DESCRIPTION

TITLE: METHOD OF LOCATING A VEHICLE, ASSOCIATED ELECTRONIC LOCATION DEVICE AND COMPUTER PROGRAM PRODUCT

The invention relates to a method for locating a vehicle.

The invention also relates to an electronic device for locating a vehicle, and to a computer program product suitable for implementing the location method.

The invention relates to the field of locating a vehicle moving on a railway track.

Document DE 10 2012 209311 discloses a method of locating a railway vehicle. The method comprises the generation of a plurality of hypotheses on the position of the vehicle. The method then comprises, at a characteristic instant, a measurement of an inclination of the track on which the vehicle is traveling, a measurement of the speed of the vehicle and a measurement of the acceleration of the vehicle. From the measurements obtained at the characteristic instant, the method comprises the calculation of the probability of veracity of each hypothesis using a Bayesian network. The method further comprises the application of particulate filter(s) to the probabilities of obtaining the position of the vehicle.

However, such location method is complex to implement.

The subject matter of the invention is thus to propose a method of locating a vehicle that is simpler to implement.

To this end, the subject matter of the present invention is a method of locating a vehicle, in particular a railway vehicle, the method being implemented by an electronic location device and comprising the following steps:

- measurement, at successive instants, of a speed of the vehicle and of an inclination of the track along at least one direction, in order to obtain a dataset at each instant, the set of datasets forming an instantaneous profile of the track,
- comparison of the instantaneous profile with a plurality of signatures, and identification of signatures corresponding to the instantaneous profile and defining a section of the profile of the track, the plurality of signatures defining a profile of the track over time, each signature including: at least one measurement of speed, at least one measurement of inclination of the track along at least one direction, and at least one position; and
- determination of a position of the vehicle based on the position of the at least one identified signature.

According to other particular embodiments, the method comprises one or a plurality of the following features, taken individually or according to all technically possible combinations:

- the plurality of signatures is generated from a vehicle traveling on the track, each signature comprising, for a time specific to the signature: a measurement of the speed of the vehicle, a measurement of the inclination of the track and a measurement of the position of the vehicle,
- each measurement of inclination is selected from a group comprising: a roll angle of the vehicle and a pitch angle of the vehicle,
- the method further comprises a resampling step during which, if the speed measurements of the instantaneous profile differ from the speed measurements of the signatures by more than a first predefined value, at least one dataset is deleted from the instantaneous profile and/or at least one additional dataset is added to the instantaneous profile, each additional dataset comprising a speed measurement and an inclination measurement, at an additional instant comprised between two measurement instants for which the instantaneous profile includes a dataset,
- the method further comprises a step of updating the plurality of signatures by adding to the plurality of signatures a newly generated signature comprising: a dataset of the instantaneous profile, and the determined position,
- the method further comprises the following steps:
    - reception of a position of the vehicle, called the received position, and
    - calculation of an improved vehicle position by merging data between at least the determined position and the received position, and
- the method further comprises the following steps:
    - reception of a position of the vehicle, called the received position; and
    - selection of signature(s) from the plurality of signatures the position of which differs from the received position by at most a second value,
    - a second step of comparison of at least one of the inclination measurements of the instantaneous profile to the inclination measurement of each selected signature, and
    - detection of anomaly(ies) if, in the second comparison step, at least one deviation between two compared inclination measurements is greater than a third value.

The present invention further relates to an electronic device for locating a vehicle, in particular a railway vehicle, moving on a track, the electronic location device comprising:

- at least one sensor configured to measure, at successive instants, a speed of the vehicle and an inclination of the track along at least one direction, in order to obtain a dataset at each instant, the set of datasets forming an instantaneous profile of the track,
- a comparison module configured to compare the instantaneous profile with a plurality of signatures, the plurality of signatures defining a profile of the track over time, each signature comprising: at least one measurement of speed, at least one measurement of inclination of the track along at least one direction, and at least one position, and to identify the signature(s) corresponding to the instantaneous profile and defining a section of the profile of the track, and
- a determination module configured to determine a position of the vehicle from the position of the at least one identified signature.

