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(54) **SATELLITE NAVIGATION/DEAD-RECKONING NAVIGATION INTEGRATED POSITIONING DEVICE**

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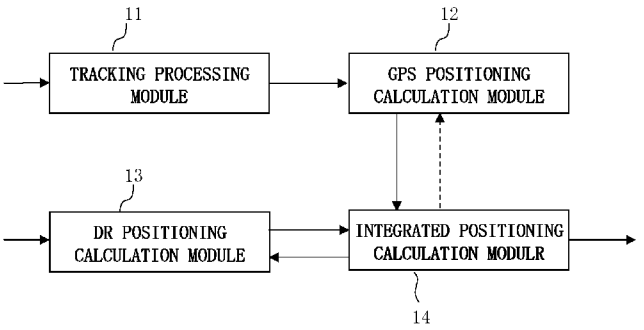
(57) **ABSTRACT**

Disclosed is a satellite navigation/dead-reckoning navigation integrated positioning device with improved accuracy of navigation data including position, velocity, and the like, which can be constituted at low cost. A tracking processing module (**31**) performs, based on a GPS positioning signal, acquisition processing and tracking processing thereof and demodulation processing of a navigation message. A GPS positioning calculation module (**32**) calculates position, velocity, and the like based on a pseudo-range observation, a Doppler frequency observation, and ephemeris data and gives the calculated position, velocity, and the like to an output judgment module (**43**) and the tracking processing module (**31**). Based on external support information including output of an inertial sensor, map information or information about the difference between a map position and a measured position, and the like in addition to the pseudo-range observation and the Doppler frequency observation, an integrated positioning calculation module (**42**) estimates the position, velocity, and the like, and gives the estimated position, velocity, and the like to the output judgment module (**43**). The output judgment module (**43**) compares the outputs of the GPS positioning calculation module (**32**) and the outputs of the integrated positioning calculation module (**42**) to judge the reliability of output data from the integrated positioning calculation module (**42**) and the abnormality of external support data.



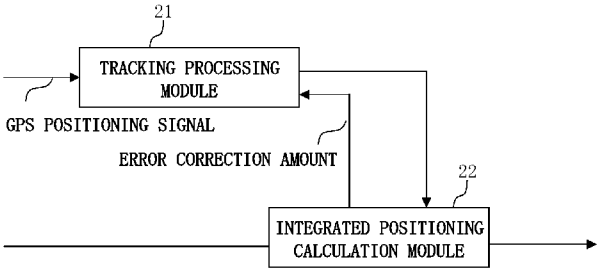


FIG. 1(A)

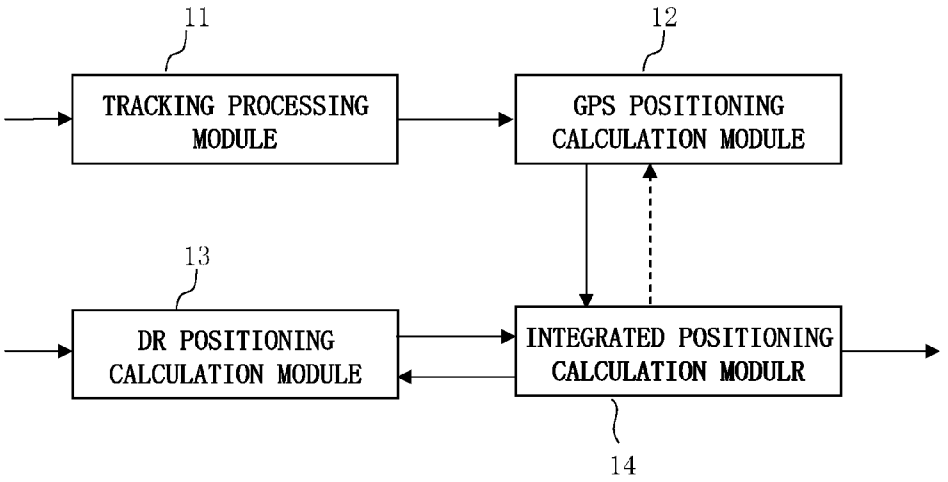

11
12
TRACKING PROCESSING MODULE
GPS POSITIONING CALCULATION MODULE
13
DR POSITIONING CALCULATION MODULE
INTEGRATED POSITIONING CALCULATION MODULR
14

FIG. 1(B)

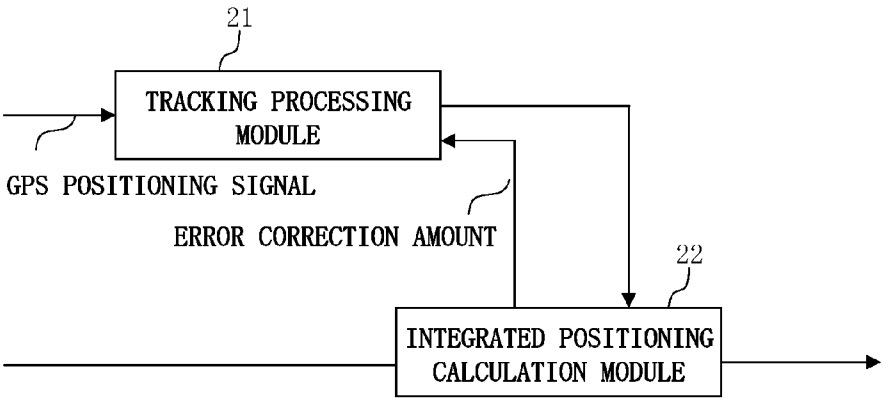

21
TRACKING PROCESSING MODULE
GPS POSITIONING SIGNAL
ERROR CORRECTION AMOUNT
22
INTEGRATED POSITIONING CALCULATION MODULE

