

Description

ON-VEHICLE EQUIPMENT FOR DETECTING TRAVELING ROUTE

Technical Field

[0001] This invention relates to an on-vehicle machine for travel route detection.

In more detail, the present invention is designed to be capable of determining a traveling route or travel route accurately by use of a configuration simple in hardware and software in finding a route, by which a vehicle traveled, with the use of an estimated position obtained based on data by a GPS receiver or the like, and road information.

Background Art

[0002] As an electronic toll collection system in a toll road, a radio-based toll collection system is available. With the radio-based toll collection system, communications are carried out between a base station installed at a tollbooth of the toll road and an onboard or on-vehicle machine installed on a vehicle (automobile) to perform recognition and authentication of the vehicle and payment.

The use of such a radio-based toll collection system enables the vehicle to pass the tollbooth in a nonstop, cashless manner.

[0003] Further, a GPS (global positioning system) road toll charging system, which detects the position of the vehicle, the route of travel, and the distance traveled by use of GPS, and charges a toll based on the detection data, is under study as a next-generation radio-based toll collection system.

[0004] With the GPS road toll charging system, radio waves

transmitted from a GPS satellite are received by a GPS receiver provided in the on-vehicle machine. The GPS receiver detects the position, where the vehicle is traveling, based on the received radio waves. When the vehicle enters a toll charging area (for example, a specific urban area), charging of a toll starts, and when the vehicle departs from the toll charging area, charging of the toll ends. While the vehicle is traveling in the toll charging area, the vehicle position, the travel route, and the travel distance are detected.

[0005] The on-vehicle machine starts recording of the travel route at a time when the vehicle enters the toll charging area, determines the distance traveled based on the travel route when the vehicle exits from the toll charging area, charges a toll based on the travel distance, and transmits toll charging information to a toll charging center.

[0006] Such a GPS road toll charging system can abolish the toll booth (gate facilities) which has been necessary under the conventional radio-based toll collection system.

The GPS road toll charging system is intended to charge tolls to vehicles flowing into cities, thereby limiting the amount of traffic and easing congestion in the cities.

[0007] Fig. 7 is an explanation drawing showing the image of the GPS road toll charging system.

A vehicle 01 shown in Fig. 7 is equipped with an on-vehicle machine having a GPS receiver, a GPS antenna, and various sensors. This on-vehicle machine is one which can estimate the position of the vehicle 01 every moment by having the GPS receiver receive radio waves sent from

a plurality of GPS satellites 02.

When radio waves transmitted from the GPS satellites 2 cannot be received and GPS positioning cannot be performed, for example, while the vehicle 01 is traveling in a tunnel, a self-sustaining sensor (distance sensor or direction sensor) is used to detect the distance traveled and the direction of travel, and information on the current position is estimated from information on the previous position detected by the GPS receiver based on the traveled distance and the travel direction detected by the self-sustaining sensor.

[0008] The on-vehicle machine installed on the vehicle 01 finds the route from the coordinates of the estimated position, and takes records, for the purpose of toll charging at a time when the vehicle 01 enters a toll charging area 03. At a time when the vehicle 01 departs from the toll charging area 03, the on-vehicle machine obtains the distance traveled from the route, charges a toll, and transmits toll charging information to a toll charging center 04.

[0009] Next, the on-vehicle machine will be described with reference to Fig. 8. An on-vehicle machine 10 has a GPS receiver 11, an acceleration sensor 12, a vehicle speed sensor 13, a gyro 14, a position estimating section 15, a map matching section 16, a storage section 17, and a toll charging treatment section 18.

[0010] The GPS receiver 11 receives a radio wave sent from the GPS satellite via a GPS antenna (not shown), measures the position based thereon, and outputs information on the position (positional information).

The acceleration sensor 12 detects acceleration

along the direction in which the vehicle is traveling, and outputs an acceleration signal.

The vehicle speed sensor 13 detects the vehicle speed of the vehicle, and outputs a vehicle speed signal.

The gyro 14, which is a direction sensor, detects the direction in which the vehicle is traveling, and outputs a travel direction signal.

[0011] If position measurement by the GPS receiver 11 is possible, the position estimating section 15 outputs the positional information, obtained by the GPS receiver 11, as an estimated position X,Y. This estimated position X,Y is outputted at every preset constant cycle.

[0012] If position measurement by the GPS receiver 11 becomes impossible, on the other hand, the position estimating section 15 finds the position based on the acceleration signal or the speed signal, and the travel direction signal, and outputs the found position as an estimated position X,Y.

That is, in order to allow the acceleration sensor 12 and the speed sensor 13 to function as distance sensors, the distance traveled and the travel direction are calculated based on distance information obtained by integrating the acceleration signal twice, or distance information obtained by integrating the speed signal once, and the travel direction signal obtained from the gyro 14. Furthermore, a relative traveling position is found by using, as a starting point, a position at a point in time immediately before a point in time at which position measurement by the GPS receiver 11 cannot be made any more, and the relative traveling position is outputted as an estimated position

X,Y. This estimated position X,Y is outputted at every preset constant cycle.

