

# ACCURATE POSITIONING SYSTEM FOR A VEHICLE AND ITS POSITIONING METHOD

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

5           The present invention relates to the vehicle positioning technology and more particularly, to an accurate positioning system for a vehicle and its positioning method.

### 2. Description of Related Art

FIG. 1 is a schematic drawing showing a car equipped with a GPS  
10   navigation system. As illustrated, the GPS navigation system comprises a GPS (Global Position System) **81** and a navigation device **82**. The GPS **81** is adapted to receive and analyze signals from multiple GPS satellites to determine the co-ordinates data of the car. The microprocessor **821** of the navigation device **82** compares the co-ordinates data obtained from the GPS  
15   **81** with its built-in electronic map database (e-Map database) **822**, thereby determining the location of the car on the earth and showing a sign representing the car on the map that is displayed on the display **83** corresponding to the location of the car on the earth to help the driver navigate the car.

20           The GPS **81** receives and analyzes signals from multiple GPS satellites to determine the co-ordinates data of the car, and outputs the co-ordinates data of the car once per second. However, when the car is running at a high speed, the long time interval of outputting the co-ordinates data of the car once per second may result in a big error. If the

microprocessor **821** compares the inaccurate co-ordinates data of the car to the built-in electronic map database **822**, the microprocessor **821** will allocate the sign representing the car on the map at an inaccurate location and thus give a wrong navigation. Further, when the car passes along a tunnel, the GPS **81** cannot receive signals from the GPS satellites and will output inaccurate co-ordinates data, thereby causing the car to be unable to obtain the accurate position. Therefore, there is still room for improvement in the GPS devices for determining vehicle location.

### SUMMARY OF THE INVENTION

The present invention has been accomplished under the circumstances in view. It is therefore the main object of the present invention to provide an accurate positioning system for a vehicle and its accurate positioning method, which eliminates the big error problem of the prior art GPS navigation system resulting from the long time interval of outputting vehicle coordinates data once per second during a high speed running, enabling the vehicle carrying the precision vehicle position system of the present invention to obtain the accurate position. It is another object of the present invention to provide an accurate positioning system for a vehicle and its accurate positioning method, which eliminates the problem of providing an error position data of the prior art GPS navigation system when it is unable to receive GPS satellite signals.

To achieve these and other objects of the present invention, the accurate positioning system is installed in a vehicle, comprising a GPS (Global Positioning System), a Gyro sensor, a vehicle speedometer, and a

controller.

The GPS outputs the current GPS coordinates of the vehicle once per every first time interval. The Gyro sensor outputs an azimuth indicative of the current heading direction of the vehicle. The vehicle speedometer  
5 outputs a vehicle speed signal indicative of the current speed of the vehicle. The controller is respectively and electrically connected to the GPS, the Gyro sensor and the vehicle speedometer. The controller obtains the azimuth from the Gyro sensor and the vehicle speed signal from the vehicle speedometer and reads in the GPS coordinates from the GPS, calculates  
10 reference coordinates of the vehicle subject to the data of the fetched azimuth, vehicle speed signal and GPS coordinates, and assigns the reference coordinates thus calculated to be the accurate coordinates at the corresponding time point for output. The controller also obtains the azimuth from the Gyro sensor and the vehicle speed signal from the vehicle  
15 speedometer and reads in last accurate coordinates once per every second time interval that is shorter than the first time interval, calculates reference coordinates of the vehicle subject to the data of the obtained azimuth, vehicle speed signal and last accurate coordinates, and assigns the reference coordinates thus calculated to be the accurate coordinates at the  
20 corresponding time point for output. After the GPS has outputted the following GPS coordinates as the first time interval has expired, the controller calculates the next reference coordinates of the vehicle and the distance between the next GPS coordinates and the next reference coordinates, and then compares the distance between the next GPS

coordinates and the next reference coordinates to a reference distance, and then assigns the next GPS coordinates to the accurate coordinates for output when the distance between the next GPS coordinates and next reference coordinates is greater than the reference distance, or assigns the next  
5 reference coordinates to be the accurate coordinates for output when the distance between the next GPS coordinates and next reference coordinates is smaller than the reference distance.