FIG. 2

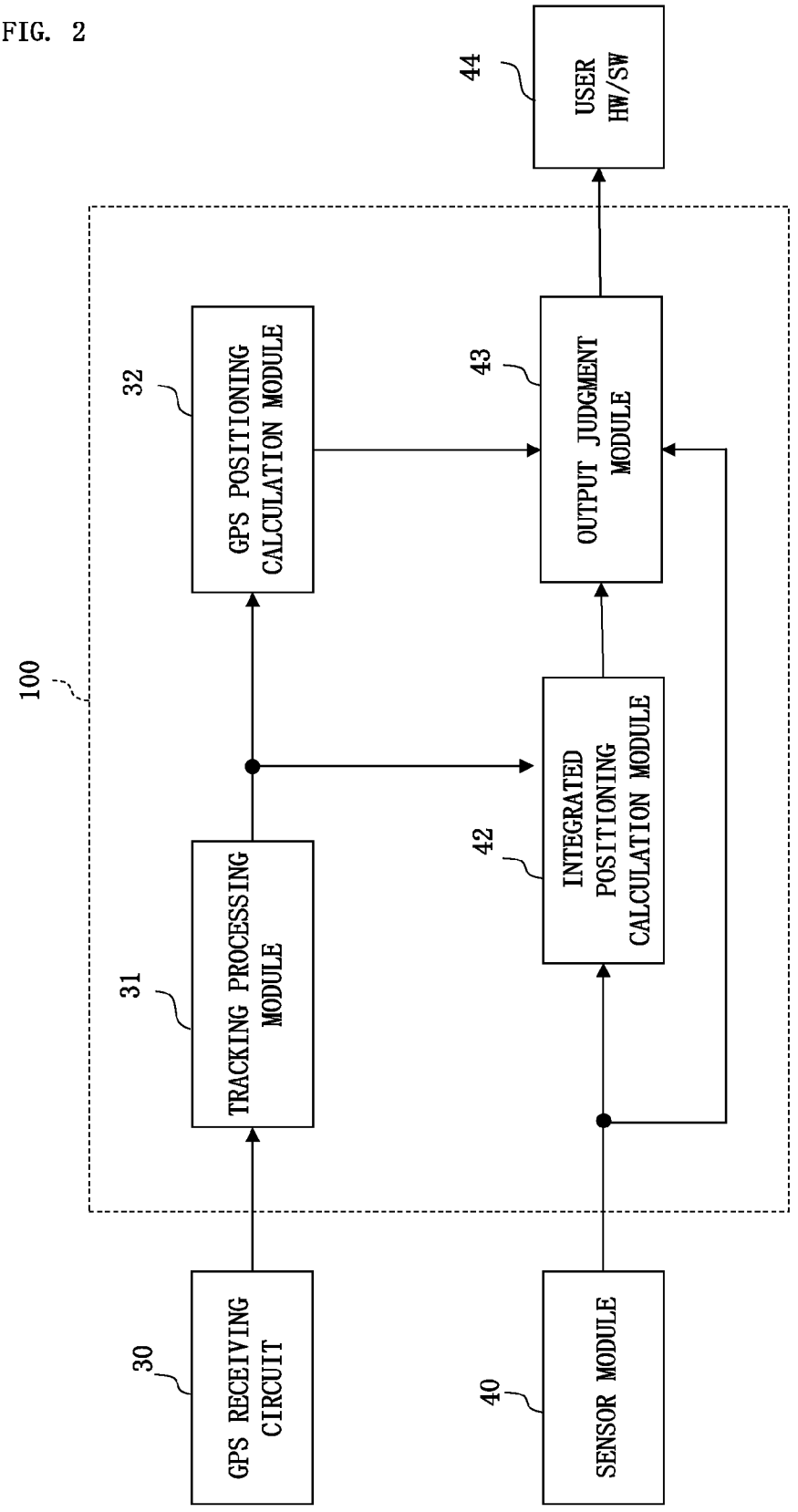

100
30
GPS RECEIVING CIRCUIT
31
TRACKING PROCESSING MODULE
32
GPS POSITIONING CALCULATION MODULE
40
SENSOR MODULE
42
INTEGRATED POSITIONING CALCULATION MODULE
43
OUTPUT JUDGMENT MODULE
44
USER HW/SW

