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(54) **Title**: METHOD AND DEVICE FOR TRACKING THE PATH OF AN OBJECT

(57) Abstract: Method for tracking the path of an object, comprising the following steps : a) detecting an acceleration signal from at least one accelerometer; b) calculating the displacement of said object starting from said acceleration signal; c) detecting an orientation signal from at least one magnetometer and/or orientation meter; d) estimating the position of the object instant by instant on the basis of the signals generated by said sensors, e) detecting a rotation signal from at least one gyroscope; f) comparing the change of the orientation signal in two subsequent instants with a predetermined value; g) when the change exceeds such predetermined value, correcting the orientation signal on the basis of the signal generated by the gyroscope.

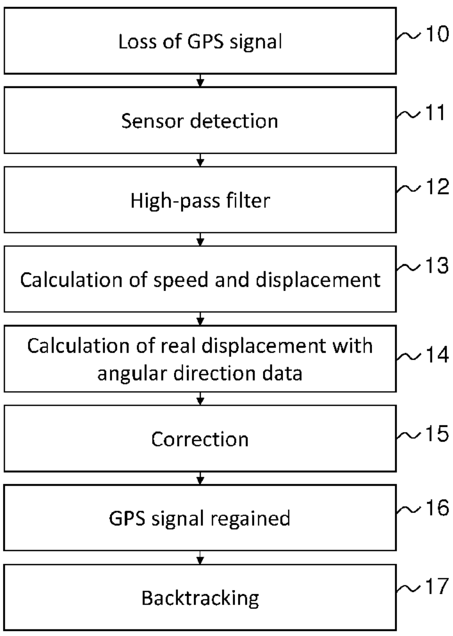

Fig. 1

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Method and device for tracking the path of an object.

The present invention relates to a method and a device for tracking the path of an object.

The method for tracking the path of an object comprises the following steps:

a) detecting an acceleration signal from at least one accelerometer;

b) calculating the displacement of said object starting from said acceleration signal;

c) detecting an orientation signal from at least one magnetometer and/or from a further device determining the orientation, so called orientation meter;

d) estimating the position of the object instant by instant on the basis of the signals generated by said sensors starting from a position detected by a GPS sensor, at an instant immediately preceding the loss of said signal of the GPS sensor.

Methods using said steps for tracking the path of an object are currently known and fall within a technology called as "dead reckoning", namely determining the position by calculating the displacements from a known starting point. A particular type of dead reckoning is represented by the so called inertial navigation systems (INS) using signals generated by inertial sensors to track a path of an object.

In the currently known INSs however the calculation is carried out only on the basis of signals of accelerometers and signals of magnometer or orientation meter.

The use of gyroscopes is known but, as described for example in the document US 5,583,776 they are mainly used to remove gravity effects from what detected by accelerometers.

The present invention is advantageously, but not exclusively, applied to the tracking of underwater paths.

Within such field the document US 2014/0126334 A1 describes an underwater acoustic navigation system, wherein however it is necessary to provide additional instruments external to the tracking device. Moreover the acoustic communication is difficult since temperature changes depending on depth resulting in changes in the speed of sound that is the base of refraction problems for the signal passing through layers with different density. It results that there are great problems in defining the position between a movable device and a reference system if the communication therebetween occurs at different depths.

Therefore currently there is the unsatisfied need for an INS using accelerometers, gyroscopes and magnetometers and/or orientation meters in a synergic manner to achieve a tracking characterized by high accuracies.

The present invention aims at achieving said objects and at overcoming the drawbacks of the currently known systems, with a method as described hereinbefore which further comprises the additional following steps:

e) detecting a rotation signal from at least one gyroscope;

f) comparing the change of the orientation signal in two subsequent instants with a predetermined value;

g) when the change exceeds such predetermined value, correcting the orientation signal on the basis of the signal generated by the gyroscope.

This allows gyroscopes to be used for correcting measurements of magnetometer and/or orientation meter when they detect sudden and considerable changes, namely when it is likely that a measurement error is provided that can cause errors, even important ones, in evaluating the tracked path above all if due to a plurality of measurement errors summed over time.

Therefore the method is able to guarantee high accuracies, as it has been tested by carrying out comparisons with corresponding GPS tracks that turned out to be very positive.

