1 / s$) for calculating the weighting coefficient w , which includes the standard deviation s as a parameter. The position-information obtaining unit 11 calculates the weighting coefficient w by substituting the standard deviation s output from the GPS unit 111 into this formula. As described earlier, the value of w is restricted within the range from 0 to 1.0.

{0036}

The intersection-information storage unit 12 stores intersection information for at least one intersection, in which the coordinates (latitude and longitude) of different intersection positions are registered for individual combinations of a direction of entry into and a turning direction at the intersection. Furthermore, an intersection region R (see Fig. 4), which will be described later, is set for each intersection, and information about this intersection region R is also included in the intersection information.

{0037}

For example, as shown in Fig. 3, at a broad intersection, etc., the traveling route during a turn at the intersection

often varies depending on the direction of entry into the intersection and the turning direction at the intersection (a right turn, a left turn, etc.). Thus, it is preferred to set a reference position of an intersection in accordance with the direction of entry and the turning direction. This is because the accuracy of position-information correction at an intersection is likely to be degraded if a reference position of an intersection is set uniformly (e.g., at the center of the intersection) irrespective of the direction of entry and the turning direction.

{0038}

In this embodiment, for example, as shown in Fig. 3, the coordinates of an intersection position A are registered for the case where the direction of entry is the South and the turning direction is a left turn, whereas the coordinates of an intersection position B are registered for the case where the direction of entry is the South and the turning direction is a right turn.

The directions of entry and turning directions associated with the coordinates of intersection positions should preferably be set with some margins. This is because the direction of entry conceivably varies depending on the moving object when a road is broad and because the position detection and direction detection by the GPS unit 111 and the dead reckoning unit 112 involve errors.

{0039}

As shown in Fig. 4, the detecting unit 13 determines that the moving object has turned at an intersection when the angle θ made by the advancing direction at a first predetermined time T_1 [seconds] before and the current advancing direction (hereinafter referred to as the "turning angle θ ") in the intersection region R set for each intersection has reached a first predetermined angle θ_1 [deg] and detects the position of the moving object at that time as a reference detection position.

Here, the first predetermined time T_1 [seconds] and the first predetermined angle θ_1 are values that may be set arbitrarily. For example, the first predetermined time T_1 [seconds] is set between 5 [seconds] and 20 [seconds], and the first predetermined angle θ_1 is set between 40 [deg] and 65 [deg]. Obviously, these values may be set outside these ranges depending on the case.

For example, the first predetermined time T_1 [seconds] is set to be 15 [seconds], and the first predetermined angle θ_1 is set to be 45 [deg].

{0040}

Alternatively, the detecting unit 13 may determine that the moving object has turned at an intersection when the angle θ made by the advancing direction at a second predetermined time T_2 [seconds] before, which is earlier than the first

predetermined time T_1 [seconds] before, and the current advancing direction has reached a second predetermined angle θ_2 [deg], which is greater than the first predetermined angle θ_1 [deg], in the intersection region R set for each intersection and then may detect the position of the moving object at the time when the turning angle θ reached the first predetermined angle θ_1 [deg] as a reference detection position based on the traveling route from the present back to the second predetermined time T_2 [seconds] before.

{0041}

Here, the second predetermined time T_2 [seconds] and the second predetermined angle θ_2 are values that may be set arbitrarily. For example, the second predetermined time T_2 [seconds] is set between 25 [seconds] and 35 [seconds], and the second predetermined angle θ_2 is set between 80 [deg] and 95 [deg]. Obviously, these values may be set outside these ranges depending on the case.

{0042}

As shown in Fig. 5, for example, the intersection region R is set so as to have a radius x [m] about the center O of each intersection. Here, the radius x [m] is a value that may be set arbitrarily. Although the intersection regions R should preferably be set such that adjacent ones do not overlap each other, in the case where there is an overlap, it is determined that the moving object has turned a nearer

intersection.

{0043}

Examples of the methods of detecting a turn at an intersection and detecting the above-described reference detection position by the detecting unit 13 include the following methods.

[First method]

For example, the detecting unit 13 monitors the integral value of an angular-velocity sensor provided in the moving object, determines that the moving object has turned at an intersection when the integral value of the angular-velocity sensor from the first predetermined time T_1 [seconds] before to the current time has reached a value corresponding to the first predetermined angle θ_1 [deg], and detects the position of the moving object at that time as a reference detection position.