[0013] The storage section 17 has map data in storage. As the map data, only road information is stored, and information on buildings, tollbooths or the like is not included.

As the road information, a route R (R1, R2, R3 ... Rn) set per road (link), and a node J (J1, J2, J3 ... Jn) set per nodal point (or node) such as an intersection or a corner are stored, in addition to positional information along each road.

[0014] The map matching section 16 carries out map matching with the use of the estimated position X,Y and the road information stored in the storage section 17. That is, a position on the road, which is the closest to the position indicated by the estimated position X,Y, is outputted as a map matched position mX,mY. The map matched position mX,mY is outputted at every preset constant cycle.

[0015] The toll charging treatment section 18 starts to record the map matched positions mX,mY outputted, one after another, from the map matching section 16 at a time when the vehicle enters the toll charging area. At a time when the vehicle departs from the toll charging area, the toll charging treatment section 18 obtains the distance traveled based on the travel route found from the map matched positions mX,mY, charges a toll, and transmits toll charging information to the toll charging center.

[0016] The configuration of the on-vehicle machine 10 shown in Fig. 8 is basically the same configuration as that of an on-vehicle car navigation device currently in wide use,

and fulfills functions in common therewith. However, the following differences exist:

1) The car navigation device aims at the navigation of a driver. Thus, the on-vehicle machine for car navigation needs to display the position of the driver's own vehicle in real time in a state superposed on the map.

By contrast, it is important for the on-vehicle machine 10 under the GPS road toll charging system to find the distance and the route correctly, and display in real time is not required of the on-vehicle machine 10.

2) A low cost is demanded of the on-vehicle machine 10 under the GPS road toll charging system for the purpose of use. Thus, the data volume which can be held is limited to a low volume as compared with the car navigation device. Under this situation, the on-vehicle machine 10 is desired to hold only road information (positional information along the road, route R, node J), and not to hold information necessary only for navigational display, such as topography, buildings or landmarks.

[0017] Patent Document 1: JP-A-61-56910

Disclosure of the Invention

Problems to be solved by the invention

[0018] The map matching section 16 shown in Fig. 8 selects the position on the road that is the closest to the estimated position X,Y, and outputs it as the map matched position mX,mY. If the calculation error of the estimated position X,Y is great, however, there is a possibility for the selection of the wrong road (route R).

[0019] For example, assume that a road along the route R1 and a road along the route R2 are present, as shown in Fig.

9, and the vehicle is actually traveling on the road along the route R1. In Fig. 9, triangles (Δ) signify the estimated positions X,Y, solid circles ($\bullet$) denote the map matched positions mX,mY, and R1 and R2 represent the routes indicating the roads. Further, the estimated positions X,Y and the map matched positions mX,mY represent data later in terms of time (data newer in terms of time) as their adscripts are larger.

[0020] In the case of Fig. 9, the estimated positions (X1,Y1), (X2,Y2) and (X3,Y3) are close to the route R1. Thus, the map matched positions (mX1,mY1), (mX2,mY2) and (mX3,mY3) are located on the route R1 indicating the road where the vehicle is actually traveling.

However, the estimated positions (X4,Y4) and (X5,Y5) are remote from the route R1 and close to the route R2. Thus, the map matched positions (mX4,mY4) and (mX5,mY5) are located on the route R2. That is, the vehicle is erroneously judged to be traveling on the road indicated by the route R2, although the vehicle is actually traveling on the road indicated by the route R1.

[0021] Such an erroneous judgment of the travel route occurs, with a high probability, particularly after passing an intersection or a branch point.

[0022] If the vehicle is erroneously judged to be traveling on a route different from the route where the vehicle is actually traveling, as mentioned above, there is the problem that the correct travel route cannot be determined, and accurate toll charging cannot be done. Thus, a demand is made that selections of the wrong road (route) be decreased, and accuracy in determining the correct route be increased.

[0023] As a technology for improving the route determination performance of the map matching section in the car navigation device, there is a technique which comprises checking positional information on a tollbooth or the like, when the vehicle passes it, against the position of the tollbooth on the map, and making a correction; or recognizing a building in the surroundings, similarly checking it against map information, and making a correction.

If such a technique is adopted, however, it becomes necessary to store the position of the tollbooth, or information on the building, a landmark or the like in the storage section, and there is a need for a sensor, a processing unit, software or the like necessary for building recognition or recognition of information on tollbooth passage for modifying the position in real time. Thus, system configuration becomes complicated, leading to expensive instruments.

Hence, the adoption of such a position correcting technology for car navigation is not realistic for the on-vehicle machine for the GPS road toll charging system which is required to be low-priced.

[0024] The present invention has been accomplished in the light of the above-described conventional technologies. It is an object of the invention to provide an on-vehicle machine for travel route detection, which can accurately detect the route of travel even after a vehicle has passed an intersection or a branch point, although the system configuration of the on-vehicle machine is simple and inexpensive.