In one embodiment, in order to correct the signal, an orientation value is generated from the rotation signal, and the value of the time-corresponding orientation signal is modified by carrying out the mean with said orientation value generated from the rotation signal.

This means that when the change of the orientation signal exceeds a predetermined threshold the orientation signal is corrected on the basis of the signal coming from gyroscopes. Such correction is carried out by obtaining an orientation value from the signal coming from the gyroscopes, and such orientation value updates the orientation signal by a mean.

The mean can be an arithmetic mean or a weighted mean, wherein the weight of the gyroscopes with respect to that of magnetometer and/or orientation meter is selected beforehand during the design phase, or it can be set by the user.

In a further embodiment there are provided two distinct orientation signals, a first orientation signal of which is generated by said magnetometer and a second orientation signal is generated by said orientation meter. A comparison of the two orientation signals is carried out and when the difference exceeds a predetermined value the first orientation signal is corrected on the basis of the second orientation signal. The first signal is now used for estimating the position of the object.

This allows two distinct measurements from the magnetometer and the orientation meter to be carried out, and it allows the second one to be used for correcting the first one if the difference exceeds a specific predetermined value, that is an anomalous difference. Also in this case the evaluation of the orientation signal is more accurate, resulting in a positive effect on the general tracking of the path.

In one embodiment the estimate of the position of the object instant by instant on the basis of the signals generated by said sensors is automatically carried out starting from the loss in the signal of a GPS detector.

Thus the detection of signals from sensors and the calculation of the path is automatically activated upon losing the global positioning signal. This allows the system to be automatically switched in the two tracking modes without the need of external interventions of the user and without interruptions.

According to a further embodiment the position detected by the GPS detector in the instant of GPS signal loss is used as the starting position for estimating the position of the object instant by instant on the basis of the signals generated by said sensors.

Thus the reconstruction of the path starts from a point measured by GPS that therefore is considered as reliable. Therefore the system for calculating the position is carrying out by starting from a "real" position in the space since it is defined by a satellite connection.

According to a further embodiment in the moment when the GPS signal is regained, the estimate of the position of the object instant by instant on the basis of the signals generated by said sensors is automatically stopped.

This allows again the system to be automatically switched from dead reckoning mode to GPS mode, as soon as the signal is available and is regained.

According to an improvement the position detected by the GPS detector in the moment when the GPS signal is regained is used as the final position, and the tracked path is corrected backwards such that the final calculated position coincides with the final position detected by the GPS detector.

The curve that defines the tracked path is therefore remodeled such to adapts itself to the starting and final positions defined by the GPS signal.

According to one embodiment, the position detected by the GPS detector in the moment when the GPS signal is regained is used as the final position, and the tracked path is corrected backwards such that the final calculated position coincides with the final position detected by the GPS detector, the starting position detected by the GPS in the moment immediately preceding the GPS signal loss and the position of arrival detected by the GPS signal upon recovering the reception of the GPS signal by the GPS sensor being considered as the correct starting position and position of arrival respectively and a curve connecting said starting and arrival positions being generated which is calculated by means of a progressive and incremental change of the position of each point on the estimated path, which points coincide with a displacement step or with each acquisition of the orientation and displacement signals of the sequence of acquisition of said signals, said progressive position change being applied in the direction of the vector connecting the estimated point of arrival and the point of arrival determined by the GPS sensor.

In a further embodiment, the change in the position of each point along the estimated path corresponding to a step of the acquisition of the displacement and/or orientation signals of the sequence of acquisition steps is determined according to the following steps:

determining the distance between the estimated point of arrival and the point of arrival determined by the GPS sensor;

determining an incremental step of the change in the position of each point which step is defined by dividing the distance between the estimated point of arrival and the point of arrival detected by the GPS sensor by the number of steps of acquisition of the orientation and displacement signals provided in said acquisition sequence;

progressively applying a multiple of said incremental step of the change in the position which multiplicative factor of such multiple is determined by the order number of the estimated point on the path correspondingly to the acquisition sequence.