According to a particular embodiment, the electronic location device comprises the characteristic according to which the plurality of signatures is comprised in a database remote from the vehicle, the device further comprising on-board means of communication suitable for exchanging data between the vehicle and the database.

The present invention further relates to a computer program product comprising software instructions suitable for, when implemented by a computer, implementing at least the steps of comparison, identification and determination of a location method as defined hereinabove.

Other features and advantages of the invention will appear upon reading the following description, of the embodiments of the invention, given only as a non-limiting example, and making reference to the enclosed drawings, wherein:

[Fig.1] Figure 1 is a partial schematic representation of a railway vehicle comprising an electronic location device according to the invention, the device communicating with a database;

[Fig.2] Figure 2 is a graphical representation of changes in measurements of the roll of a vehicle and of the cross slope of a section of a track over time; and

[Fig.3] Figure 3 is an organization chart of an example of implementation of a location method according to the invention.

An example of portion of a vehicle 10 is illustrated in Figure 1. For example, the vehicle 10 is a railway vehicle, such as a train, a subway car, or a tram.

The vehicle 10 is moving on a track 13. When the vehicle 10 is a railway vehicle, the track 13 typically comprises rails 15.

The vehicle 10 comprises on-board means of communication 20, an electronic location device 25 apt to locate the vehicle 10, and optionally an external positioning device 30 configured to obtain a position L_r, λ_r of the vehicle 10, called the received position, by means (not shown) external to the vehicle 10, and to transmit the received position L_r, λ_r to the location device 25.

The on-board means of communication 20 are connected to the location device 25 and configured to exchange signals with remote means of communication 32, as such connected to a remote database 35. The remote means of communication 32 and the database 35 are e.g. located in a centralized station such as a server room, several kilometers away from the vehicle 10. Such a database 35 is then apt to exchange signals, via the remote means of communication 32, with a plurality of vehicles 10.

In a variant, the database 35 is included within the vehicle 10, and is directly connected to the electronic location device 25.

In another variant, a part of the database 35 comprising the data corresponding to the route planned by the vehicle 10 is loaded within the location device 25 prior to the travel of the vehicle 10.

The data contained in the database 35 will be discussed in detail hereinafter.

The location device 25 comprises a set of sensor(s) 40, a computer 45 suitable for processing quantities measured by the set of sensor(s) 40, and optionally an audible or luminous warning device 46.

Optionally, the on-board means of communication 20 are comprised in the location device 25.

The assembly of sensor(s) 40 is suitable for measuring, at successive instants t_i, a speed V of the vehicle 10 and at least one inclination of the track 13 along at least one direction. To this end, the set of sensors 40 comprises e.g. a first angular sensor 50, a second angular sensor 55, a speed sensor 60 and optionally a time sensor 65 and an altitude sensor 70.

The first angular sensor 50 is configured to measure a pitch angle α of the vehicle 10. The vehicle 10 being in contact with the track 13 via the rails 15, the pitch angle α of the vehicle 10 is representative of a slope of the track 13. In other words, the pitch angle α characterizes a variation in altitude of the vehicle 10 as same advances on track 13. Thereby, when the track 13 goes up, the pitch angle α is positive. Conversely, when track 13 goes down, the pitch angle α is negative.

The second angular sensor 55 is configured to measure a roll angle β of the vehicle 10. Analogous to the pitch angle α, the roll angle β is representative of a cross slope of the track 13. The name of cross slope means herein an angle defined about a longitudinal axis

X along which the track 13 extends. The vehicle 10 is suitable for traveling along the longitudinal axis X. By convention, for a passenger of the vehicle 10 looking in the direction of travel of the vehicle 10, when the vehicle 10 leans to the left, the associated roll angle β is positive. Again by convention, for the same passenger, when the vehicle 10 leans to the right, the associated roll angle β is negative. It results therefrom that when the vehicle 10 is not leaning to the left or to the right, the roll angle β is substantially zero.

Note that for a rail vehicle, when the rails 15 are such that the vehicle 10 makes a turn to the left, the roll angle β is positive. Similarly, when the rails 15 are such that the vehicle 10 makes a turn to the right, the roll angle β is negative.