Means for solving the problems

[0025] An aspect of the present invention for solving the above-described problems is an on-vehicle machine for travel route detection, comprising:

a GPS receiver which receives radio waves sent from GPS satellites, makes position measurement based thereon, and outputs positional information;

traveling distance detecting means for outputting traveling distance information indicating a distance traveled by a vehicle;

traveling direction detecting means for outputting traveling direction information indicating a traveling direction of the vehicle;

a position estimating section which, if the position measurement can be made by the GPS receiver, cyclically outputs a position, indicated by the positional information outputted by the GPS receiver, as an estimated position (X,Y), but if the position measurement cannot be made by the GPS receiver, finds a traveling position of the vehicle based on the traveling distance information and the traveling direction information, and cyclically outputs the found position as an estimated position (X,Y);

a storage section having road information in storage, the road information including positional information along roads, a route (R) set per road in order to distinguish respective roads, and a node (J) set per intersection, branch point, or corner of the road;

a map matching section for cyclically outputting a position on the road, which is closest to the position indicated by the estimated position (X,Y), as a map matched position (mX,mY) by use of the estimated position (X,Y) and

the road information; and

a buffering modification section for cyclically outputting a modified position (cX,cY), obtained by modification of the map matched position (mX,mY), by use of the map matched position (mX,mY) and the road information, wherein

the buffering modification section has a storage portion for storing the map matched positions (mX,mY) inputted one after another from the map matching section;

if a plurality of the map matched positions (mX,mY), which are old in terms of time relative to the map matched position (mX,mY) inputted most lately, were located on an old route being a certain identical route, but the newest map matched position (mX,mY) is located on a route different from the old route, the buffering modification section judges this different route to be a new route, and judges that the vehicle has entered the new route;

when the buffering modification section judges that the vehicle has entered the new route, the buffering modification section incorporates the plurality of map matched positions (mX,mY) on the old route from the storage portion;

referring to a state of arrangement of the routes (R) indicated by the road information, the buffering modification section determines whether the old route is present between the new route and an old old route which is a route where the map matched position (mX,mY) older in terms of time than the map matched position (mX,mY) located on the old route is located, and if the old route is present between the old old route and the new route, the buffering

modification section determines that the old route is a correct route, but if the old route is not present between the old old route and the new route, the buffering modification section determines that the old route is a wrong route;

when the buffering modification section determines that the old route is the correct route, the buffering modification section does not change positional data on the plurality of map matched positions (mX,mY) on the old route, but instead, outputs a plurality of the modified positions (cX,cY) whose positional data are identical with those of the plurality of map matched positions (mX,mY); and

when the buffering modification section determines that the old route is the wrong route, the buffering modification section changes the positional data on the plurality of map matched positions (mX,mY) on the old route to positional data on the node (J) on an entrance side of the new route, and outputs the modified positions (cX,cY) whose positional data have been changed to the position on the node (J) on the entrance side of the new route.

[0026] Another aspect of the present invention is an on-vehicle machine for travel route detection, comprising:

a GPS receiver which receives radio waves sent from GPS satellites, makes position measurement based thereon, and outputs positional information;

traveling distance detecting means for outputting traveling distance information indicating a distance traveled by a vehicle;

traveling direction detecting means for outputting traveling direction information indicating a traveling

direction of the vehicle;

a position estimating section which, if the position measurement can be made by the GPS receiver, cyclically outputs a position, indicated by the positional information outputted by the GPS receiver, as an estimated position (X,Y), but if the position measurement cannot be made by the GPS receiver, finds a traveling position of the vehicle based on the traveling distance information and the traveling direction information, and cyclically outputs the found position as an estimated position (X,Y);

a storage section having road information in storage, the road information including positional information along roads, a route (R) set per road in order to distinguish respective roads, and a node (J) set per intersection, branch point, or corner of the road;

a map matching section for cyclically outputting a position on the road, which is closest to the position indicated by the estimated position (X,Y), as a map matched position (mX,mY) by use of the estimated position (X,Y) and the road information; and

a buffering modification section for cyclically outputting a modified position (cX,cY), obtained by modification of the map matched position (mX,mY), by use of the map matched position (mX,mY) and the road information,

wherein

the buffering modification section has a storage portion for storing the map matched positions (mX,mY) inputted one after another from the map matching section;

if a plurality of the map matched positions (mX,mY), which are old in terms of time relative to the map matched

position (mX,mY) chronologically immediately before the map matched position (mX,mY) inputted most lately, were located on an old route being a certain identical route, but the newest map matched position (mX,mY) and the map matched position (mX,mY) chronologically immediately before the newest map matched position (mX,mY) are located on an identical route different from the old route, the buffering modification section judges this different route to be a new route, and judges that the vehicle has entered the new route;

when the buffering modification section judges that the vehicle has entered the new route, the buffering modification section incorporates the plurality of map matched positions (mX,mY) on the old route from the storage portion;

referring to a state of arrangement of the routes (R) indicated by the road information, the buffering modification section determines whether the old route is present between the new route and an old old route which is a route where the map matched position (mX,mY) older in terms of time than the map matched position (mX,mY) located on the old route is located, and if the old route is present between the old old route and the new route, the buffering modification section determines that the old route is a correct route, but if the old route is not present between the old old route and the new route, the buffering modification section determines that the old route is a wrong route;

when the buffering modification section determines that the old route is the correct route, the buffering

modification section does not change positional data on the plurality of map matched positions (mX,mY) on the old route, but instead, outputs a plurality of the modified positions (cX,cY) whose positional data are identical with those of the plurality of map matched positions (mX,mY); and

when the buffering modification section determines that the old route is the wrong route, the buffering modification section changes the positional data on the plurality of map matched positions (mX,mY) on the old route to positional data on the node (J) on an entrance side of the new route, and outputs the modified positions (cX,cY) whose positional data have been changed to the position on the node (J) on the entrance side of the new route.