{0044}

[Second method]

As shown in Fig. 6, the detecting unit 13 monitors the integral value from the angular-velocity sensor from the second predetermined time T_2 [seconds] before to the current time, the second predetermined time T_2 [seconds] being longer than the first predetermined time T_1 [seconds], and determines that the moving object has turned at an intersection in the case where it has detected that the angular-velocity integral

value from the second predetermined time T_2 [seconds] before has reached a value Z_2 corresponding to the second predetermined angle θ_2 , which is greater than the first predetermined angle θ_1 . Then, the detecting unit 13 detects, as a reference detection position, the position of the moving object at the time when the angular-velocity integral value reached a value Z_1 corresponding to the first predetermined angle θ_1 (the position of the moving object at the time indicated by a double circle in Fig. 6) based on the history of the angular-velocity integral value from the second predetermined time T_2 [seconds] before to the current time.

{0045}

Figs. 6 and 7 shows examples in which the first predetermined time T_1 [seconds] is set to be 15 [seconds], the first predetermined angle θ_1 is set to be 45 [deg], the second predetermined time T_2 [seconds] is set to be 30 [seconds], and the second predetermined angle θ_2 is set to be 90 [deg]. Fig. 6 shows the history of the angular-velocity integral value Z in the case of a right turn, and Fig. 7 shows the history of the angular-velocity integral value Z in the case of a left turn. It is possible to distinguish between a right turn and a left turn by distinguishing whether the integral value is positive or negative.

{0046}

The second predetermined angle θ_2 should preferably be

set to be an angle that is sufficiently large to ascertain that the moving object has turned at an intersection (e.g., 90 [deg]). More specifically, with the first method described above, for example, in the case where the traveling direction of the moving object is considerably changed to detour around an automobile stopped at an intersection and the moving object passes straight through the intersection in a meandering fashion, there is a possibility of wrongly ascertaining that the moving object has turned at the intersection. In contrast, with the second method, since it is determined that the moving object has turned at an intersection when the turning angle θ has reached the second predetermined angle θ_2 , it is possible to exclude the case where the moving object has passed straight through the intersection in a meandering fashion.

{0047}

[Third method]

The detecting unit 13 detects the turning angle θ based on, for example, a result of measurement by a gyro, a result of GPS positioning, a difference between the rotation speeds of right and left wheels, a handle steering angle, etc. and determines that the moving object has turned at an intersection when the turning angle θ has reached the first predetermined angle θ_1 or the second predetermined angle θ_2 .

Furthermore, as for the detection of a reference

detection position in this case, as shown in Fig. 8, the detecting unit 13 monitors the values measured by the angular-velocity sensor since the moving object entered the intersection region R and detects, as a reference detection position, the position of the moving object at the time when the value measured by the angular-velocity sensor exhibited a peak value. Fig. 8 shows the history of the angular velocity in the case of a right turn, and Fig. 9 shows the history of the angular velocity in the case of a left turn. It is possible to distinguish between a right turn and a left turn by distinguishing whether the angular velocity is positive or negative.

{0048}

The intersection-position obtaining unit 14 obtains the coordinates of the relevant intersection position from the intersection information stored in the intersection-information storage unit 14 based on the direction of entry of the moving object into the intersection region R and the turning direction thereof in the intersection region.

For example, as shown in Figs. 10 and 11, in the case where the moving object enters an intersection from the South direction and turns right, the intersection-position obtaining unit 14 obtains, from the intersection information, the coordinates of the intersection position for which the South direction is registered as the direction of entry and a right

turn is set as the turning direction in the intersection region. The deviation of the traveling route from the road in Fig. 10 indicates a large error in GPS positioning.

{0049}

As another example, as shown in Fig. 12, in the case where the moving object enters an intersection from the South direction and turns left, the intersection-position obtaining unit 14 obtains, from the intersection information, the coordinates of the intersection position for which the South direction is registered as the direction of entry and a left turn is set as the turning direction in the intersection region.

As another example, as shown in Fig. 13, in the case where the moving object enters an intersection from the East direction and turns right, the intersection-position obtaining unit 14 obtains, from the intersection information, the coordinates of the intersection position for which the East direction is registered as the direction of entry and a right turn is set as the turning direction in the intersection region.

As described above, the coordinates of individually different intersection positions are obtained from the intersection information in accordance with the directions of entry into the intersection region and the turning directions in the intersection region.

{0050}

The correcting unit 15 corrects the position information output from the position-information obtaining unit 11 by using the position coordinates of the intersection position obtained by the intersection-position obtaining unit 14 and the reference detection position detected by the detecting unit 13.