According to a further example, the method for reconstructing the path on the basis of the estimation data and the starting and arrival signals detected by the GPS comprises the following steps:

determining a number of detections of displacement and/or orientation signals during the displacement of an object which detections are carried out by displacement and/or orientation sensors;

defining a starting point by the GPS sensor;

estimating a point of arrival of the displacement by means of sensors different from the GPS sensor;

detecting the point of arrival by the GPS sensor;

determining the distance and direction between the estimated point of arrival and the point of arrival detected by the GPS sensor;

dividing the distance between the estimated point of arrival and the point of arrival detected by the GPS sensor by the number of detections of displacement and/or orientation signals during the displacement of an object;

defining along the estimated path between the starting point and the point of arrival a number of points corresponding to the position where the acquisitions have been carried out or dividing the estimated path in a number of points along said path corresponding to the number of said detections;

moving each point along the same direction of the difference in the position between estimated point of arrival and point of arrival detected by the GPS sensor for a distance corresponding to said distance divided by the number of said detections, multiplied by the order number of said point along the estimated path starting from the starting position detected by the GPS;

possibly connecting said displaced points by a curve.

The present invention further relates to a device for tracking a path, comprising at least one accelerometer, at least one gyroscope, at least one orientation meter and/or magnetometer and a processing unit connected to said sensors for estimating the position of the device instant by instant on the basis of the signals generated by said sensors. The processing unit comprises a sub-unit comparing the change of the signal generated by the orientation meter and/or magnetometer in two subsequent instants with a predetermined value, such that when the change exceeds such predetermined value, the processing unit carries out a correction of the signal generated by the orientation meter and/or magnetometer on the basis of the signal generated by the gyroscope.

Preferably there are provided three accelerometers arranged along three axes parallel with each other and three gyroscopes intended to detect the rotation about three axes parallel with each other.

In one embodiment there is provided a GPS detector connected to said processing unit, and the processing unit comprises a sub-unit monitoring the GPS detector. Upon losing the GPS signal, the processing unit automatically starts to carry out the estimate of the position of the device instant by instant on the basis of the signals generated by said sensors and in the moment when the GPS signal is regained, the processing unit automatically stops such estimate.

In one embodiment the position detected by the GPS detector in the instant of the signal loss is used by the processing unit as the starting position for tracking the path.

In a further embodiment the position detected by the GPS detector in the moment when the GPS signal is regained, is used as the final position by the processing unit, which processing unit corrects backwards the tracked path such that the final calculated position coincides with the final position detected by the GPS detector.

In one preferred embodiment said accelerometer is a linear accelerometer.

Unlike traditional accelerometers the linear accelerometers act such to natively filter the gravitational acceleration component. The use of such type of accelerometers prevents gyroscopes from being used for removing gravity effects, such as for example done in currently known systems.

In a preferred example, there are provided water-resistant means, such that the device is intended to be used underwater.

This is very advantageous since the underwater navigation cannot use GPS signals, that cannot be detected underwater.

In a further preferred example the device is composed of a tablet, a smartphone or the like.

The invention therefore relates to an underwater self-locating and orientation system for movable devices, and it consists in providing a computational system able to process instant by instant the data provided by inertial sensors usually present in movable devices such as tablets, smartphones or the like and to give back presumed geographical position information about the device during the diving phases, in the absence of satellite coverage, internet connection or any type of communication with external units.

Therefore the present invention allows geolocated data and observations to be recorded, its position to be consulted with respect to previous recorded paths, GIS functionalities to be accessed, photos and videos with geotags to be collected and data collecting tables to be filled in that have been set by the user by geolocating in real-time such detections. The device is further able to communicate by short-distance wi-fi with external sensors, to record received data as well as to integrate them in the computational process calculating the position instant by instant.

The present invention relates also to a device for supporting a tablet, smartphone or the like, for an underwater sea scooter which has a base resting on said sea scooter and a seat removably housing said tablet, which housing seat has the dimensions corresponding to those of the tablet and it is shaped such that the tablet is kept with an inclination lower than 60° with respect to the plane defined by the sea scooter.

The path tracking method operates in an efficacious manner if the tracking device is not subjected to too pronounced inclinations about its axes, and in particular if it keeps an initial position substantially unchanged. It results that if using a sea scooter, it is particularly advantageous to rigidly restrain the tracking device to the sea scooter, such that the detected movements are those of the sea scooter, which therefore becomes the object whose path is tracked.

The inclination lower than 60° is particularly advantageous to allow the user to display and possibly to act on the touchscreen of the tablet or smartphone.

In one embodiment there are provided two elements shaped in the same manner to each other and spaced from each other by spacing elements, each element having a side resting on the sea scooter, such that the two rest sides of the two elements are said rest base, and at least one inclined side provided with a recess, such that the two recesses of the two elements are said housing seat.