[0027] Still another aspect of the present invention is the above-mentioned on-vehicle machine for travel route detection, further comprising:

a toll charging treatment section for obtaining a distance traveled based on a traveling route found from the modified positions (cX,cY) outputted from the buffering modification section, and performing a toll charging treatment.

Effects of the Invention

[0028] According to the present invention, it is determined, by reference to the route R and the node J of the road information, whether the position indicated by the map matched position obtained by map matching of the estimated position is located on the correct route. If this position is located on the wrong route, positional information is modified. As a result, determinations of the wrong road (route) can be decreased, and the estimated position can

be modified to lie on the correct route. Thus, the correct route can be found.

[0029] Furthermore, the storage section of the on-vehicle machine for travel route detection is designed to hold only the road information (positional information along the road, the route R, the node J), and not to hold information necessary only for navigational display, such as topography, buildings or landmarks. Thus, the configuration simple in software as well as hardware and decreased in data volume can be realized, and cost reduction can be achieved.

Brief Description of the Drawings

[0030] [Fig. 1] is a configurational diagram showing an on-vehicle machine for travel route detection according to Embodiment 1 of the present invention.

[Fig. 2] is a block diagram showing a buffering modification section used in the on-vehicle machine of Embodiment 1.

[Fig. 3(a)] is an explanation drawing showing concrete modifying actions in the buffering modification section.

[Fig. 3(b)] is a characteristics table showing positional data before modification (left column) and positional data after modification (right column).

[Fig. 4(a)] is an explanation drawing showing concrete modifying actions in the buffering modification section.

[Fig. 4(b)] is a characteristics table showing positional data before modification (left column) and positional data after modification (right column).

[Fig. 5(a)] is an explanation drawing showing

concrete modifying actions in the buffering modification section.

[Fig. 5(b)] is a characteristics table showing positional data before modification (left column) and positional data after modification (right column).

[Fig. 6(a)] is an explanation drawing showing concrete modifying actions in the buffering modification section.

[Fig. 6(b)] is a characteristics table showing positional data before modification (left column) and positional data after modification (right column).

[Fig. 7] is an explanation drawing showing a GPS road toll charging system.

[Fig. 8] is a configurational diagram showing an on-vehicle machine for travel route detection according to a conventional technology.

[Fig. 9] is an explanation drawing showing a map matching technique in the conventional technology.

Description of the Numerals

- [0031] 100 On-vehicle machine
 - 111 GPS receiver
 - 112 Acceleration sensor
 - 113 Vehicle speed sensor
 - 114 Gyro
 - 115 Position estimating section
 - 116 Map matching section
 - 117 Storage section
 - 118 Toll charging treatment section
- 200 Buffering modification section
- 201 Memory

- 211 Determining function portion
- 212 Incorporating function portion
- 213 Modifying function portion

Best Mode for Carrying Out the Invention

[0032] The best mode for carrying out the present invention will now be described in detail based on the following embodiments:

Embodiment 1

[0033] Fig. 1 shows an on-vehicle machine 100 for travel route detection according to Embodiment 1 of the present invention.

The on-vehicle machine 100 has a GPS receiver 111, an acceleration sensor 112, a vehicle speed sensor 113, a gyro 114, a position estimating section 115, a map matching section 116, a storage section 117, a toll charging treatment section 118, and a buffering modification section 200.

[0034] The GPS receiver 111 receives a radio wave sent from a GPS satellite via a GPS antenna (not shown), measures the position of a vehicle based thereon, and outputs positional information.

The acceleration sensor 112 detects acceleration along the direction in which the vehicle is traveling, and outputs an acceleration signal.

The vehicle speed sensor 113 detects the vehicle speed of the vehicle, and outputs a vehicle speed signal.

The gyro 114, which is a direction sensor, detects the direction in which the vehicle is traveling, and outputs a travel direction signal.

[0035] If position measurement by the GPS receiver 111 is possible, the position estimating section 115 outputs

positional information, obtained by the GPS receiver 111, as an estimated position X,Y. This estimated position X,Y is outputted at every preset constant cycle.

[0036] If position measurement by the GPS receiver 111 becomes impossible, on the other hand, the position estimating section 115 finds the position based on the acceleration signal or the speed signal, and the travel direction signal, and outputs the found position as an estimated position X,Y.

That is, in order to allow the acceleration sensor 112 and the speed sensor 113 to function as distance sensors, the distance traveled and the travel direction are calculated based on distance information obtained by integrating the acceleration signal twice, or distance information obtained by integrating the speed signal once, and the travel direction signal obtained from the travel direction signal. Furthermore, a relative traveling position is found by using, as a starting point, a position at a point in time immediately before a point in time at which position measurement by the GPS receiver 111 cannot be made any more, and the relative traveling position is outputted as an estimated position X,Y. This estimated position X,Y is outputted at every preset constant cycle.