Specifically, the correcting unit 15 includes a correcting-amount calculating unit 151 and a position correcting unit 152. As shown in Fig. 14, the correcting-amount calculating unit 151 calculates an offset vector V_t for making the reference detection position P_1 detected by the detecting unit 13 coincide with the coordinates P_0 of the intersection position obtained by the intersection-position obtaining unit 14.

The position correcting unit 152, by using the offset vector V_t , corrects the position information of the moving object obtained by the position-information obtaining unit 11. For example, the position correcting unit 152 corrects the position information by adding the offset vector V_t to the position information of the moving object obtained by the position-information obtaining unit 11.

{0051}

More specifically, when the correcting-amount calculating unit 151 has calculated the offset vector V_t for making the

reference detection position P1 coincide with the coordinates P0 of the intersection position, the position correcting unit 152 corrects the offset vector V_t by multiplying the offset vector V_t by a weighting coefficient a that gradually decreases to zero as time passes.

For example, as shown in Fig. 15, the position correcting unit 152 has a function in which the weighting coefficient a is 1 during a predetermined period (the period until time T_3 in Fig. 15) from the time when the reference detection position P1 is detected by the GPS unit 111 (hereinafter referred to as the "correction start time") and then the weighting coefficient a decreases to zero at a constant rate during a predetermined period (the period from time T_3 to time T_4 in Fig. 15).

{0052}

The position correcting unit 152, by using this function, obtains the weighting coefficient a corresponding to the time elapsed since the correction start time and corrects the offset vector V_t by multiplying the offset vector V_t by the obtained weighting coefficient a . Then, the position correcting unit 152 corrects the position information of the moving object obtained by the position-information obtaining unit 11 by adding the corrected offset vector to the position information of the moving object.

Thus, as shown in Fig. 14, the values of the corrected

position information become closer to those of the position information obtained by the position-information obtaining unit 11 as the position becomes farther from the vicinity of an intersection.

{0053}

The output unit 16 outputs the corrected position information to the map matching unit 30 in the case where the position has been corrected by the correcting unit 15, whereas the output unit 16 outputs the position information output from the position-information obtaining unit 11 to the map matching unit 30 in the case where the position has not been corrected by the correcting unit 15. Thus, the output unit 16 outputs the position information received from the correcting unit 15 until the weighting coefficient a becomes zero, whereas the output unit 16 outputs the position information of the moving object output from the position-information obtaining unit 11 after the weighting coefficient a becomes zero.

{0054}

The map matching unit 30 has map information in which roads are constituted of multiple links and each link has unique identification information (link ID) assigned thereto. The map matching unit 30 identifies a link that is closest to the current position of the moving object by using the position information of the moving object output from the

positioning unit 10.

{0055}

In the map information, for example, as shown in Fig. 2, roads are virtually divided into multiple links, and each of the links has an associated link ID, which serves as identification information unique to the link, and associated position information (e.g., latitude and longitude). In the map information, nodes (see black dots in the figure) are set at road intersections and branches, and basically the line segments between nodes are defined as links. Alternatively, the links that have been set as described above may be further divided into smaller segments to configure multiple links between nodes. In Fig. 2, 44885, 43492, 31847, etc. represent individual link IDs.

The map matching unit 30 identifies the current position of the moving object on a road by identifying, from the map information, the link ID corresponding to the position information of the moving object output from the positioning unit 10.

{0056}

The charging processing unit 40 has a database (not shown) in which link IDs for which positions related to charging have been set are registered. The charging processing unit 40 executes processing related to charging in the case where a link ID registered in the database is input

from the map matching unit 30. Examples of the processing related to charging include processing for notifying the driver of the start of charging or the fixing of a toll to be collected, processing for starting charging, and processing for fixing a toll to be collected.

{0057}

Next, the operation of the apparatus for vehicle 1 according to this embodiment will be described.

First, the position-information obtaining unit 11 sequentially obtains position information of the moving object according to equation (1), given earlier, by using the position detected by the GPS unit 111 and the position detected by the dead reckoning unit 112 and outputs the position information to each of the detecting unit 13, the intersection-position obtaining unit 14, the correcting unit 15, and the output unit 16.