These and other characteristics and advantages of the present invention will be more clear from the following description of some non limitative embodiments shown in the annexed drawings wherein:

Fig.1 is a flow chart of the method;

Fig.2 is a functional block diagram of the device;

Figs.3 and 4 are two views of the supporting device.

Figure 5 is an example of a method for reconstructing the path starting from the estimated path and from the starting point and point of arrival whose position is determined by the GPS sensor.

Figure 6 schematically is the application of a factor correcting the displacements and orientation that is applied to the displacement and orientation values of the sensors.

The method described in figure 1 starts upon losing the GPS signal 10. When the signal loss is detected, the estimate of the object position is automatically launched instant by instant on the basis of signals generated by the sensors. Therefore the lack of GPS signal activates an analysis of the data from inertial sensors. The position detected by the GPS detector in the instant of GPS signal loss is used as the starting position for estimating the object position instant by instant on the basis of the signals generated by the sensors.

To this end a detection 11 of signals coming from accelerometer, gyroscope, magnetometer and orientation meter is carried out instant by instant.

The term instant by instant means that a repetition frequency is defined for the operations acquiring and processing the signals from said sensors, namely for example the accelerometer and/or gyroscope and/or magnetometer and/or orientation meter.

According to one embodiment, such signal detection and/or processing frequency can be unchangeably defined for the whole path, or it can be changed, but always remaining a constant or according to still another alternative, the frequency for acquiring the signals provided by said several devices can automatically dynamically change depending on one or more of the displacement parameters detected by one or more of said sensors.

In one embodiment the detection frequency can change depending on the displacement speed as measured by one or more of said sensors.

According to a further characteristic that can be provided as an alternative or in combination with the previous one, the detection frequency can change not only depending on the frequency of the change in direction of the trajectory made by the object.

Such automatic change in the detection frequency occurs according to a loop feedback control logic where the data provided by one or more sensors are used in real-time to change the frequency of repetition of the actions reading the signals of said sensors.

According to one embodiment, the processing of the signals of one or more of said sensors can be carried out with frequencies processing the sequence of acquired displacement data that are identical or different from the acquisition frequencies, said data being stored by associating to them a time marker about the instant when the detection has occurred. This allows the data sequence to be arranged in the proper chronological acquisition order, thus the individual estimated displacements are arranged according to the proper time sequence.

The data provided by the accelerometer are treated in order to exclude from the analysis process the noise-related disturbances corresponding for example to accidental position changes of the device. In particular a high-pass filter 12 is applied.

Therefore speed and displacement 13 are calculated starting from the data of the accelerometer, that is acceleration data. Acceleration is taken as being constant within the considered time range, that is between two subsequent measurements. In order to calculate the speed and displacement an integration is carried out respectively, according to the following formula:

$$v = v_0 + at$$

and a double integration, according to the following formula:

$$x = x_0 + vt + \frac{1}{2}at^2$$

Therefore the real displacement 14 is calculated, which is integrated with data of angular direction with respect to earth north. The data coming from the magnetometer and/or orientation meter are processed again on trigonometric bases and refer to a geodetic coordinate system such as for example WGS84 system.

The term orientation in this case means a device provided with sensors that determines an orientation of the object and that provides data uniquely defining the orientation of the object in the displacement path.

The sensors of the orientation meter can be also of the magnetic type or can be composed of accelerometers arranged according to three axes perpendicular to each other.

As regards the present invention, the term orientation meter, opposite to magnetometer or accelerometers or also gyroscopes, has to be intended as a device determining the orientation that acts according to a diversity principle with respect to a magnetometer or a gyroscope and that provides orientation data based on a different construction of the sensor with respect to magnetometer and/or gyroscope and/or an assembly of linear accelerometers and/or an algorithm processing the signals of said individual sensors for determining the orientation values which algorithm even if based on the same physical laws results from a different implementation mode by means of a program processing the signals of sensors. This results in that the different devices produce different orientation signals which can be used for correcting the estimated displacement values.

Therefore a correction 15 to the real displacement calculated at step 14 is carried out. To this end a comparison of the change of the orientation signal is carried out in two subsequent instants with a predetermined value and when the change exceeds such predetermined value, the orientation value is corrected on the basis of the signal generated by the gyroscope.