The unit of measurement of the pitch angles α and roll angles β is e.g. the degree, denoted °.

The first 50 and second 55 angular sensors are e.g. included in a two-axis inclinometer integrated into the vehicle 10.

The speed sensor 60 is configured to measure the speed V of the vehicle 10 along the longitudinal axis X. In a variant, the speed sensor 60 receives the speed V of the vehicle 10 from an on-board computer (not shown) included in the vehicle 10. The unit of measurement of the speed V of the vehicle 10 is e.g. the kilometers/hour.

The time sensor 65, or chronometer, is configured to measure the elapsed time. More specifically, the chronometer 65 is configured to measure each measurement instant t_i at which the set of sensor(s) 40 performs a measurement.

The altitude sensor 70, or altimeter, is configured to measure an altitude of the vehicle 10 above sea level. The altitude sensor 70 is known per se and is e.g. suitable for measuring the altitude of the vehicle 10 from the ambient air pressure measurement. The unit for the altitude H is e. g. the meter.

At each measurement instant t_i, the set of sensor(s) 40 is configured to measure the pitch angle α, the roll angle β, the speed V, and optionally the measurement instant t_i, and the altitude H. A duration between two measurement instants t_i is e.g. equal to five seconds or fifteen seconds. Thereby, the acquisition frequency of each sensor 50, 55, 60, 65, 70 is preferably equal, so that at each measurement instant t_i, each sensor 50, 55, 60, 65, 70 performs a measurement simultaneously.

The set of sensor(s) 40 is configured to form, for each measurement instant t_i, a set of measurements, and to form an instantaneous profile of the track 13 by concatenation of successive sets of measurements. Furthermore, the set of sensor(s) 40 is configured to send the instantaneous profile of the track 13 to the computer 45. An example of an instantaneous profile of the track is shown in the following Table 1:

[Table 1]

V (km/h)	280	281	279	280
α (°)	1.1	1.0	1.0	0.9
β (°)	2.1	2.3	2.5	1.9
t_i (s)	t_1	t_1+5	t_1+10	t_1+15
H (m)	112	114	115	115

where t_1 denotes an arbitrarily chosen measurement instant.

The instantaneous profile of the track 13 is a set of data measured at successive instants and characterizing a time-dependent evolution of the data of the track 13 traveled by the vehicle 10 between a first measurement instant t_1 and a last measurement instant.

In a variant, the set of sensors 40 is configured to send each dataset to the computer 45. The computer 45 is then configured to generate the instantaneous profile of the track 13 by concatenating the datasets received.

The computer 45 comprises a processor 75 and seat base 80. The memory 80 is suitable for storing software modules, or software bricks, intended to be executed by the processor 75. Furthermore, the computer 45 comprises a plurality of communication ports, in particular *Universal Serial* Bus *or USB* ports, or else Ethernet ports, via which the computer 45 is connected to the set of sensors 40 and to the on-board means of communication 20, by connectors. The computer 45 is configured to exchange data with equipment external to the vehicle 10 via the on-board means of communication 20.

The memory 80 comprises a comparison software module 85, a determination software module 90, and optionally an update software module 95, a calculation software module 100, a selection software module 105, and a detection software module 110.

The comparison module 85 is configured to compare the instantaneous profile, received from the set of sensors 40, with a plurality of signatures received from the database 35 via the on-board means of communication 20. The means of communication can be supported by general public networks, or else private networks. Same can use GSM-R technologies, or else FRMCS.

The plurality of signatures defines a profile of the track 13 in time. More specifically, each signature comprises data characteristic of the track 13. More particularly, each signature is specific to a position expressed by a longitude L and a latitude λ. Each signature comprises a slope α' and a cross slope β' of the track 13 to the abovementioned position. For example, each signature corresponds to measurements made by a vehicle (not shown) which has traveled on the track 13 before the vehicle 10 and the position L, λ of which at each instant was known. Thereby, the slope α' and the cant β' are measurements of the pitch angle and roll angle, respectively, of the machine, acquired at a respective instant t'_i

of the signature. Furthermore, each signature comprises a speed V′ of the machine at the instant t'_i of the signature, the instant t'_i of the signature, and the altitude H′ of the machine at the instant t'_i of the signature.