The detecting unit 13 determines whether the moving object has entered any intersection region R or not based on the intersection regions R registered in the intersection information stored in the intersection-information storage unit 12 and the position information received from the position-information obtaining unit 11. In the case where it is determined, as a result, that the moving object has entered an intersection region R, the detecting unit 13 determines whether the moving object has turned the relevant intersection

or not. Then, in the case where it is determined that the moving object has turned at the intersection, the detecting unit 13 detects, as a reference detection position, the position of the moving object at the time when the angle θ made by the advancing direction at the first predetermined time T_1 [seconds] earlier and the current advancing direction (hereinafter referred to as the "turning angle θ ") reached the first predetermined angle θ_1 [deg] in the relevant intersection region R.

The methods for carrying out the above determination and detection of the reference detection position have been described earlier.

The detecting unit 13 reports the direction of entry at the time of entry into the intersection region R and the turning direction in the intersection region R to the intersection-position obtaining unit 14 and outputs the reference detection position to the correcting unit 15.

{0058}

Based on the direction of entry into the intersection region R and the turning direction in the intersection region R of the moving object, reported from the detecting unit 13, the intersection-position obtaining unit 14 obtains the coordinates of the relevant intersection position from the intersection information stored in the intersection-information storage unit 12 and outputs the coordinates of the

intersection position to the correcting unit 15.

{0059}

The correcting-amount calculating unit 151 of the correcting unit 15 calculates an offset vector V_t for making the reference detection position detected by the detecting unit 13 coincide with the position coordinates of the intersection position obtained by the intersection-position obtaining unit 14 (see Fig. 14) and outputs the offset vector V_t to the position correcting unit 152.

The position correcting unit 152 adds the result of multiplying the offset vector V_t by a weighting coefficient a obtained from a function shown in Fig. 15 to the position information of the moving object received from the position-information obtaining unit 11, thereby correcting the position information of the moving object, and outputs the corrected position information to the output unit 16.

{0060}

During periods in which corrected position information is being input from the correcting unit 15, the output unit 16 outputs the corrected position information to the map matching unit 30. On the other hand, during periods in which corrected position information is not being input from the correcting unit 15, the output unit 16 outputs the position information output from the position-information obtaining unit 11 to the map matching unit 30.

{0061}

The map matching unit 30 obtains a link ID corresponding to the position information input from the output unit 16 from map information and outputs the link ID to the charging processing unit 40.

The charging processing unit 40 searches a database (not shown) by using the link ID input from the map matching unit 30 as a key and, for example, executes charging processing in the case where the link ID input from the map matching unit 30 is registered in the database. For example, in the case of a link ID that requires a notification about charging, the charging processing unit 40 sends a notification about charging to the driver.

{0062}

As described above, with the apparatus for vehicle 1 and the position correcting method therefor according to this embodiment, for each intersection, the coordinates of intersection positions that serve as references are registered in association with directions of entry into the intersection and turning directions at the intersection. When the moving object passes through an intersection, the position information is corrected by using the coordinates of an appropriate intersection position based on the direction of entry into and turning direction at the intersection. Thus, for example, compared with the case where the same

intersection position is registered irrespective of the direction of entry and turning direction, it is possible to improve the accuracy of position-information correction after passing through the intersection. Accordingly, for example, in the case where a charging position is set ahead of the exit of the intersection, it is possible to quickly detect that the charging position has been passed through. This makes it possible to immediately notify the driver that the charging position has been passed through.

{0063}

With the apparatus for vehicle 1 and the position correcting method therefor according to the embodiment described above, after an intersection is passed, the position information is corrected by adding an offset vector V_t in accordance with time to the result of positioning by the GPS unit 111. Although this method is effective when substantially the same offset is constantly applied, the detection error of the GPS unit 111 may change as time passes. In this case, an expected level of accuracy may not necessarily be attained with the above-described position detection based on the offset vector V_t . Thus, the following correcting method may be employed instead of the above-described correcting method.

{0064}

For example, as shown in Fig. 16, after the reference

detection position detected by the detecting unit 13 is made to coincide with the position coordinates of the intersection position, when calculating the position information of the moving object, the weighting coefficient w in equation (1) given earlier may be set to zero to switch to position detection by the dead reckoning unit 112 with reference to the position coordinates of the intersection position.

Accordingly, the result of positioning by the GPS unit 111 is not reflected, and the position information detected by the dead reckoning unit 112 is output from the position-information obtaining unit 11 to the output unit 16 as the position information of the moving object and is then output to the map matching unit 30. In this case, after the weighting coefficient a of the offset vector V_t becomes zero, for example, the weighting coefficient w is determined according to the earlier-described formula based on the standard deviation s .