FIG. 3

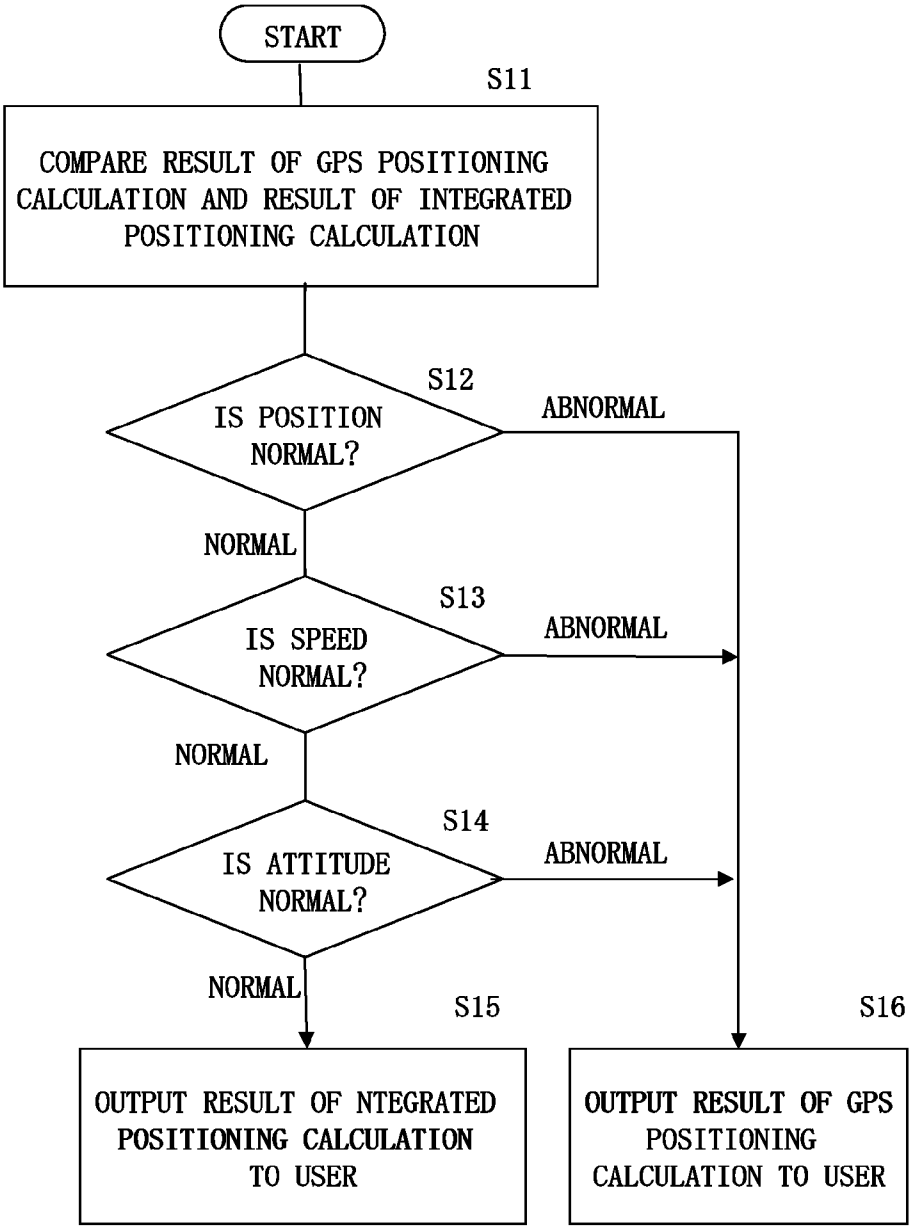

START
S11
COMPARE RESULT OF GPS POSITIONING CALCULATION AND RESULT OF INTEGRATED POSITIONING CALCULATION
S12
IS POSITION NORMAL?
ABNORMAL
NORMAL
S13
IS SPEED NORMAL?
ABNORMAL
NORMAL
S14
IS ATTITUDE NORMAL?
ABNORMAL
NORMAL
S15
OUTPUT RESULT OF NTEGRATED POSITIONING CALCULATION TO USER
S16
OUTPUT RESULT OF GPS POSITIONING CALCULATION TO USER

FIG. 4

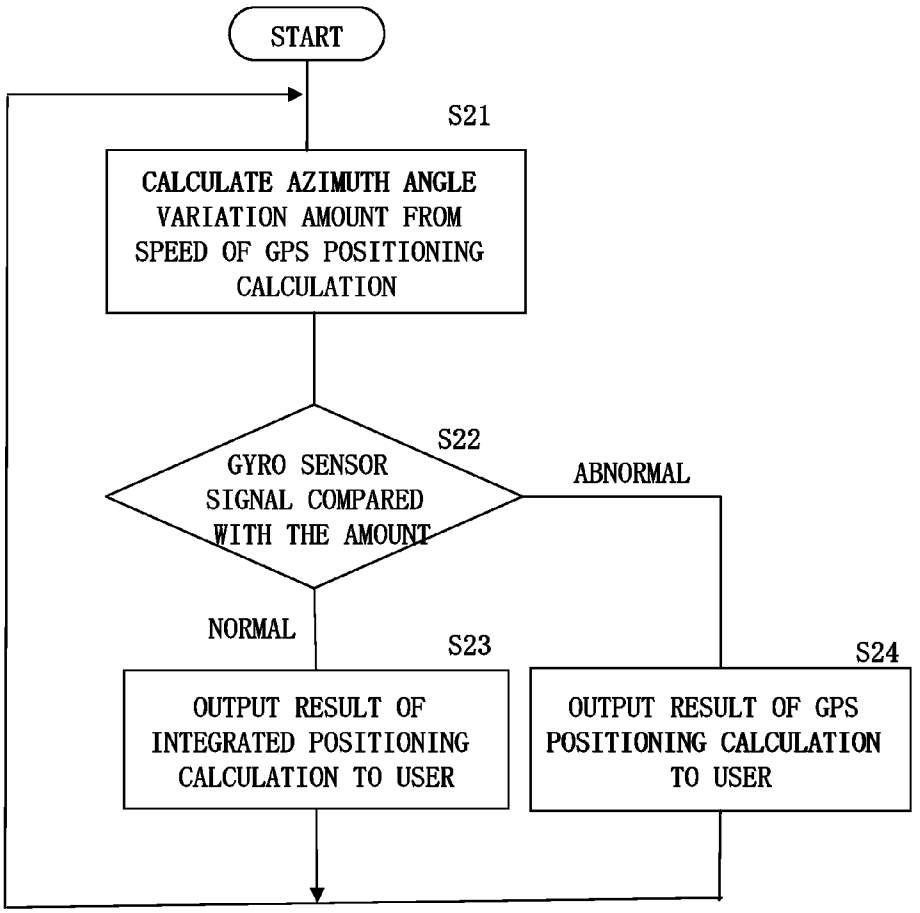

START
S21
CALCULATE AZIMUTH ANGLE VARIATION AMOUNT FROM SPEED OF GPS POSITIONING CALCULATION
S22
GYRO SENSOR SIGNAL COMPARED WITH THE AMOUNT
ABNORMAL
NORMAL
S23
OUTPUT RESULT OF INTEGRATED POSITIONING CALCULATION TO USER
S24
OUTPUT RESULT OF GPS POSITIONING CALCULATION TO USER