An example of a profile over time of a section of the track 13 is presented in the following table:

[Table 2]

V' (km/h)	140	139	139	137	137	139	140	141
α' (°)	1.0	1.2	1.1	1.0	0.9	0.8	0.9	1.0
β' (°)	2.1	2.3	2.4	2.4	2.5	2.1	1.9	1.7
t'_i (s)	t'_0	t'_0+5	t'_0+10	t'_0+15	t'_0+20	t'_0+25	t'_0+30	t'_0+35
H' (m)	112	113	113	114	114	115	115	115
L (°)	-1.1511	-1.1511	-1.1510	-1.1510	-1.1510	-1.1510	-1.1510	-1.1509
λ (°)	46.1603	46.1604	46.1604	46.1605	46.1606	46.1606	46.1606	46.1606

where t'_0 is an arbitrarily chosen instant.

The comparison module 85 is thus configured to compare the measurements of each of the instantaneous profile of the track 13 and the signatures. To this end, the comparison module 85 is configured e.g. to generate a likelihood indicator between the instantaneous profile and part of the signatures of the database 35.

The likelihood indicator characterizes similarities between the instantaneous profile and part of the signatures. Thereby, the higher the likelihood indicator, the more the instantaneous profile corresponds to the part of the signatures.

More particularly, in one example, the comparison module 85 is configured to calculate an integral of each measurement with respect to time. Figure 2 graphically shows an example of time evolution of the roll angle β by circles connected by solid lines, and of the cross slope β' by crosses connected by dotted lines. Thereby, as can be seen in Figure 2, the data to be integrated are discrete. For example, each integral is obtained using a method of rectangles, trapezoids or Runge-Kutta of order four. Consequently, the comparison module 85 is configured to generate the likelihood indicator from the difference(s) between the integrals of the instantaneous profile and the integrals of the signatures.

Furthermore, the comparison module 85 is configured to identify among the plurality of signatures, the signatures corresponding to the instantaneous profile. To this end, the comparison module 85 is configured e.g. to apply an operational search algorithm to the likelihood indicator by varying the signatures chosen, the algorithm providing a set of signatures, called identified signatures, maximizing the likelihood indicator with the

instantaneous profile. Thereby, the signatures identified are specific to the section traveled by the vehicle 10, and for which the instantaneous profile is measured.

As an optional supplement, the comparison module 85 is configured to resample the datasets of the instantaneous profile prior to the comparison. The comparison module 85 is configured to resample the datasets of the instantaneous profile if the speeds of the instantaneous profile differ from the speeds of the signatures by more than a first predefined value. In other words, the comparison module 85 is configured to, where appropriate, delete one or a plurality of sets of data from the instantaneous profile and/or add, to the instantaneous profile, one or a plurality of sets of additional data, corresponding to an additional instant comprised between two instants of measurement of the instantaneous profile. The measurements of the additional dataset are then obtained, e.g. by averaging the measurements of the dataset at the instant preceding the additional instant and the measurements of the dataset at the instant following the additional instant in the instantaneous profile. The comparison module 85 is then configured to adapt the measurements of speed of the instantaneous profile so that same correspond to the speeds V of the signatures.

In the example shown in Figure 2 and Tables 1 and 2, the speeds V' of the signatures in the database 35 are twice as low as same of the vehicle 10 contained in the instantaneous profile of the track. Thereby, in Figure 2, the roll angle β presents a similar evolution to the evolution of the cross slope β' of the signatures represented. However, the shape of the curve representing the roll angle β is more contracted than same representing the cross slope β', because the speeds of the instantaneous profile are greater than same of the signatures represented. The comparison module 85 is then configured to add an additional set of data between each dataset of the instantaneous profile of the track 13. More particularly, the additional dataset between the first two datasets of the instantaneous profile of the track 13 includes e.g. an additional pitch angle α" equal to 1.05°, an additional roll angle β" equal to 2.2°, an additional measurement instant t''_i equal to t_1+2.5, an additional altitude H" equal to 113 m. The speed V″ of the additional set is e.g. equal to 140.5 km/h.