[0037] The storage section 117 has map data in storage. As the map data, only road information is stored, and information on buildings, tollbooths or the like is not included.

As the road information, a route R (R1, R2, R3 ... Rn) set per road (link) in order to distinguish the respective roads, and a node J (J1, J2, J3 ... Jn) set per nodal point

(or node), such as an intersection, a branch point, or a corner, in order to distinguish the respective nodal points, are stored, in addition to positional information along each road.

[0038] A low cost is demanded of the on-vehicle machine 100 for travel route detection, which is applied to the GPS road toll charging system, for the purpose of use. Thus, a data volume which can be held is limited to a low volume as compared with a car navigation device. In this view, the on-vehicle machine 100 is designed to hold only road information (positional information along the road, route R, node J), and not to hold information necessary only for navigational display, such as topography, buildings or landmarks. By so doing, a configuration simple in software as well as hardware and decreased in data volume is achieved.

[0039] The map matching section 116 carries out map matching with the use of the estimated position X,Y and the road information stored in the storage section 117. That is, a position on the road, which is the closest to the position indicated by the estimated position X,Y, is outputted as a map matched position mX,mY. The map matched position mX,mY is outputted at every preset constant cycle.

[0040] The buffering modification section 200 modifies the map matched position mX,mY, and outputs a modified position cX,cY. The modified position cX,cY is outputted at every preset constant cycle.

Details of the modification treatment by the buffering modification section 200 will be described later. By making this modification, the route can be determined accurately even after the vehicle passes an intersection

or a branch point.

[0041] The toll charging treatment section 118 starts to record the modified positions cX,cY outputted, one after another, cyclically from the buffering modification section 200 at a time when the vehicle enters the toll charging area. At a time when the vehicle departs from the toll charging area, the toll charging treatment section 118 obtains the distance traveled based on the travel route found from the modified positions cX,cY, performs a toll charging treatment (calculates a toll conformed to the distance traveled), and transmits charging information (calculated toll) to the toll charging center.

[0042] The configuration and modifying actions of functional portions in the buffering modification section 200 will be described by reference to Fig. 2 as a functional block diagram, and Figs. 3(a), 3(b) to 6(a), 6(b).

[0043] The buffering modification section 200 has a memory 201 and a modifying portion 210.

The modifying portion 210 has a new route determining function portion 211, an incorporating function portion for incorporating a map matched position on an old route, and a modifying function portion 213 for modifying the incorporated map matched position on the old route.

The respective function portions 211, 212, 213 are functional portions for computing and determining by software. They are shown in Fig. 2 as a block diagram.

[0044] The respective function portions 211, 212, 213 incorporate the routes R (R1, R2, R3 ... Rn) and the intersections or nodes J (J1, J2, J3 ... Jn) stored in the storage section 117.

[0045] The map matched position mX, mY cyclically outputted from the map matching section 116 is inputted and incorporated into the memory 201.

The memory 201 has a preset memory capacity. In this memory 201, if data on the map matched position mX, mY , which exceeds this memory capacity, is newly inputted, the oldest data on the map matched position mX, mY is erased, and the newly inputted data on the map matched position mX, mY is stored.

[0046] The new route determining function portion 211 checks the map matched positions mX, mY (e.g., $(mX1, mY1)$, $(mX2, mY2)$, $(mX3, mY3)$, $(mX4, mY4)$, $(mX5, mY5)$...), which are inputted one after another into the buffering modification section 200, against the routes R ($R1, R2, R3 \dots Rn$) of the map data (road information) stored in the storage section 117, thereby determining whether the vehicle has entered a new route.

Concretely, assume that a plurality of the map matched positions mX, mY , which are old in terms of time relative to the map matched position mX, mY inputted most lately, were located on a certain identical route (this is called "old route"), but the newest map matched position mX, mY is located on a route different from the old route. In this case, the new route determining function portion 211 judges this different route to be a new route, and makes a judgment that the vehicle has entered the new route.

[0047] When the new route determining function portion 211 judges that the vehicle has entered the new route, the incorporating function portion 212 incorporates the plurality of map matched positions mX, mY on the old route,

and sends them to the modifying function portion 213.

[0048] The modifying function portion 213 takes in the plurality of map matched positions mX, mY on the old route sent from the incorporating function portion 212, then modifies them, and outputs a modified position cX, cY .

[0049] The method of modification is as follows:

1) The modifying function portion 213 deems the new route to show the correct route. That is, the modifying function portion 213 deems that the vehicle is located at a position indicated by the newest map matched position mX, mY on the new route.

2) Then, the modifying function portion 213 refers to the state of arrangement of the routes R shown by the road information, and determines whether the old route exists between the new route and the route where the map matched position mX, mY older in terms of time than the map matched position mX, mY located on the old route is located (this route is called "old old route").

If the old route is present between the old old route and the new route, a determination is made that the old route is the correct route.