FIG. 5

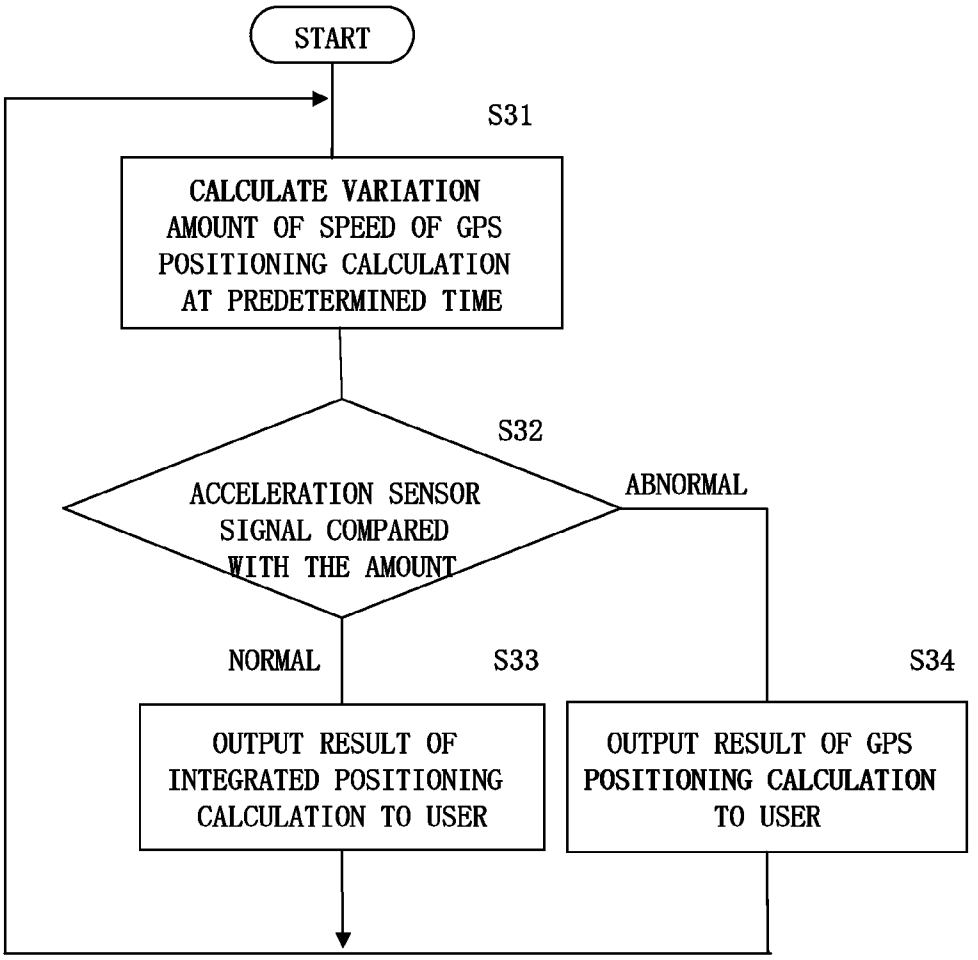
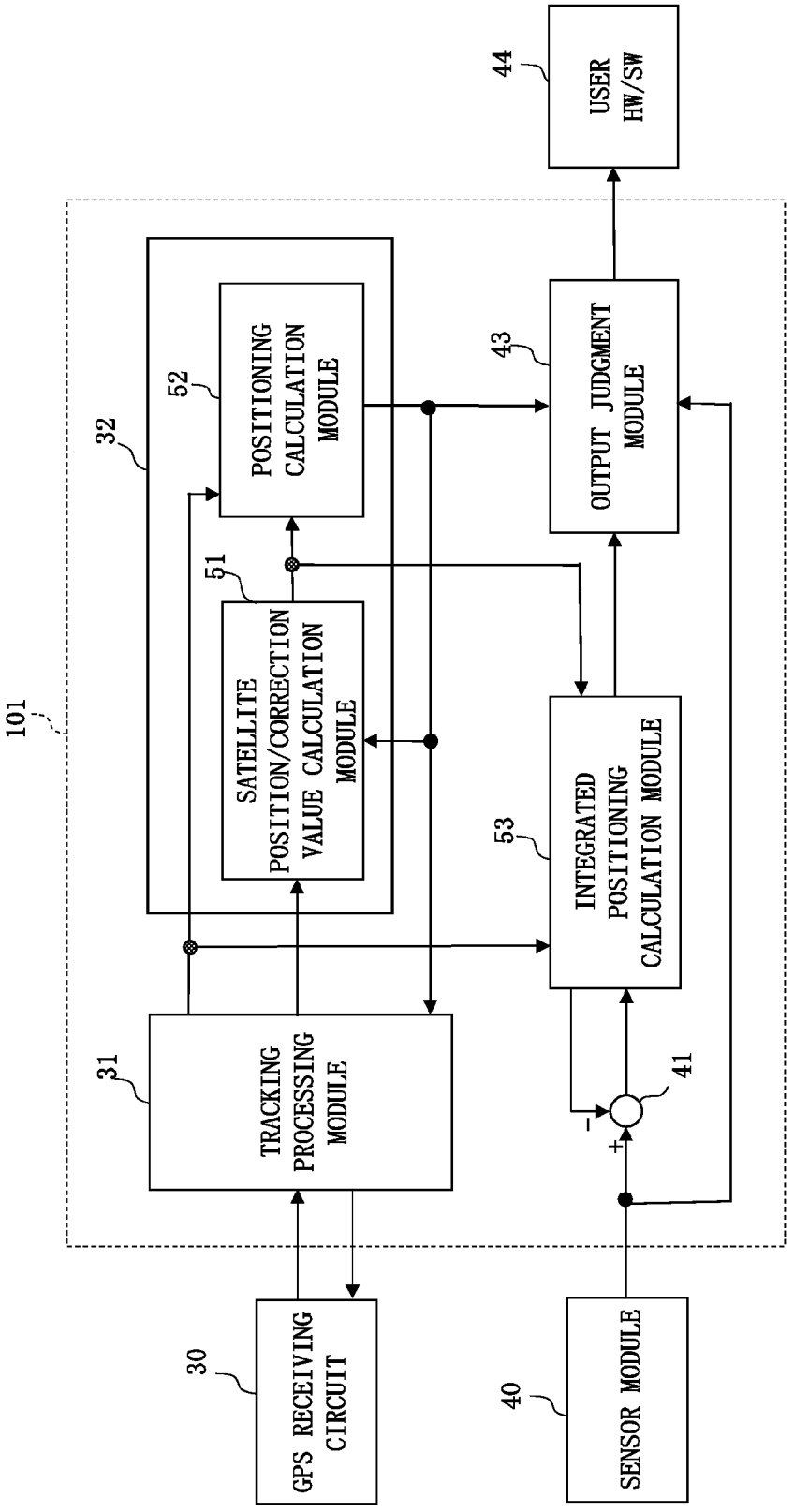

START
S31
CALCULATE VARIATION AMOUNT OF SPEED OF GPS POSITIONING CALCULATION AT PREDETERMINED TIME
S32
ACCELERATION SENSOR SIGNAL COMPARED WITH THE AMOUNT
ABNORMAL
NORMAL
S33
S34
OUTPUT RESULT OF INTEGRATED POSITIONING CALCULATION TO USER
OUTPUT RESULT OF GPS POSITIONING CALCULATION TO USER

FIG. 6


44
USER HW/SW
43
OUTPUT JUDGMENT MODULE
52
POSITIONING CALCULATION MODULE
32
51
SATELLITE POSITION/CORRECTION VALUE CALCULATION MODULE
101
53
INTEGRATED POSITIONING CALCULATION MODULE
31
TRACKING PROCESSING MODULE
41
-
+
30
GPS RECEIVING CIRCUIT
40
SENSOR MODULE

SATELLITE NAVIGATION/DEAD-RECKONING NAVIGATION INTEGRATED POSITIONING DEVICE

TECHNICAL FIELD

[0001] The present invention relates to a satellite navigation/dead-reckoning navigation integrated positioning device that integrates an observation obtained by receiving a positioning signal from a navigation satellite and an observation obtained from a dead-reckoning navigation device to perform positioning.

BACKGROUND ART

[0002] There have been known various configurations in terms of which observation to use for positioning and how to integrate the observations for positioning in a satellite navigation/dead-reckoning navigation integrated positioning device (hereinafter, referred to as "GPS/DR integrated positioning device") in which an observation (hereinafter, referred to as "GPS observation") obtained from a GPS positioning system, for example, as a non-autonomous system, and an observation (hereinafter, referred to as "DR observation") obtained from a dead-reckoning navigation system (DR: dead-reckoning navigation system), as an autonomous system, are integrated (for example, see Patent Documents 1 and 2).