To achieve these and other objects of the present invention, the accurate positioning method comprises the steps of: A) obtaining an  
10 azimuth of the heading direction of a vehicle, a vehicle speed signal and a GPS coordinates, wherein the azimuth is outputted by a Gyro sensor installed in the vehicle; the vehicle speed signal is outputted by a vehicle speedometer installed in the vehicle; the GPS coordinates are outputted by a GPS (Global Positioning System) installed in the vehicle once per every  
15 first time interval; B) calculating the reference coordinates of the vehicle and assigning the reference coordinates to be the accurate coordinates at the corresponding time point, and outputting the accurate coordinates; C) obtaining the azimuth of the currently heading direction of the vehicle from the Gyro sensor and the vehicle speed signal from the vehicle speedometer  
20 and reading in the last accurate coordinates once per every second time interval, wherein the second time interval is shorter than the first time interval; D) calculating the reference coordinates of the vehicle and assigning the calculated reference coordinates to be the current accurate coordinates of the vehicle, and outputting the current accurate coordinates;  
25 E) calculating the next reference coordinates of the vehicle after the GPS

has outputted the next GPS coordinates as the first time interval has expired, and then calculating the distance between the next GPS coordinates and the next reference coordinates; and F) comparing the distance between the next GPS coordinates and the next reference coordinates to a reference distance to be greater or smaller than the reference distance, and assigning the next GPS coordinates to be the next accurate coordinates and outputting the next accurate coordinates when the distance between the next GPS coordinates and the next reference coordinates is greater than the reference distance.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing showing a car equipped with a GPS navigation system in accordance with the prior art.

FIG. 2 is a system block diagram of an accurate positioning system in accordance with the present invention.

FIG. 3 shows the content of the coordinates of the accurate positions of the vehicle calculated by the controller at different time points in accordance with the present invention.

FIG. 4 is a flow chart of the present invention.

FIG. 5 is a schematic drawing showing the GSP coordinates and accurate coordinates of the vehicle at different time points in accordance with the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention relates to an accurate positioning system for a vehicle. The accurate positioning system is installed in a vehicle **M** to provide

accurate position to the vehicle **M** in real time. FIG. 2 is a system block diagram of the accurate positioning system. As illustrated, the accurate positioning system comprises a GPS (Global Positioning System) **11**, a Gyro sensor **21**, a vehicle speedometer **22**, a controller **3**, a display **51**, a memory device **12**, and adjusting device **4**, an A/D converter **211**, and an electronic map database (e-Map database) **23**. The GPS **11** outputs the current GPS coordinates **P** of the vehicle **M** at every first time interval **T**. According to this embodiment, the first time interval **T** is one second. The Gyro sensor **21** frequently outputs an azimuth indicating the currently heading direction of the vehicle **M** relative to the global coordinate system.

The A/D converter **211** is electrically connected between the Gyro sensor **21** and the controller **3** to convert the analog signal of the azimuth outputted by the Gyro sensor **21** into digital signal  $\theta$  for computing by the controller **3**.

The vehicle speedometer **22** frequently outputs a vehicle speed signal **V** indicating the current speed of the vehicle **M** relative to the global coordinate system. The vehicle speed signal **V** includes a series of pulse signals. The frequency of the series of pulse signals is directly proportional to the current speed of the vehicle **M** relative to the global coordinate system.

The controller **3** is electrically connected to the GPS **11**, the Gyro sensor **21**, and the vehicle speedometer **22**. The memory device **12** is electrically connected to the controller **3**, and adapted to store the accurate coordinates **A**, which will be described further, and a reference distance **r**.

The memory device **12** can be, for example, a flash memory built in the controller **3**.

The adjusting device **4** is electrically connected to the controller **3**, and adapted to edit the reference distance **r** in the memory device **12**, so as  
5 to adjust the precision of the accurate positioning system. The adjusting device **4** may be a wired input device, a wireless input device such as an infrared transmitter and receiver module means, an input port such as a USB plug, or a wireless receiver for receiving update data from a GPRS cell phone wirelessly. In accordance with this embodiment, the adjusting device  
10 **4** is a keypad installed into the dashboard inside the vehicle **M**.