The determination module 90 is configured to determine a position L_D, λ_D of the vehicle 10 from the position L, λ of at least one of the identified signatures. For this purpose, the determination module 90 is configured to determine the longitude L_D of the vehicle 10, e.g. equal to the average of the longitudes L of the identified signatures, and the latitude λ_D e.g. equal to the average of the latitudes λ of the identified signatures. In the example shown in the tables Table 1 and Table 2 and in Figure 2, the determination module 90 is configured to determine a position whose longitude L_D is equal to -1.1510 and whose latitude λ_D is

equal to 46.1605. In a variant, the determined position L_D, λ_D is equal to the position L, λ of the selected signature whose instant t'_i of which is the latest.

As an optional supplement, the updating module 95 is configured to update the database 35 on the basis of the instantaneous profile of the track 13 and the determined position L_D, λ_D. The updating module 95 is then configured to generate a new signature comprising the determined position L_D, λ_D and one of the datasets of the instantaneous profile or a combination of the datasets of the instantaneous profile. As an example, the signature generated comprises e.g. the determined position L_D, λ_D and the dataset of the instantaneous profile corresponding to the latest measurement instant t_i. Thereby, in the example of Table 1 and Table 2 and Figure 2, the generated signature is represented in the following Table 3:

[Table 3]

V''' (km/h)	280
α''' (°)	0.9
β''' (°)	1.9
t_i''' (s)	t_1+15
H''' (m)	115
L_D (°)	-1.1510
λ_D (°)	46.1605

Optionally, the updating module 95 is further configured to send the newly generated signature to the database 35 via the on-board means of communication 20. The newly generated signature is then included in the database 35.

As an optional supplement, the calculation module 100 is configured to receive the received position L_r, λ_r from said external positioning device 30 when the vehicle 10 comprises the external positioning device 30. The received position L_r, λ_r comprises a received longitude L_r and a received latitude λ_r. Furthermore, the calculation module 100 is configured to calculate an improved position of the vehicle 10, comprising an improved longitude L_a and an improved latitude λ_a, on the basis of the position L_D, λ_D determined by the determination module 90 and the received position L_r, λ_r. To this end, the calculation module 100 is configured to merge data between the determined position L_D, λ_D and the received position L_r, λ_r.

Optionally, the calculation module 100 is optionally configured, furthermore, to replace the longitude L_D and the latitude λ_D determined by the improved longitude L_a and the improved latitude λ_a in the signature newly generated by the updating module 95.

As an optional supplement, the selection module 105 is configured, when the vehicle 10 comprises the external positioning device 30, to select from the plurality of signatures of

the database 35, the signature(s) the position L, λ of which differs from the received position L_r, λ_r by at most a second value. In other words, the selection module 105 is configured to select the signatures the position L, λ of which is within a predefined perimeter around the received position L_r, λ_r. For example, the selection module 105 is configured to define a circle around the received position L_r, λ_r, a radius of which is equal to the second value, and to select, from among the signatures of the database 35, the signature(s), the position L, λ of which is comprised within said circle.

Optionally, the anomaly detection module 110 is configured to compare each measurement of pitch α and roll β of the instantaneous profile with the slopes α' and cross slopes β' of each signature selected by the selection module 105. The detection module 110 is also configured to detect an anomaly if, during the comparison of the measurements of inclination of the instantaneous profile and same of the selected signatures, at least one difference between two compared measurements of inclination is greater than a third value.

In a variant, the detection module 110 is configured to calculate an average of the pitch α and roll β measurements of the instantaneous profile, and an average of the slopes α' and the cross slopes β' of the selected signatures. The detection module 110 is configured to detect the anomaly if one of the differences between the averages of pitch and of slopes and between the averages of roll and of cross slopes is greater than the third absolute value.