[0003] Which type of configuration is employed in order to integrate the GPS observation and the DR observation largely depends on the cost of the device, required accuracy and the like. FIG. **1** is a block diagram of a typical example of the aforementioned integration type.

[0004] FIG. **1**(A) shows a loosely-coupled approach, and FIG. **1**(B) shows a tightly-coupled approach and a deeply-coupled approach.

[0005] In FIG. **1**(A), a tracking processing module **11** tracks a phase of a GPS positioning signal of a baseband obtained by receiving a signal from a GPS satellite, and finds a position, a velocity, and the like of each satellite. A GPS positioning calculation module **12** finds a position and a velocity at a receiving point based on a pseudo range (PR), a Doppler frequency observation and the position and velocity of each satellite found by the tracking processing module **11**. A DR positioning calculation module **13** finds the position and velocity based on external support data of an inertial sensor and the like. Then, an integrated positioning calculation module **14** integrates the GPS observation, such as the position and velocity obtained by the GPS positioning calculation module **12** and the DR observation, such as the position and velocity obtained by the DR positioning calculation module **13** to provide the position and velocity of higher quality to a user.

[0006] In FIG. **1**(B), a tracking processing module **21** tracks a phase of a GPS positioning signal of a baseband obtained by receiving a signal from a GPS satellite, and finds a position, a velocity, and the like of each satellite. In the case of the tightly-coupled approach, an integrated positioning calculation module **22** integrates a pseudo range and a Doppler frequency obtained by the tracking processing module **21** as the GPS observation and an external support data of the inertial sensor and the like as the DR observation in one integrated positioning calculation module **22** to provide the position and velocity of higher quality to a user.

[0007] In the case of the deeply-coupled approach, the integrated positioning calculation module **22** uses a baseband complex signal (I, Q) obtained by the tracking processing module **21** as the GPS observation and an external support data of the inertial sensor as the DR observation to perform an integrated positioning calculation.

[0008] Note that the GPS positioning calculation module **12** and the integrated positioning calculation module **14** of the loosely-coupled approach and the integrated positioning calculation module **22** of the tightly/deeply-coupled approach are also referred to as a "navigation filter" in which usually the position and position error, the velocity and velocity error, inertial sensor error and the like are estimated by a Kalman filter, and the estimated respective errors are negatively fed back as a correction amount to a certain portion to be corrected.

[0009] In PNDs (Portable Navigation Devices) for personal and vehicle use, which have attracted attention in recent years, lower price and higher accuracy are required. For this reason, as disclosed in Patent Documents 1 and 2, being used is a device which integrates the external support data of a low-price inertial sensor (such as a gyroscope and an acceleration sensor), map data and the like, and the GPS observation using the loosely-coupled approach or the tightly-coupled approach.

[0010] Patent Document 1: JP 2007-93483(A)

[0011] Patent Document 2: U.S. Pat. No. 6,643,587

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0012] However, the GPS/DR integrated positioning device of related art, including Patent Documents 1 and 2, has had problems as described below.

[0013] (1) In the loosely-coupled approach, the data of the position, velocity, and the like at the receiving point found by the GPS positioning calculation module and the position and velocity found by the DR positioning calculation module are integrated. Thus, in the loosely-coupled approach, until a result of the GPS positioning calculation is obtained, the GPS data cannot be utilized for calculation of the DR positioning. A general method for the GPS positioning needs at least four satellites to find four variables of a three-dimensional position (X, Y, Z) and a time. However, for the reason above, unless signals from four or more satellites can be acquired and tracked, the GPS data cannot be utilized for the DR calculation.

[0014] Further, the biggest drawback of the loosely-coupled approach is the error of the position and velocity obtained from the GPS positioning calculation module **12** being colored noise, which does not meet a white noise error condition as an indispensable requirement of a Kalman filter in the integrated positioning calculation module **22**.

[0015] (2) In the tightly-coupled approach, the pseudo range and Doppler frequency as the GPS observation, and the DR observation are integrated in one integrated positioning calculation module; therefore, detailed knowledge about the GPS is required to design the Kalman filter. Furthermore, compared with the loosely-coupled approach, the integrated positioning calculation module has a very complex design.

[0016] Additionally, when an abnormality occurs in an output from the inertial sensor, for example, the position, velocity, attitude or the like (hereinafter, referred to as navigation data) cannot be provided to the user.

[0017] (3) In the deeply-coupled approach, a positioning result fed back to the tracking processing module of the GPS positioning signal is affected by an input value (such as map-match data) from the sensor module and the user. For this reason, for example, if the abnormal sensor data is input, the GPS satellite cannot be tracked to make it impossible to detect the abnormality of the sensor using the GPS positioning results.

[0018] In this way, a method for detecting an abnormality is very important technology, particularly in the case of using the inertial sensor, which has low reliability, but is low in cost in order to balance the cost with the performance However, the GPS/DR integrated positioning device of related art, including Patent Documents 1 and 2, cannot determine the abnormality of the output of the positioning calculation module due to the abnormality of the external support data of the inertial sensor and the like.

[0019] Consequently, an object of the invention is to provide a satellite navigation/dead-reckoning navigation integrated positioning device which can be constituted by low cost, and in which accuracy of the navigation data including the position and velocity is improved.

Means for Solving the Problems

[0020] The satellite navigation/dead-reckoning navigation integrated positioning device of the invention is constituted as below in order to solve the problems.

[0021] (1) According to an aspect of the invention, a satellite navigation/dead-reckoning navigation integrated positioning device is configured to include:

[0022] a tracking processing module for receiving positioning signals transmitted from navigation satellites to track the positioning signals (phase information of the positioning signals) and finding a pseudo range and Doppler frequency information;

[0023] a satellite navigation positioning calculation module for executing a positioning calculation based on the pseudo range and the Doppler frequency information to find a position and a velocity of a moving body; an integrated positioning calculation module for determining, based on the pseudo range and the Doppler frequency information found by the tracking processing module and external support data (such as data of an inertial sensor and map data), errors of the external support data to correct the external support data, and finding the position and velocity of the moving body; and

[0024] an abnormality determination module for comparing a result of the positioning calculation by the satellite navigation positioning calculation module with a result of the positioning calculation by the integrated positioning calculation module to determine the abnormality of the external support data.