{0065}

Alternatively, instead of completely switching between the obtaining of position information by the dead reckoning unit 112 and the obtaining of position information by the GPS unit 111 as described above, for example, as shown in Fig. 17, a function with which the weighting coefficient w increases gradually may be prepared in advance, and the position information of the moving object may be obtained by using this

function.

{0066}

Accordingly, at the correction start time, the position information of the moving object in which the result of detection by the dead reckoning unit 112 is reflected more strongly is output to the output unit 16, and as time passes, the position information of the moving object in which the result of detection by the GPS unit 111 is reflected more strongly is output to the output unit 16.

For example, the position detection by the dead reckoning unit 112 is executed by integrating the values measured by sensors. Thus, although a certain level of accuracy can be expected at the beginning, errors increase as time passes, which results in the problem of degraded detection accuracy. Therefore, the dead reckoning unit 112 is mainly used during an initial period of correction, in which the detection accuracy of the dead reckoning unit 112 is expected to be higher than that of the GPS unit 111, then the weight of the position detection by the GPS unit 111 is gradually increased, and finally, the operation is completely switched to position detection by the GPS unit 111. This makes it possible to employ an appropriate position detecting means in accordance with the elapse of time, which makes it possible to further improve the accuracy of position detection.

{0067}

Alternatively, as a modification of the above-described method, as shown in Fig. 18, the result of positioning by the GPS unit 111 may be used for velocity detection by the dead reckoning unit 112. For example, integration by an acceleration sensor is sometimes used for velocity, and in such cases, there is a concern that the accuracy of velocity detection will gradually degrade due to the accumulation of errors as described above. Thus, for velocity detection, in which errors accumulate, the result of positioning by the GPS unit 111 may be used to avoid an increase in errors due to integration.

{0068}

Furthermore, although only the position information is output from the positioning unit 10 to the map matching unit 30 in this embodiment, a link ID that exists ahead of a turn at the intersection may be output together with the position information. By outputting the link ID of the link that the moving object enters next after passing through the intersection, it becomes possible for the map matching unit 30 to uniquely identify the link.

In order to attach such a link ID, for example, in association with the coordinates of each intersection position, a link ID that exists ahead of a turn at the intersection should be registered.

{0069}

Although the embodiment of the present invention has been described above in detail with reference to the drawings, specific configurations are not limited to the embodiment, and the present invention encompasses design modifications, etc. that do not depart from the scope thereof.

{Reference Signs List}

{0070}

- 1 Apparatus for vehicle
- 10 Positioning unit
- 11 Position-information obtaining unit
- 12 Intersection-information storage unit
- 13 Detecting unit
- 14 Intersection-position obtaining unit
- 15 Correcting unit
- 16 Output unit
- 30 Map matching unit
- 40 Charge processing unit
- 111 GPS unit
- 112 Dead reckoning unit
- 151 Correcting-amount calculating unit
- 152 Position correcting unit

{CLAIMS}

{Claim 1}

An apparatus for vehicle comprising:

a position-information obtaining means for obtaining position information of a moving object;

an intersection-information storage means for storing intersection information in which, for at least one intersection, the coordinates of intersection positions are registered in association with combinations of a direction of entry into and a turning direction at the intersection;

a detecting means for detecting, as a reference detection position, a position of the moving object at the time when an angle made by an advancing direction at a first predetermined time before and a current advancing direction reached a first predetermined angle in an intersection region set for each intersection;

an intersection-position obtaining means for obtaining, from the intersection information, the coordinates of a relevant intersection position based on a direction of entry of the moving object into the intersection region and a turning direction of the moving object in the intersection region; and

a correcting means for correcting the position information of the moving object obtained by the position-information obtaining means by using the position coordinates

of the intersection position obtained by the intersection-position obtaining means and the reference detection position detected by the detecting means.

{Claim 2}

The apparatus for vehicle according to Claim 1, wherein, in a case where an angle made by an advancing direction at a second predetermined time before and a current advancing direction, the second predetermined time being longer than the first predetermined time, has reached a second predetermined angle, the second predetermined angle being greater than the first predetermined angle, the detecting means detects, as a reference position, the position of the moving object where the moving object is at the first predetermined angle relative to the advancing direction at the second predetermined time before based on a traveling history from the second predetermined time before to a current time.

{Claim 3}

The apparatus for vehicle according to Claim 1 or 2, further comprising an angular-velocity sensor,

wherein the detecting means detects a traveling angle by using an integral value of values measured by the angular-velocity sensor.