The display screen **51** and the electronic map database (e-Map database) **23** are respectively and electrically connected to the controller **3**. The electronic map database **23** has stored therein multiple road map data. The controller **3** reads in the road map data from the electronic map  
15 database **23** corresponding to the accurate coordinates **A**, and outputs the road map data to the display screen **51** for display. These road map data in the electronic map database **23** include the names of multiple roads and the coordinates of the starting points and end points of the roads. These road map data further include multiple road links and surrounding facilities  
20 corresponding to the names of the multiple roads.

FIG. 3 shows the content of the accurate coordinates **A** of the vehicle **M** calculated by the controller at different time points (**t0~t10**). FIG. 4 is a flow chart of the present invention. FIG. 5 is a schematic drawing showing the vehicle positions at different time points in accordance with the

present invention. When at the time point  $t_0$ , the controller 3 starts to calculate the accurate coordinates of the vehicle  $M$ . At this time point  $t_0$ , the GPS 11 outputs the GPS coordinate  $P_m$  as the accurate coordinates  $A_0$  of the vehicle  $M$  at the time point  $t_0$ . When at the time point  $t_1$ , the controller 3 fetches the azimuth  $\theta_1$  of the currently heading direction of the vehicle  $M$  from the Gyro sensor 21 and the vehicle speed signal  $V_1$  from the vehicle speedometer 22 and reads in the GPS coordinate  $P_m$  from the GPS 11 (Step A), and then converts the analog heading direction azimuth signal into digital signal (Step A1), and then calculates the reference coordinates  $G_1$  of the vehicle  $M$  subject to equation  $G_1 = P_m + f(V_1, \theta_1)$  (Step B). Thereafter, the controller 3 assigns the reference coordinates  $G_1$  to be the accurate coordinates  $A_1$  at the time point  $t_1$  for output. The controller 3 reads in the road map data from the electronic map database 23 subject to the accurate coordinates  $A_1$ , and outputs the road map data (Step B1).

Thereafter, the controller 3 fetches the azimuth  $\theta_i$  ( $i=2,3,4,\dots,j$ ) of the currently heading direction of the vehicle  $M$  from the Gyro sensor 21 and the vehicle speed signal  $V_i$  from the vehicle speedometer 22 and reads in the previous accurate coordinates  $A_{i-1}$  (Step C), and then calculates the reference coordinates  $G_i$  of the vehicle  $M$  subject to equation  $G_i = A_{i-1} + f(V_i, \theta_i)$  ( $i=2,3,4,\dots,j$ ) (Step D), in which the second time interval  $t$  is shorter than the first time interval  $T$ . In accordance with this embodiment, the second time interval  $t$  is 0.25 second. The controller 3 assigns the reference coordinates  $G_i$  to be the accurate coordinates  $A_i$  at the corresponding time

point and outputs the reference coordinates  $G_i$ , i.e., when at the time point  $t_2$ , the controller 3 fetches the azimuth  $\theta_2$  of the current heading direction of the vehicle  $M$  from the Gyro sensor 21 and the vehicle speed signal  $V_2$  from the vehicle speedometer 22 and reads in the last accurate coordinates  $A_1$ , and then calculates the reference coordinates  $G_2$  of the vehicle  $M$  subject to equation  $G_2=A_1+f(V_2, \theta_2)$ . The controller 3 also assigns the reference coordinates  $G_2$  to be the accurate coordinates  $A_2$  at the corresponding time point, and outputs the data. When at the time point  $t_3$ , the controller 3 works in the same way as at the time point  $t_2$ .

When at the time point  $t_4$ , after the GPS 11 has outputted the next GPS coordinates  $P_{m+1}$  as the first time interval (one second)  $T$  has expired, the controller 3 fetches the next azimuth  $\theta_4$  of the heading direction of the vehicle  $M$  from the Gyro sensor 21 and the next vehicle speed signal  $V_4$  from the vehicle speedometer 22 and reads in the previous accurate coordinates  $A_3$ , and then calculates the reference coordinates  $G_4$  of the vehicle  $M$  subject to equation  $G_4=A_3+f(V_4, \theta_4)$ , and then the controller 3 calculates the distance  $d$  between the next GPS coordinates  $P_{m+1}$  and the next reference coordinates  $G_4$  (step E). Thereafter, the controller 3 compares the distance  $d$  to the reference distance  $r$  to be greater than the reference distance  $r$  or not (Step F). If the distance  $d$  is greater than the reference distance  $r$ , it means the error has surpassed the tolerance radius  $r$ . To avoid error, the controller 3 assigns the next GPS coordinates  $P_{m+1}$  to be the next accurate coordinates  $A_4$  for correction, and outputs the data. In accordance with this embodiment, the aforesaid reference distance  $r$  is 25

meters. This reference distance **r** can be adjusted to 5 meters, 10 meters, or 50 meters by means of the adjusting device **4** when desired.