[0025] With the aforementioned configuration, unlike the loosely-coupled approach of related art, even in a state where a satellite navigation positioning calculation is impossible or is not completed, the position and velocity of the moving body can be found based on the pseudo range and Doppler frequency information already observed. Further, if the external support data becomes abnormal and thus the integrated positioning calculation is impossible, a calculation result by the satellite navigation positioning calculation module can be provided to an user.

[0026] (2) The external support data may include, for example, data by an inertial sensor, and the abnormality determination module may compare the result of the positioning calculation by the satellite navigation positioning calculation module with the data by the inertial sensor to determine the abnormality of the inertial sensor.

[0027] With the aforementioned configuration, the abnormality of the inertial sensor can be detected; therefore, positioning accuracy can be prevented from lowering due to the use of the inertial sensor in an abnormality state.

[0028] (3) The external support data may include, for example, map data input information, and the abnormality determination module may compare the result of the positioning calculation by the satellite navigation positioning calculation module with the map data to determine the abnormality of the map data input information.

[0029] With the aforementioned configuration, the abnormality of the map data input information can be detected; therefore, positioning accuracy can be prevented from lowering due to the use of the abnormal map data.

[0030] (4) The abnormality determination module may compare the result found by the satellite navigation positioning calculation module with the result found by the integrated positioning calculation module to determine the abnormality of the result of the calculation of the integrated positioning calculation module.

[0031] With the aforementioned configuration, the abnormality of the external support data used for the integrated positioning calculation or the abnormality of the integrated positioning calculation module can be detected; therefore, the abnormal navigation data can be prevented from being provided to the user.

[0032] (5) A module may be provided to output the calculation results by the satellite navigation positioning calculation module to the user if the abnormality determination module determines an abnormality. The user may be informed of the abnormality state along with the calculation result.

[0033] With the aforementioned configuration, even if the abnormality state is determined, the calculation result of the satellite navigation positioning calculation module can be obtained. Additionally, if the abnormality state is output to the user, the user can grasp the abnormality state.

[0034] (6) The integrated positioning calculation module, when, for example, resuming the positioning calculation from a state where the integrated positioning calculation module is stopped due to the abnormality of the external support data, may resume the integrated positioning calculation using the position and the velocity found by the satellite navigation positioning calculation module as initial values.

[0035] This makes it possible for the integrated positioning calculation module to quickly obtain the positioning result when recovering from the down state of the integrated positioning calculation.

[0036] (7) The integrated positioning calculation module may execute the positioning calculation based on the pseudo range and the Doppler frequency information by a single difference between satellites found by the tracking processing module.

[0037] In this way, if the positioning calculation is performed based on the single difference between satellites, the integrated positioning calculation module does not need to estimate a clock error of a receiver and changes thereof by the Kalman filter. Therefore, not only a computational load of the Kalman filter in the integrated positioning calculation module

can be reduced, but also the clock error and a model of the changes thereof do not need to be considered.

EFFECT OF THE INVENTION

[0038] According to the aspect of the invention, unlike the loosely-coupled approach of related art, even in a state, for example, where the satellite navigation positioning calculation is impossible or is not completed with the positioning signals from four or more navigation satellites not being received, the position and velocity of the moving body can be obtained based on the pseudo range and Doppler frequency information already observed. Further, in a case where the external support data becomes abnormal and thus the integrated positioning calculation is impossible, the calculation result by the satellite navigation positioning calculation module can be provided to the user.

BEST MODE FOR CARRYING OUT THE INVENTION

[0039] Hereinafter, several specific embodiments are described.

First Embodiment

[0040] FIG. **2** is a block diagram showing a configuration of a satellite navigation/dead-reckoning navigation integrated positioning device according to a first embodiment.

[0041] A GPS receiving circuit **30** converts a positioning signal from a satellite received by a GPS antenna into an intermediate frequency and A/D-converts it to output a so-called baseband GPS positioning signal.

[0042] A sensor module **40** is an external device, which includes at least an acceleration sensor, an angular velocity sensor, and a gyroscope inertial sensor, for obtaining orientation information and outputs external support data.

[0043] For the external support information other than the value obtained by the above various sensors, used are map position input information (map-match data) or error input information of the map position (map-match data error) input by a user.

[0044] A tracking processing module **31** performs, based on the above GPS positioning signal, acquisition processing and tracking processing thereof and demodulation processing of a navigation message including ephemeris data (satellite orbit information), and gives a pseudo-range observation and a Doppler frequency observation to a GPS positioning calculation module **32** and an integrated positioning calculation module **42**.

[0045] The GPS positioning calculation module **32** calculates the navigation data such as a position, a velocity by a usual method based on the pseudo-range observation, the Doppler frequency observation, the ephemeris data and the like.

[0046] Based on the external support information including an output of the inertial sensor (gyroscope and acceleration sensor as needed), the above map information (map-match data) or information about the difference between the map position and a measured position (map-match data error), and the like as needed in addition to the pseudo-range observation and the Doppler frequency observation, the integrated positioning calculation module **42** estimates the position, position error, velocity, velocity error, error of the external support data of the inertial sensor or the like using a known Kalman filter. Then, the integrated positioning calculation module **42** gives the navigation data such as the position, velocity and the like to an output judgment module **43**. Moreover, the estimated error of the external support data is fed back to a predetermined processing module as a correction amount.

[0047] The navigation data of the GPS positioning calculation module **32** is calculated independent of the integrated positioning calculation module **42**. With this configuration, even if an abnormality caused due to the external support data occurs in the navigation data of the integrated positioning calculation module **42**, the navigation data of the GPS positioning calculation module **32** is not affected by the abnormality of the external support data, and the navigation data of the GPS positioning calculation module **32** can be used to determine an abnormality of the navigation data of the integrated positioning calculation module **42**. That is, in the output judgment module **43**, all or any piece of the navigation data calculated by the GPS positioning calculation module **32** can be used as a comparative criterion to determine reliability of the output of the integrated positioning calculation module **42** output to a hardware/software **44** of the user.

[0048] Note that the GPS positioning calculation module **32** and the integrated positioning calculation module **42** are provided, along with the pseudo range and Doppler frequency, with the ephemeris data, which has no direct relation therewith in the first embodiment, thus is omitted in the figure.

[0049] Next, a method for determining various abnormalities by the output judgment module **43** is described with reference to FIG. **3** to FIG. **5**.

[0050] FIG. **3** is a flowchart showing a procedure of abnormality determination of the integrated positioning calculation module executed by the output judgment module **43**.