The detected anomaly thus corresponds to a discrepancy between the angles α, β measured by the set of sensor(s) 40 and the slopes α' or cross slopes β' of the selected signatures. Such a discrepancy is e.g. due to a landslide, to an error during the formation of the database 35, or to a calibration error of the first 50 and/or second 55 angular sensor(s). In this respect, the detection module 110 is configured to detect inconsistencies between the measurements made by the vehicle 10 and same present in the database 35.

Furthermore, the detection module 110 is optionally configured, in the event of detection of anomaly(ies), to send an alarm signal to the horn 46 of the vehicle 10.

Optionally, the horn 46 is configured to then emit an audible signal or to light up a warning light intended to alert a driver of the vehicle 10.

In a variant or as an optional supplement, the detection module 110 is configured to send the alarm signal to the database 35 via the on-board means of communication 20.

As an optional supplement, the external positioning device 30 is configured to obtain the received position L_r, λ_r by communication with systems (not shown) external to the vehicle 10. To this end, the external positioning device 30 is e.g. a GNSS (*Global Navigation Satellite System*) receiver integrated into the on-board computer of the vehicle 10. The external positioning device 30 is then configured to exchange signals with satellites and

obtain the received position L_r, λ_r of the vehicle 10 according to a technique known per se. The external positioning device 30 can also use satellite-based augmentation systems (SBAS).

In a variant, the external positioning device 30 is a GSM (*Global System for Mobile Communication*s) module configured to exchange signals with telephone relay antennas (not shown) and to deduce the position L_r, λ_r of the vehicle 10 from said signals according to a technique known per se.

In another variant, the external positioning device 30 is configured to receive directly the position L_r, λ_r of the vehicle 10 from a balise (not shown) on the track 13, suitable for communicating with said device 30. The external positioning device 30 is connected to the computer 45 and is configured to send to the computer 45 the position received from the vehicle 10.

In a variant, the software modules 85, 90, 95, 100, 105, and 110 of the computer 45 are moved to the server room where the database 35 is located. Thereby, in such a variant, the computer 45 is only a relay serving to transmit the instantaneous profile to the set of software modules 85, 90, 95, 100, 105 and 110, via the on-board means of communication 20.

The operation of the electronic location device 25 will now be described with reference to Figure 3 an organization chart of a method implemented by said device 25.

Prior to putting the vehicle 10 into service on the track 13, the database 35 is generated from measurements made by one or a plurality of machines traveling on the track 13 and acquiring, at different successive instants t'_i, measurements of the longitude L, of the latitude λ, of the speed V′ thereof, of the slope α′ of the track 13 and/or of the cross slope β′ of the track 13. Optionally, the machine(s) also acquire measurements of the altitude H′ of the track 13, and of the measurement instant t'_i. Such measurements are compiled in the form of a plurality of signatures and stored in the database 35 then forming a profile of the track 13 over time.

Initially, the vehicle 10 travels on the track 13 and the driver thereof, or an automatic control system for automatic piloting, wishes to determine the position L_D, λ_D of said vehicle 10.

During a measurement step 210, the set of sensor(s) 40 measures, at successive measurement instants t_i, the speed V, the pitch angle α and/or the roll angle β of the vehicle 10. As an optional supplement, the set of sensor(s) 40 measures, furthermore, the altitude H of the vehicle 10 and the measurement instant t_i at which the measurements are made. At each measurement instant t_i, the measurements form a dataset. All the datasets then

form an instantaneous profile of the track 13. The instantaneous profile of the track 13 is then sent, by the set of sensors 40, to the computer 45.

Optionally, during a resampling step 220, if the speed measurements V of the instantaneous profile differ from the speeds V′ of the signatures by more than the first value, the comparison software module 85 resamples the instantaneous profile of the track 13 by adding one or a plurality of additional datasets to the instantaneous profile of the track 13, or by deleting datasets of the instantaneous profile and by modifying the speeds V of the instantaneous profile so that same correspond to the speeds V' of the signatures.