If the old route is not present between the old old route and the new route, on the other hand, a determination is made that the old route is the wrong route.

3) If the modifying function portion 213 determines that the old route is the correct route, it does not change the positional data on the plurality of map matched positions mX, mY on the old route, but instead, outputs a plurality of modified positions cX, cY ($cX=mX, cY=mY$) whose positional data are the same as those of the plurality of map matched

positions mX, mY .

If the modifying function portion 213 determines that the old route is the wrong route, it changes the positional data on the plurality of map matched positions mX, mY on the old route to positional data on the node J on the entrance side of the new route, and outputs modified positions cX, cY whose positional data have been changed to the position of the node J on the entrance side of the new route.

[0050] Concrete modifying actions in the buffering modification section 120 will be described using concrete examples of the map matched position mX, mY and the map data (route data R).

[0051] In the example of Fig. 3(a), the newest map matched position $mX5, mY5$ is located on the route R3, a plurality of the map matched positions $(mX2, mY2)$, $(mX3, mY3)$ and $(mX4, mY4)$ old in terms of time are located on the old route R2, and the map matched position $(mX1, mY2)$ is located on the old old route R1.

[0052] Since the newest map matched position $mX5, mY5$ is located on the route R3 which is different from the old route R2, the new route determining function portion 211 judges the route R3 to be a new route, and judges that the vehicle has entered the new route.

[0053] When the new route determining function portion 211 judges that the vehicle has entered the new route R3, the incorporating function portion 212 incorporates the plurality of map matched positions $(mX2, mY2)$, $(mX3, mY3)$, and $(mX4, mY4)$ located on the old route R2.

[0054] Since the old route R2 is not present between the

old old route R1 and the new route R3, the modifying function portion 213 determines that the old route R2 is the wrong route.

Further, the modifying function portion 213 changes the positional data on the plurality of map matched positions (mX2,mY2), (mX3,mY3), and (mX4,mY4) located on the old route R2 to positional data (J1X,J1Y) on the node J1 on the entrance side of the new route R3, and outputs three modified positions cX,cY whose positional data have become the changed positional data (J1X,J1Y).

[0055] After all, the modifying function portion 213 outputs the modified positions cX,cY whose positional data have become the positional data (J1X,J1Y) on the node J1 on the entrance side of the new route R3 deemed to be the correct route, instead of the data on the map matched positions (mX2,mY2), (mX3,mY3), and (mX4,mY4) located on the wrong old route R2. In this manner, erroneous determination of the route is prevented.

Fig. 3(b) shows the positional data before modification (left column) and the positional data after modification (right column).

[0056] In the example of Fig. 4(a), the newest map matched position mX15,mY15 is located on the route R13, a plurality of the map matched positions (mX12,mY12), (mX13,mY13) and (mX14,mY14) old in terms of time are located on the old route R12, and the map matched position (mX11,mY12) is located on the old old route R11.

[0057] Since the newest map matched position mX15,mY15 is located on the route R13 which is different from the old route R12, the new route determining function portion 211

judges the route R13 to be a new route, and judges that the vehicle has entered the new route.

[0058] When the new route determining function portion 211 judges that the vehicle has entered the new route R13, the incorporating function portion 212 incorporates the plurality of map matched positions (mX12,mY12), (mX13,mY13), and (mX14,mY14) located on the old route R12.

[0059] Since the old route R12 is not present between the old old route R11 and the new route R13, the modifying function portion 213 determines that the old route R12 is the wrong route.

Further, the modifying function portion 213 changes the positional data on the plurality of map matched positions (mX12,mY12), (mX13,mY13), and (mX14,mY14) located on the old route R12 to positional data (J11X,J11Y) on the node J11 on the entrance side of the new route R13, and outputs three modified positions cX,cY whose positional data have become the changed positional data (J11X,J11Y).

[0060] After all, the modifying function portion 213 outputs the modified positions cX,cY whose positional data have become the positional data (J11X,J11Y) on the node J11 on the entrance side of the new route R13 deemed to be the correct route, instead of the data on the map matched positions (mX12,mY12), (mX13,mY13), and (mX14,mY14) located on the wrong old route R12. In this manner, erroneous determination of the route is prevented.

Fig. 4(b) shows the positional data before modification (left column) and the positional data after modification (right column).

[0061] In the example of Fig. 5(a), the newest map matched

position mX25,mY25 is located on the route R23, a plurality of the map matched positions (mX22,mY22), (mX23,mY23) and (mX24,mY24) old in terms of time are located on the old route R22, and the map matched position (mX21,mY22) is located on the old old route R21.

[0062] Since the newest map matched position mX25,mY25 is located on the route R23 which is different from the old route R22, the new route determining function portion 211 judges the route R23 to be a new route, and judges that the vehicle has entered the new route.

[0063] When the new route determining function portion 211 judges that the vehicle has entered the new route R23, the incorporating function portion 212 incorporates the plurality of map matched positions (mX22,mY22), (mX23,mY23), and (mX24,mY24) located on the old route R22.

[0064] Since the old route R22 is not present between the old old route R21 and the new route R23, the modifying function portion 213 determines that the old route R22 is the wrong route.