[0051] The output judgment module **43** compares the output of the GPS positioning calculation module **32** and the output of the integrated positioning calculation module **42** (S**11**). In an example shown in FIG. **3**, the reliability of the output data of the integrated positioning calculation module **42** is determined by the AND condition of the position determination, velocity determination and attitude determination of the navigation data (S**12**, S**13**, S**14**).

[0052] Between the navigation data found respectively by the GPS positioning calculation module **32** and the integrated positioning calculation module **42**, if a difference of the positions is equal to or more than a predetermined threshold value, the navigation data found by the GPS positioning calculation module **32** is switched to be output to the hardware/software **44** of the user (S**12**→S**16**). Similarly, if a difference of the velocities thereof is equal to or more than a predetermined threshold value, the navigation data found by the GPS positioning calculation module **32** is switched to be output to the hardware/software **44** of the user (S**13**→S**16**).

[0053] Further, if a difference between the attitude of the moving body found by the GPS positioning calculation module **32** and the attitude of the moving body found by the integrated positioning calculation module **42** is equal to or more than a predetermined threshold value, the navigation data found by the GPS positioning calculation module **32** is switched to be output to the hardware/software **44** of the user (S**14**→S**16**). Here, the attitude of the moving body is an orientation which the moving body is directed, and is found, for example, from a position vector at a certain time in a case of being found based on the position information, and is

found using a ratio with respect to a horizontal velocity component in a case of being found based on the velocity information.

[0054] If the position, velocity and attitude are all less than the predetermined threshold values, the navigation data found by the integrated positioning calculation module **42** is output to the hardware/software **44** of the user.

[0055] Note that when the integrated positioning calculation module **42** resumes the positioning calculation, the processing of the integrated positioning calculation module is resumed using the position and velocity found by the GPS positioning calculation module **32** as initial values or the velocity thereof as an initial value.

[0056] The reliability of the output data of the integrated positioning calculation module **42** may be determined by a combination of the OR condition of the position determination, velocity determination and attitude determination of the navigation data, or by the AND or OR condition of any two of them and the AND or OR condition of the rest. For example, determination may be performed by a condition of (position AND velocity) OR attitude, or a condition of (position OR velocity) AND attitude.

[0057] FIG. **4** is a flowchart showing a procedure of abnormality determination of the external support data executed by the output judgment module **43**.

[0058] The output judgment module **43** executes the abnormality determination of the external support data using the output of the GPS positioning calculation module **32**. For example, the abnormality of the signal of the gyroscope inertial sensor for obtaining the orientation information is determined by calculating an azimuth variation at a predetermined time interval of an azimuth angle calculated based on the velocity of the GPS positioning calculation module **32**, at least during movement, and comparing the signal of the gyroscope inertial sensor with the azimuth angle variation amount as a reference (S**21**→S**22**). If a difference between them is less than a predetermined threshold value, the navigation data found by the integrated positioning calculation module **42** is output to the hardware/software **44** of the user (S**22**→S**23**). If the difference between them is equal to or more than the predetermined threshold value, the signal of the gyroscope inertial sensor is determined to be abnormal, and the navigation data found by the GPS positioning calculation module **32** is switched to be output to the hardware/software **44** of the user (S**22**→S**24**).

[0059] Note that a program may be defined in a case in which the azimuth variation is equal to or more than a certain value; if the signal of the gyroscope inertial sensor does not change, the output of the gyroscope inertial sensor is determined to be abnormal.

[0060] FIG. **5** is a flowchart showing a procedure of abnormality determination of another external support data executed by the output judgment module **43**.

[0061] The output judgment module **43** calculates a variation amount of the velocity at a predetermined time interval found by the GPS positioning calculation module **32**, and, with the velocity variation amount being used as a reference value, compares the reference value with a signal of the acceleration sensor (S**31**→S**32**). If a difference between them is less than a predetermined threshold value, the navigation data found by the integrated positioning calculation module **42** is output to the hardware/software **44** of the user (S**32**→S**33**). If the difference between them is equal to or more than the predetermined value, the signal of the acceleration sensor is determined to be abnormal and the navigation data found by the GPS positioning calculation module **32** is output to the hardware/software **44** of the user (S**32**→S**34**).

[0062] Note that the program may be defined in a case in which the velocity variation is equal to or more than the predetermined threshold value set in advance; if the signal of the acceleration sensor does not change, the acceleration sensor is determined to be abnormal.

[0063] Similarly, in a case where a velocity sensor is used for the external support data, the abnormality of the signal of the velocity sensor is determined by comparing, with the velocity of the GPS positioning calculation module **32** being as a reference value, the reference value with the signal of the velocity sensor. Further, in a case where the velocity is equal to or more than a predetermined threshold value, if the signal of the velocity sensor does not change, the velocity sensor may be determined to be abnormal.

[0064] Further, the abnormality of the map position input information is determined by, with the position found by the GPS positioning calculation module **32** being used as a reference value, comparing the reference value with the map position input information.

[0065] Similarly, the abnormality of the error input information of the map position is determined by, with the velocity found by the GPS positioning calculation module **32** or the position variation at a predetermined time interval being as a reference value, comparing the reference value with the error input information of the map position.

[0066] The above map position input information is specifically the map position data of, for example, the satellite navigation/dead-reckoning navigation integrated device generated in a car navigation system, and the map position is input as latitude and longitude data.

[0067] Additionally, the error input information of the map position is specifically information of a difference between, for example, data of the car navigation system or other position measurement devices and the map position data, and are input as position error information.

[0068] Note that in any of the above abnormality determinations, the abnormality of the input data may be determined depending on not only whether or not the difference between the reference value and a value of the target to be determined about abnormality thereof exceeds a predetermined threshold value, but also whether or not the number of cases where the difference exceeds the predetermined threshold value reaches a predetermined number.

Second Embodiment

[0069] FIG. **6** is a block diagram showing a configuration of a satellite navigation/dead-reckoning navigation integrated positioning device according to a second embodiment of the invention.

[0070] This embodiment is different from the satellite navigation/dead-reckoning navigation integrated positioning device shown in FIG. **2** of the first embodiment in the configuration of the integrated positioning calculation module **53** and a relationship between the integrated positioning calculation module **53** and the GPS positioning calculation module **32**.