When the next first time interval **T** has expired, i.e., when at the time point **t8**, the controller **3** compares the reference distance **d** to be shorter or equal to the reference distance **r**, it means the error is within the tolerance radius **r**, and therefore no correction is necessary. Thus, the controller **3** directly assigns the next reference coordinates **G8** to be the next accurate coordinates **A8** for output.

FIG. 5 shows the GPS coordinates **Pm**, **Pm+1** and **Pm+2** as well as the accurate coordinates **A0~A8** at the time points **t0~t10**. As shown in FIG. 5, the GPS of the prior art GPS navigation system outputs GSP coordinates at time points **t0**, **t4** and **t8** only. By means of the Gyro sensor **2** and the vehicle speedometer **22**, the invention shows the accurate coordinates **A0~A10** at time points **t0~t10**.

As indicated above, the GPS of the prior art GPS navigation system outputs the current heading direction of the vehicle once per every second. When the vehicle is running at a high speed, the one-second time interval will result in a big error. By means of the Gyro sensor **21** and the vehicle speedometer **22**, the invention calculates and outputs the coordinates of the currently heading direction of the vehicle once per every 0.25 second, enabling the position of the vehicle to be accurately displayed on the display screen **51**. Further, the invention compares the GPS coordinates outputted by the GPS **11** to the reference coordinates calculated subject to the azimuth of the heading direction of the vehicle obtained from the Gyro

sensor **21** and the vehicle speed signal obtained from the vehicle speedometer **22**, and uses the GPS coordinates as the next accurate coordinates when the distance **d** of the comparison result surpasses the tolerance radius **r**. Therefore, the invention frequently corrects the  
5 coordinates of the vehicle, avoids the problem of receiving no GPS satellite signal as the vehicle is passing through a tunnel, and eliminates errors of the Gyro sensor **21** and the vehicle speedometer **22** due to the earth's rotation, so that the vehicle carrying the accurate positioning system of the present invention can obtain the most accurate position.

10           Although the present invention has been explained in relation to its preferred embodiments, it is to be understood that many other possible modifications and variations can be made without departing from the spirit and scope of the invention as hereinafter claimed.

## WHAT IS CLAIMED IS:

1. An accurate positioning system installed in a vehicle, comprising:  
a GPS (Global Positioning System), the GPS outputting the current  
GPS coordinates of the vehicle once per every first time interval;

5 a Gyro sensor, the Gyro sensor outputting an azimuth indicative of  
the currently heading direction of the vehicle;

a vehicle speedometer, the vehicle speedometer outputting a vehicle  
speed signal indicative of the current speed of the vehicle; and

a controller respectively and electrically connected to the GPS, the  
10 Gyro sensor and the vehicle speedometer;

wherein:

the controller obtains the azimuth from the Gyro sensor and the  
vehicle speed signal from the vehicle speedometer and reads in the GPS  
coordinates from the GPS, calculates a reference coordinates of the vehicle  
15 subject to the data of the fetched azimuth, vehicle speed signal and GPS  
coordinates, and assigns the reference coordinates thus calculated to be an  
accurate coordinates at the corresponding time point for output;

the controller also obtains the azimuth from the Gyro sensor and the  
vehicle speed signal from the vehicle speedometer and reads in last accurate  
20 coordinates once per every second time interval that is shorter than the first  
time interval, calculates a reference coordinates of the vehicle subject to the  
data of the fetched azimuth, vehicle speed signal and last accurate  
coordinates, and assigns the reference coordinates thus calculated to be the  
accurate coordinates at the corresponding time point for output;

after the GPS has outputted a next GPS coordinates as the first time interval has expired, the controller calculates a next reference coordinates of the vehicle and the distance between the next GPS coordinates and the next reference coordinates, and then compares the distance between the  
5 next GPS coordinates and the next reference coordinates to a reference distance, and then assigns the next GPS coordinates to the accurate coordinates for output when the distance between the next GPS coordinates and next reference coordinates is greater than the reference distance, or assigns the next reference coordinates to be the accurate coordinates for  
10 output when the distance between the next GPS coordinates and next reference coordinates is smaller than the reference distance.