Further, the modifying function portion 213 changes the positional data on the plurality of map matched positions (mX22,mY22), (mX23,mY23), and (mX24,mY24) located on the old route R22 to positional data (J21X,J21Y) on the node J21 on the entrance side of the new route R23, respectively, and outputs three modified positions cX,cY whose positional data have become the changed positional data (J21X,J21Y).

[0065] After all, the modifying function portion 213 outputs the modified positions cX,cY whose positional data have become the positional data (J21X,J21Y) on the node J21 on the entrance side of the new route R23 deemed to be the correct

route, instead of the data on the map matched positions (mX22,mY22), (mX23,mY23), and (mX24,mY24) located on the wrong old route R22. In this manner, erroneous determination of the route is prevented.

Fig. 5(b) shows the positional data before modification (left column) and the positional data after modification (right column).

[0066] In the example of Fig. 6(a), the newest map matched position mX35,mY35 is located on the route R33, the map matched positions (mX32,mY32), (mX33,mY33) and (mX34,mY34) old in terms of time are located on the old route R32, and the map matched position (mX31,mY32) is located on the old old route R31.

[0067] Since the newest map matched position mX35,mY35 is located on the route R33 which is different from the old route R32, the new route determining function portion 211 judges the route R33 to be a new route, and judges that the vehicle has entered the new route.

[0068] When the new route determining function portion 211 judges that the vehicle has entered the new route R33, the incorporating function portion 212 incorporates the plurality of map matched positions (mX32,mY32), (mX33,mY33), and (mX34,mY34) located on the old route R32.

[0069] Since the old route R32 is present between the old old route R31 and the new route R33, the modifying function portion 213 determines that the old route R32 is the correct route.

Further, the modifying function portion 213 does not change the positional data on the plurality of map matched positions (mX32,mY32), (mX33,mY33), and (mX34,mY34)

located on the old route R32, but instead, outputs the modified positions cX,cY whose positional data have become these unchanged positional data.

[0070] After all, the modifying function portion 213 outputs the modified positions cX,cY whose positional data have become the same positional data on the map matched positions (mX32,mY32), (mX33,mY33), and (mX34,mY34) located on the correct old route R2.

Fig. 6(b) shows the positional data before modification (left column) and the positional data after modification (right column). In this example, the positional data before and after modification are the same.

[0071] In the present embodiment, as described above, the erroneous determination of the road (route), which is apt to occur after passage of an intersection or a branch point, is prevented, and the route where the vehicle traveled can be accurately determined.

[0072] Furthermore, the storage section 117 of the on-vehicle machine 100 for travel route detection, which is applied to the GPS road toll charging system, is designed to hold only road information (positional information along the road, route R, node J), and not to hold information necessary only for navigational display, such as topography, buildings or landmarks. Thus, the configuration simple in software as well as hardware and decreased in data volume can be realized, and cost reduction can be achieved.

Embodiment 2

[0073] In Embodiment 1 described above, if a plurality of the map matched positions mX,mY, which were old in terms of time relative to the map matched position mX,mY inputted

most lately, were located on a certain identical route (this is called "old route"), but the newest map matched position mX,mY is located on a route different from the old route, the new route determining function portion 211 of the buffering modification section 200 judges this different route to be a new route, and judges that the vehicle has entered the new route.

[0074] In Embodiment 2, the above method of determination is replaced by the following method: If a plurality of the map matched positions mX,mY, which were old in terms of time relative to the map matched position mX,mY chronologically immediately before the map matched position mX,mY inputted most lately, were located on a certain identical route (this is called "old route"), but the newest map matched position mX,mY and the map matched position mX,mY chronologically immediately before the newest map matched position mX,mY are located on an identical route different from the old route, the new route determining function portion 211 judges this different route to be a new route, and judges that the vehicle has entered the new route.

[0075] In the above-mentioned manner, in a case where the two map matched positions mX,mY, i.e., the newest one and the next newest one, are located on the same route different from the old route, this different route is judged to be a new route, and a judgment is made that the vehicle has entered the new route. Thus, the accuracy of judgment of entry into the new route improves.

[0076] The configuration, actions and functions of other portions are the same as those in Embodiment 1.

Claims

[1] An on-vehicle machine for travel route detection, comprising:

a GPS receiver which receives radio waves sent from GPS satellites, makes position measurement based thereon, and outputs positional information;

traveling distance detecting means for outputting traveling distance information indicating a distance traveled by a vehicle;

traveling direction detecting means for outputting traveling direction information indicating a traveling direction of the vehicle;

a position estimating section which, if the position measurement can be made by the GPS receiver, cyclically outputs a position, indicated by the positional information outputted by the GPS receiver, as an estimated position (X,Y), but if the position measurement cannot be made by the GPS receiver, finds a traveling position of the vehicle based on the traveling distance information and the traveling direction information, and cyclically outputs the found position as an estimated position (X,Y);

a storage section having road information in storage, the road information including positional information along roads, a route (R) set per road in order to distinguish respective roads, and a node (J) set per intersection, branch point, or corner of the road;

a map matching section for cyclically outputting a position on the road, which is closest to the position indicated by the estimated position (X,Y), as a map matched