[0071] A satellite position correction value calculation module **51** in the GPS positioning calculation module **32** calculates values concerning satellite position and correction values including a position and a velocity of a satellite, a satellite time correction value, an ionospheric correction

value, a tropospheric correction value and the like from information, such as the ephemeris and the positioning results obtained by the positioning calculation module **52**. The values themselves have configurations similar to the general GPS receiver. The values calculated by the satellite position/correction value calculation module **51** are used in both the positioning calculation module **52** and the integrated positioning calculation module **53**.

[0072] In this way, the satellite position/correction amount calculation module **51** is commonly used, and thus, the calculation processing load on the satellite navigation/dead-reckoning navigation integrated positioning device can entirely be reduced. Therefore, processing can be performed with a low velocity CPU, leading to low cost correspondingly.

[0073] Note that in the embodiments shown above, the example using GPS for the satellite navigation positioning is shown, but it is similarly applicable to a case of using another satellite navigation positioning system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0074] FIGS. **1**(A) and **1**(B) are block diagrams showing typical configuration examples of an integration type of a satellite navigation/dead-reckoning navigation integrated positioning device of related art.

[0075] FIG. **2** is a block diagram showing a configuration of a satellite navigation/dead-reckoning navigation integrated positioning device according to a first embodiment.

[0076] FIG. **3** is a flowchart showing a procedure of abnormality determination of an integrated positioning calculation module executed by an output judgment module of the satellite navigation/dead-reckoning navigation integrated positioning device.

[0077] FIG. **4** is a flowchart showing a procedure of abnormality determination of external support data executed by the output judgment module of the satellite navigation/dead-reckoning navigation integrated positioning device.

[0078] FIG. **5** is a flowchart showing a procedure of abnormality determination of another external support data executed by the output judgment module of the satellite navigation/dead-reckoning navigation integrated positioning device.

[0079] FIG. **6** is a block diagram showing a configuration of a satellite navigation/dead-reckoning navigation integrated positioning device according to a second embodiment.

BRIEF DESCRIPTION OF THE NUMERALS

[0080] **30** . . . GPS Receiving Circuit; **31** . . . Tracking Processing Module; **32** . . . GPS Positioning Calculation Module; **42** . . . Integrated Positioning Calculation Module; **43** . . . Output Judgment Module; **51** . . . Satellite Position Correction Value Calculation Module; **52** . . . Positioning Calculation Module; **53** . . . Integrated Positioning Calculation Module; and **100**, **101** . . . Satellite Navigation/Dead-Reckoning Navigation Integrated Positioning Device.

1. A satellite navigation/dead-reckoning navigation integrated positioning device, comprising:

a tracking processing module for receiving positioning signals of navigation satellites to track the positioning signals and finding a pseudo range and Doppler frequency information;

a satellite navigation positioning calculation module for executing a positioning calculation based on the pseudo range and the Doppler frequency information to find a position and a velocity of a moving body;

an integrated positioning calculation module for finding, based on the pseudo range and the Doppler frequency information found by the tracking processing module and external support data obtained from an external device, a position and a velocity of the moving body; and

an abnormality determination module for comparing a result of the positioning calculation by the satellite navigation positioning calculation module with a result of the positioning calculation by the integrated positioning calculation module to determine abnormality of the external support data.

2. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **1**, wherein the external support data includes data by an inertial sensor, and the abnormality determination module compares the result of the positioning calculation by the satellite navigation positioning calculation module with the data by the inertial sensor to determine abnormality of the inertial sensor.

3. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **1**, wherein the external support data includes map data input information, and the abnormality determination module compares the result of the positioning calculation by the satellite navigation positioning calculation module with the map data to determine abnormality of the map data input information.

4. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **1**, wherein the abnormality determination module compares the result found by the satellite navigation positioning calculation module with the result found by the integrated positioning calculation module to determine abnormality of the result of the calculation of the integrated positioning calculation module.

5. The satellite navigation/dead-reckoning navigation integrated positioning device of any one of claims **1** to **4**, comprising a module for outputting the calculation result by the satellite navigation positioning calculation module to a user if the abnormality determination module determines an abnormality.

6. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **1**, wherein the integrated positioning calculation module, when resuming the positioning calculation from a state where the positioning calculation is stopped due to the abnormality of the external support data, resumes the integrated positioning calculation using the position and the velocity found by the satellite navigation positioning calculation module as initial values.

7. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **1**, wherein the integrated positioning calculation module executes the positioning calculation based on the pseudo range and the Doppler frequency information by a single difference between the satellites found by the tracking processing module.

8. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **2**, wherein the integrated positioning calculation module, when resuming the positioning calculation from a state where the positioning calculation is stopped due to the abnormality of the external support data, resumes the integrated positioning calculation using the position and the velocity found by the satellite navigation positioning calculation module as initial values.

9. The satellite navigation/dead-reckoning navigation integrated positioning device of claims **3**, wherein the integrated

positioning calculation module, when resuming the positioning calculation from a state where the positioning calculation is stopped due to the abnormality of the external support data, resumes the integrated positioning calculation using the position and the velocity found by the satellite navigation positioning calculation module as initial values.

10. The satellite navigation/dead-reckoning navigation integrated positioning device of any one of claim **4**, wherein the integrated positioning calculation module, when resuming the positioning calculation from a state where the positioning calculation is stopped due to the abnormality of the external support data, resumes the integrated positioning calculation using the position and the velocity found by the satellite navigation positioning calculation module as initial values.

11. The satellite navigation/dead-reckoning navigation integrated positioning device of claims **5**, wherein the integrated positioning calculation module, when resuming the positioning calculation from a state where the positioning calculation is stopped due to the abnormality of the external support data, resumes the integrated positioning calculation using the position and the velocity found by the satellite navigation positioning calculation module as initial values.

12. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **2**, wherein the integrated positioning calculation module executes the positioning calculation based on the pseudo range and the Doppler frequency information by a single difference between the satellites found by the tracking processing module.

13. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **3**, wherein the integrated positioning calculation module executes the positioning calculation based on the pseudo range and the Doppler frequency information by a single difference between the satellites found by the tracking processing module.

14. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **4**, wherein the integrated positioning calculation module executes the positioning calculation based on the pseudo range and the Doppler frequency information by a single difference between the satellites found by the tracking processing module.

15. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **5**, wherein the integrated positioning calculation module executes the positioning calculation based on the pseudo range and the Doppler frequency information by a single difference between the satellites found by the tracking processing module.

16. The satellite navigation/dead-reckoning navigation integrated positioning device of claim **6**, wherein the integrated positioning calculation module executes the positioning calculation based on the pseudo range and the Doppler frequency information by a single difference between the satellites found by the tracking processing module.

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