2. The accurate positioning system as claimed in claim 1, further comprising an analog-to-digital converter electrically connected between the Gyro sensor and the controller and adapted to convert the analog signal  
15 of the azimuth indicative of the current heading direction of the vehicle into a digital signal.

3. The accurate positioning system as claimed in claim 1, wherein the vehicle speed signal of the vehicle speedometer includes a series of pulse signals, the series of pulse signals having a frequency directly  
20 proportional to the current running speed of the vehicle.

4. The accurate positioning system as claimed in claim 1, wherein the controller comprises memory means having stored therein the accurate coordinates and the reference distance.

5. The accurate positioning system as claimed in claim 4, further

comprising an adjusting device electrically connected to the controller and adapted to edit the reference distance in the memory means.

6. The accurate positioning system as claimed in claim 5, wherein the adjusting device is a keypad.

5           7. The accurate positioning system as claimed in claim 1, further comprising a display screen and an electronic map database respectively and electrically connected to the controller, the electronic map database having stored therein multiple road map data, wherein the controller reads  
10 in road map data from the electronic map database relative to the accurate coordinates, and outputs the fetched road map data to the display screen for display.

8. The accurate positioning system as claimed in claim 7, wherein the multiple road map data of the electronic map database include names of multiple roads and the coordinates of starting points and end points of the  
15 multiple roads.

9. The accurate positioning system as claimed in claim 8, wherein the multiple road map data further include multiple road links and multiple surrounding facilities corresponding to the names of multiple roads.

10. The accurate positioning system as claimed in claim 1, wherein  
20 the first time interval is one second, and the second time interval is 0.25 second.

11. An accurate vehicle positioning method comprising the steps of:

A) obtaining an azimuth of the heading direction of a vehicle, a vehicle speed signal and GPS coordinates, wherein the azimuth is outputted

by a Gyro sensor installed in the vehicle; the vehicle speed signal is outputted by a vehicle speedometer installed in the vehicle; the GPS coordinates is outputted by a GPS (Global Positioning System) installed in the vehicle once per every first time interval;

5           B) calculating reference coordinates of the vehicle and assigning the reference coordinates to be the accurate coordinates at the corresponding time point, and outputting the accurate coordinates;

          C) obtaining the azimuth of the current heading direction of the vehicle from the Gyro sensor and the vehicle speed signal from the vehicle speedometer and reading in the last accurate coordinates once per every  
10           second time interval, wherein the second time interval is shorter than the first time interval;

          D) calculating the reference coordinates of the vehicle and assigning the calculated reference coordinates to be the current accurate coordinates  
15           of the vehicle, and outputting the current accurate coordinates;

          E) calculating the next reference coordinates of the vehicle after the GPS has outputted a next GPS coordinates as the first time interval has expired, and then calculating the distance between the next GPS coordinates and the next reference coordinates; and

20           F) comparing the distance between the next GPS coordinates and the next reference coordinates to a reference distance to be greater or smaller than the reference distance, and assigning the next GPS coordinates to be the next accurate coordinates and outputting the next accurate

coordinates when the distance between the next GPS coordinates and the next reference coordinates is greater than the reference distance.

12. The accurate vehicle positioning method as claimed in claim 11, wherein when the distance between the next GPS coordinates and the next reference coordinates is smaller than or equal to the reference distance after comparison during step F), assigning the next reference coordinates to be the next accurate coordinates and outputting the next accurate coordinates.

13. The accurate vehicle positioning method as claimed in claim 11, further comprising a sub step A1) of converting the analog signal of the azimuth of the heading direction of the vehicle into a digital signal after step A) and before step B).

14. The accurate vehicle positioning method as claimed in claim 13, wherein the sub step A1) is to use an analog-to-digital converter to convert the analog signal of the azimuth of the heading direction of the vehicle into a digital signal.

15. The accurate vehicle positioning method as claimed in claim 11, further comprising a sub step B1 of reading in a road map data from an electronic map database subject to the accurate coordinates and outputting the road map data after step B) and before step C).

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