position (mX,mY) by use of the estimated position (X,Y) and the road information; and

a buffering modification section for cyclically outputting a modified position (cX,cY), obtained by modification of the map matched position (mX,mY), by use of the map matched position (mX,mY) and the road information, wherein

the buffering modification section has a storage portion for storing the map matched positions (mX,mY) inputted one after another from the map matching section;

if a plurality of the map matched positions (mX,mY), which are old in terms of time relative to the map matched position (mX,mY) inputted most lately, were located on an old route being a certain identical route, but the newest map matched position (mX,mY) is located on a route different from the old route, the buffering modification section judges this different route to be a new route, and judges that the vehicle has entered the new route;

when the buffering modification section judges that the vehicle has entered the new route, the buffering modification section incorporates the plurality of map matched positions (mX,mY) on the old route from the storage portion;

referring to a state of arrangement of the routes (R) indicated by the road information, the buffering modification section determines whether the old route is present between the new route and an old old route which is a route where the map matched position (mX,mY) older in terms of time than the map matched position (mX,mY) located on the old route is located, and if the old route is present

between the old old route and the new route, the buffering modification section determines that the old route is a correct route, but if the old route is not present between the old old route and the new route, the buffering modification section determines that the old route is a wrong route;

when the buffering modification section determines that the old route is the correct route, the buffering modification section does not change positional data on the plurality of map matched positions (mX,mY) on the old route, but instead, outputs a plurality of the modified positions (cX,cY) whose positional data are identical with those of the plurality of map matched positions (mX,mY); and

when the buffering modification section determines that the old route is the wrong route, the buffering modification section changes the positional data on the plurality of map matched positions (mX,mY) on the old route to positional data on the node (J) on an entrance side of the new route, and outputs the modified positions (cX,cY) whose positional data have been changed to the position on the node (J) on the entrance side of the new route.

[2] An on-vehicle machine for travel route detection, comprising:

a GPS receiver which receives radio waves sent from GPS satellites, makes position measurement based thereon, and outputs positional information;

traveling distance detecting means for outputting traveling distance information indicating a distance traveled by a vehicle;

traveling direction detecting means for outputting traveling direction information indicating a traveling direction of the vehicle;

a position estimating section which, if the position measurement can be made by the GPS receiver, cyclically outputs a position, indicated by the positional information outputted by the GPS receiver, as an estimated position (X,Y) , but if the position measurement cannot be made by the GPS receiver, finds a traveling position of the vehicle based on the traveling distance information and the traveling direction information, and cyclically outputs the found position as an estimated position (X,Y) ;

a storage section having road information in storage, the road information including positional information along roads, a route (R) set per road in order to distinguish respective roads, and a node (J) set per intersection, branch point, or corner of the road;

a map matching section for cyclically outputting a position on the road, which is closest to the position indicated by the estimated position (X,Y) , as a map matched position (mX,mY) by use of the estimated position (X,Y) and the road information; and

a buffering modification section for cyclically outputting a modified position (cX,cY) , obtained by modification of the map matched position (mX,mY) , by use of the map matched position (mX,mY) and the road information,

wherein

the buffering modification section has a storage portion for storing the map matched positions (mX,mY) inputted one after another from the map matching section;

if a plurality of the map matched positions (mX,mY), which are old in terms of time relative to the map matched position (mX,mY) chronologically immediately before the map matched position (mX,mY) inputted most lately, were located on an old route being a certain identical route, but the newest map matched position (mX,mY) and the map matched position (mX,mY) chronologically immediately before the newest map matched position (mX,mY) are located on an identical route different from the old route, the buffering modification section judges this different route to be a new route, and judges that the vehicle has entered the new route;

when the buffering modification section judges that the vehicle has entered the new route, the buffering modification section incorporates the plurality of map matched positions (mX,mY) on the old route from the storage portion;

referring to a state of arrangement of the routes (R) indicated by the road information, the buffering modification section determines whether the old route is present between the new route and an old old route which is a route where the map matched position (mX,mY) older in terms of time than the map matched position (mX,mY) located on the old route is located, and if the old route is present between the old old route and the new route, the buffering modification section determines that the old route is a correct route, but if the old route is not present between the old old route and the new route, the buffering modification section determines that the old route is a wrong route;

when the buffering modification section determines that the old route is the correct route, the buffering modification section does not change positional data on the plurality of map matched positions (mX,mY) on the old route, but instead, outputs a plurality of the modified positions (cX,cY) whose positional data are identical with those of the plurality of map matched positions (mX,mY); and

when the buffering modification section determines that the old route is the wrong route, the buffering modification section changes the positional data on the plurality of map matched positions (mX,mY) on the old route to positional data on the node (J) on an entrance side of the new route, and outputs the modified positions (cX,cY) whose positional data have been changed to the position on the node (J) on the entrance side of the new route.

[3] The on-vehicle machine for travel route detection according to claim 1 or 2, further comprising:

a toll charging treatment section for obtaining a distance traveled based on a traveling route found from the modified positions (cX,cY) outputted from the buffering modification section, and performing a toll charging treatment.