Then, during a comparison step 230, the comparison module 85 compares the instantaneous profile and the signatures of the database 35. To this end, the comparison module 85 compares the pitch measurements α with the slopes α', the roll measurements β at the cross slopes β', and optionally the measurements of altitudes H with the altitudes H' of the track 13. To this end, the comparison module 85 calculates e.g. a likelihood indicator between the instantaneous profile and a portion of the plurality of signatures. To this end, the comparison module 85 applies an operational search algorithm to the likelihood indicator by varying the signatures of the database.

Following the application of such algorithm, during an identification step 235, the comparison module 85 identifies, among the plurality of signatures, which signatures correspond to the instantaneous profile of the track, i.e. same which maximize the likelihood indicator. The signatures identified then correspond to the section of the track 13 described by the instantaneous profile.

During a determination step 240, the determination module 90 determines the position L_D, λ_D of the vehicle 10 from the positions L, λ of the identified signatures. The determined position L_D, λ_D comprises e.g. a determined longitude L_D equal to the average of the longitudes L of the identified signatures, and a determined latitude λ_D equal to the average of the latitudes λ of the identified signatures.

As an optional supplement, during a reception step 245, the computer 45 receives the received position L_r, λ_r from the external positioning device 30. The received position comprises e.g. the received longitude L_r and the received latitude λ_r.

Optionally, during a calculation step 250, the calculation module 100 calculates the position L_a, λ_a improved by merging data between the determined position L_D, λ_D and the received position L_r, λ_r. To this end, the calculation module 100 calculates the improved longitude L_a and the improved latitude λ_a. To this end, the calculation module 100 implements e.g. the techniques described in the CLUG project, meaning *Certifiable Localization Unit with GNSS.*

Optionally, during an updating step 260, the updating module 95 generates the newly generated signature from the datasets of the instantaneous profile and the determined position L_D, λ_D, as described hereinabove. The updating module 95 then sends the newly generated signature to the database 35 via the on-board means of communication 20. The newly generated signature is then added to the plurality of signatures of the database 35.

As an optional supplement, during the updating step 260, the calculation module 100 replaces the determined position L_D, λ_D by the improved position L_a, λ_a in the newly generated signature.

Optionally, during a selection step 270, the selection module 105 selects, from among the signatures of the database 35, the signature(s), the position L, λ of which differs from the received position L_r, λ_r by at most the second value. In other words, the selection module 105 calculates a distance between the received position L_r, λ_r and the position L, λ of each signature and selects the signatures for which said distance is less than the second value.

As an optional supplement, during a second comparison step 280, the detection module 110 compares the measurements of inclination α, β of the instantaneous profile to the slopes α' and to the cross slopes β' of the selected signatures. More specifically, the detection module 110 compares the measurements of pitch α to the slope α' of each selected signature and the measurements of roll β to the slope β' of each selected signature.

If at least two of the compared quantities differ by more than the third value, then, during an optional detection step 290, the detection module 110 detects the anomaly.

If the anomaly is detected, during an optional sending step 300, the detection module 110 sends the alarm signal toward the horn 46 and/or toward the database 35, via the on-board means of communication 20.

In a variant, the selection step 270, the second comparison step 280, the detection step 290 and the sending step 300, which are optional, precede or are performed in parallel with the calculation steps 250 and the updating step 260.

The location method and the electronic location device 25 simplify, in particular by means of the first comparison step 230, the determination of the location of the vehicle 10.

Moreover, when the database 35 is remote from the vehicle 10, it is apt to communicate with a plurality of vehicles 10 simultaneously. It results therefrom that when the updating module 95 adds the newly generated signature to the database 35, each vehicle 10 simultaneously benefits from the addition.

Furthermore, when the database 35 is fully or partially included in the vehicle 10, the location device 25 is apt to determine the location of the vehicle 10 even when same cannot

communicate with any external system, in particular in a tunnel or in a territory without network coverage.

A person skilled in the art would understand that the variants described hereinabove can be combined so as to form new variants, provided that same are technically compatible.