{Claim 4}

The apparatus for vehicle according to any one of Claims 1 to 3,

wherein the correcting means includes:

a correcting-amount calculating means for calculating an offset vector for making the reference detection position detected by the detecting means coincide with the coordinates of the intersection position obtained by the intersection-position obtaining means; and

a position correcting means for correcting, by using the offset vector, the position information of the moving object obtained by the position-information obtaining means.

{Claim 5}

The apparatus for vehicle according to Claim 4, wherein the position correcting means corrects the offset vector by multiplying the offset vector by a weighting coefficient that gradually decreases to zero as time passes, and the position correcting means corrects the position information of the moving object by adding the corrected offset vector to the position information of the moving object obtained by the position-information obtaining means.

{Claim 6}

The apparatus for vehicle according to any one of Claims 1 to 5,

wherein the position-information obtaining means includes:

a GPS unit; and

a dead reckoning means,

wherein the correcting means executes correction for making the reference detection position coincide with the position coordinates of the intersection position, and

wherein, in a case where the correcting means has corrected the reference detection position, the position-information obtaining means adopts a position detected by the dead reckoning means with reference to the intersection position as the position information of the moving object and then switches to adopt a position detected by the GPS unit.

{Claim 7}

The apparatus for vehicle according to any one of Claims 1 to 5,

wherein the position-information obtaining means includes a GPS unit and a dead reckoning means and obtains the position information of the moving object by calculating a weighted average of the position information obtained by the dead reckoning means and the position information obtained by the GPS unit, and

wherein, in a case where the correcting means has corrected the reference detection position, a large weight is used for the dead reckoning means immediately after the correction, and a weight for the GPS unit is gradually increased as time passes.

{Claim 8}

The apparatus for vehicle according to Claim 6 or 7,

wherein information obtained by the GPS unit is used regarding velocity information when the dead reckoning means obtains position information.

{Claim 9}

The apparatus for vehicle according to any one of Claims 1 to 8, further comprising:

an output means for outputting the position information of the moving object obtained by the position-information obtaining means and for outputting corrected position information of the moving object during a period in which the position information of the moving object is being corrected by the correcting means; and

a map matching means for identifying a position of the moving object on a map by using the position information of the moving object output from the output means, the map matching means having map information in which roads are configured of multiple links and each of the links has unique identification information and position information assigned thereto.

{Claim 10}

The apparatus for vehicle according to Claim 9, wherein, together with the coordinates of each intersection position in the intersection information, the identification information of a link that exists ahead of a turn at the relevant intersection is registered, and

wherein the output means outputs the identification information of the link together with the position information of the moving object.

{Claim 11}

A position correcting method for an apparatus for vehicle, wherein intersection information is prepared in advance, in which, for at least one intersection, the coordinates of intersection positions are registered in association with combinations of a direction of entry into and a turning direction at the intersection, the position correcting method comprising:

- a position-information obtaining step of obtaining position information of a moving object;

- a detecting step of detecting, as a reference detection position, the position of the moving object at the time when an angle made by an advancing direction at a first predetermined time before and a current advancing direction reached a first predetermined angle in an intersection region set for each intersection;

- an intersection-position obtaining step of obtaining, from the intersection information, the coordinates of a relevant intersection position based on a direction of entry of the moving object into the intersection region and a turning direction of the moving object in the intersection region; and

a correcting step of correcting the position information of the moving object obtained in the position-information obtaining step by using the position coordinates of the intersection position obtained in the intersection-position obtaining step and the reference detection position detected in the detecting step.

{Claim 12}

A position correcting program for an apparatus for vehicle, wherein intersection information is stored in advance, in which, for at least one intersection, the coordinates of intersection positions are registered in association with combinations of a direction of entry into and a turning direction at the intersection, the position correcting program causing a computer to execute:

position-information obtaining processing for obtaining position information of a moving object;

detection processing for detecting, as a reference detection position, the position of the moving object at the time when an angle made by an advancing direction at a first predetermined time before and a current advancing direction reached a first predetermined angle in an intersection region set for each intersection;

intersection-position obtaining processing for obtaining, from the intersection information, the coordinates of a relevant intersection position based on a direction of entry

of the moving object into the intersection region and a turning direction of the moving object in the intersection region; and

correction processing for correcting the position information of the moving object obtained in the position-information obtaining processing by using the position coordinates of the intersection position obtained in the intersection-position obtaining processing and the reference detection position detected in the detection processing.