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CLAIMS

1. A method for locating a vehicle (10), in particular a railway vehicle, moving on a track (13), the method being implemented by an electronic tracking device (25) and comprising the following steps:

- measurement (210), at successive instants (t_i), of a speed (V) of the vehicle and of an inclination (α, β) of the track along at least one direction in order to obtain a dataset at each instant, the set of datasets forming an instantaneous profile of the track,
- comparison (230) of the instantaneous profile with a plurality of signatures, and identification (235) of signatures corresponding to the instantaneous profile and defining a section of the profile of the track, the plurality of signatures defining a profile of the track over time, each signature including: at least one speed measurement (V'), at least one track inclination measurement (α', β') along at least one direction, and at least one position (L, λ), and
- determination (240) of a position (L_D, λ_D) of the vehicle as a function of the position (L, λ) of the at least one identified signature.

2. The method according to claim 1, wherein the plurality of signatures are generated from a vehicle traveling on the track (13), each signature comprising, for an instant (t'_i) specific to the signature: a measurement of speed (V') of the machine, a measurement of inclination (α', β') of the track (13) and a measurement of position (L, λ) of the vehicle.

3. The method according to claim 1 or 2, wherein each measurement of inclination (α, β) is selected from a group comprising: a roll angle (β) of the vehicle (10) and a pitch angle (α) of the vehicle (10).

4. The method according to one of claims 1 to 3, further comprising a resampling step (220) during which, if the speed measurements (V) of the instantaneous profile differ from the speed measurements (V') of the signatures by more than a first predefined value, at least one dataset is deleted from the instantaneous profile and/or at least one additional dataset is added to the instantaneous profile, each additional dataset comprising a measurement of speed (V'') and a measurement of inclination (α'', β''), at an additional instant (t''_i) comprised between two measurement instants (t_i) for which the instantaneous profile includes a dataset.

5. The method according to any of claims 1 to 4, wherein the method further comprises a step (260) of updating the plurality of signatures by adding to the plurality of signatures a newly generated signature comprising: a dataset of the instantaneous profile; and the determined position (L_D, λ_D).

6. The method according to any of claims 1 to 5, wherein the method further comprises the following steps:

- reception (245) of a position (L_r, λ_r) of the vehicle (10), called the received position, and
- calculation (250) of an improved position (L_a, λ_a) of the vehicle (10) by merging data between at least the determined position (L_D, λ_D) and the received position (L_r, λ_r).

7. The method according to any of claims 1 to 6, further comprising the following steps:

- reception (245) of a position (L_r, λ_r) of the vehicle, called the received position,
- selection (270) of signature(s) amongst the plurality of signatures the position (L, λ) of which differs from the received position (L_r, λ_r) by at most a second value,
- a second step of comparison (280) of at least one of the measurements of inclination (α, β) of the instantaneous profile to the measurement of inclination (α', β') of each selected signature, and
- detection (290) of anomaly(ies) if, in the second comparison step (280), at least one deviation between two compared measurements of inclination (α, β; α', β') is greater than a third value.

8. An electronic location device (25) of a vehicle (10), in particular a railway vehicle, moving on a track (13), the electronic location device (25) comprising:

- at least one sensor (50, 55, 60) configured to measure, at successive instants (t_i), a speed (V) of the vehicle (10) and an inclination (α, β) of the track (13) along at least one direction to obtain a dataset at each instant (t_i), the set of datasets forming an instantaneous profile of the track (13),
- a comparison module (85) configured to compare the instantaneous profile with a plurality of signatures, the plurality of signatures defining a profile of the track over time, each signature including: at least one measurement of speed (V'), at least one measurement of inclination (α', β') of the track (13) along at least one direction, and at least one position (L, λ), and to identify the signature(s)

corresponding to the instantaneous profile and defining a section of the profile of the track (13), and

- a determination module (90) configured to determine a position (L_D, λ_D) of the vehicle (10) from the position (L, λ) of the at least one identified signature.

9. The device (25) according to claim 8, wherein the plurality of signatures is comprised in a database (35) remote from the vehicle (10), the device (25) further comprising on-board means of communication (20) suitable for exchanging data between the vehicle (10) and the database (35).

10. A computer program product comprising software instructions suitable for, when implemented by a computer, implementing at least the steps of comparison (230), identification (235) and determination (240) of a location method according to claim 1.