In this case the measurement of the orientation in two subsequent instants is necessary to determine the directional change along the path on the basis of the change of the orientation in two subsequent instants of the measurement sequence.

When such change remains within a given threshold it is believed that the detected displacement can be acceptable and does not derive from an error. The fact of exceeding the threshold causes the gyroscope signal to be used for correcting the measurement of the orientation of the magnetometer and/or orientation meter.

In order to correct the signal an orientation value is generated starting from the rotation signal, and the value of the time-corresponding orientation signal is modified by working out the mean with said orientation signal generated starting from the rotation signal.

The mean can be an arithmetic mean or a weighted mean where the weight of the gyroscopes with respect to that of the magnetometer and/or orientation meter is selected beforehand during the design phase, or it can be set by the user.

As an alternative or in combination with the correction of the orientation signal of the magnetometer and/or orientation meter on the basis of the rotation signal, it is possible to provide a correction of the orientation signal of the magnetometer on the basis of the data coming from the orientation meter.

In this case there are provided two distinct orientation signals, a first orientation signal of which is generated by said magnetometer and a second orientation signal is generated by said orientation meter. A comparison of the two orientation signals is carried out, and when the difference exceeds a predetermined value the first orientation signal is corrected on the basis of the second orientation signal. The first signal is now used for estimating the position of the object.

The correction can be carried out instant by instant or, as an alternative, periodically at predetermined intervals.

In the moment when the GPS signal is regained 16, the estimate of the position is automatically stopped.

The position detected when the GPS signal is regained is used as the final position, and the tracked path is corrected backwards in a backtracking process 17, such that the calculated final position coincides with the detected final position.

Figures 5 and 6 schematically show the backtracking process.

A and B denote the starting point and the point of arrival, whose position is determined by the GPS sensor, preferably automatically upon recovering the reception by said sensor.

B′ defines on the contrary the estimated position of arrival, using the orientation and displacement signals.

The method provides to define along the estimated path a series of points coinciding as regards number with the number of detection steps carried out during the path and therefore depend on the frequency detecting the displacement and orientation signals.

In the shown example the points and therefore the detection steps are 18.

The position and distance of the points can vary and can coincide, preferably, with the position along the path where a detection step of the sequence of detection steps occurred.

As it is clear, the real point of arrival, that is the one defined by the GPS sensor and shown by B is at a given distance from the estimated point of arrival B′.

The curve denoted by T describing the estimated path therefore is not correct and has to be modified.

The method used in the present example provides the distance vector between the estimated point of arrival B′ and the point of arrival defined by the GPS sensor to be divided in points spaced from each other whose number corresponds to the detection steps and therefore to the points on the estimated path.

As it is clear along such distance D there are provided 18 points including point B′.

For each point from 1 to N along the estimated path T, a displacement towards the distance vector D is applied corresponding to a multiple of the segment in which said distance D is divided by the N points and which multiple has a multiplicative factor for the length of said segment D/N that is equal to the number of order of said point along the estimated path T.

The hourglass black points show the position in which each corresponding point of the estimated path is moved and these are connected with each other by the curve describing therefore a reconstructed path connecting the two starting point and point of arrival whose position is determined by GPS sensors and therefore is reliable or correct. That is to say the above mentioned method starts from the following condition:

Real starting point A

Estimated point of arrival B′

Real point of arrival B

Backtracking up to A′

The method provides to calculate the distance A–A′

and B-B′ that will be equal and such distance is the same for each n-th point of lines A-B′ and A′-B.

The joining segments (e.g. A-A′) are divided into N points where N is the number of detections carried out to estimate the displacement of the object.

Starting from the fundamental aspect that point A is the real one as well as point B since they are detected by the GPS a recalculation of the trajectory is carried out as it follows:

the second point is moved by one factor 1/n of the distance of the joining segment A+1 and A′+1 and along it.

the third point will be moved by a factor 2/n of the distance A+2-A′+2;

the fourth point by a factor 3/n,

the fifth point by 4/n and so on till the point n-1 that will be moved by a factor n-1 on n and the final point that will be moved by a factor n/n coinciding with point B.

Therefore the generic point will be moved by an amount equal to its positioning inside the segment and that is a i-th point is moved by a factor i/n with i= 0,1,2…n.

According to a further characteristic shown in figure 6, it has been noted that the displacement estimates obtained by the sensors such as accelerometers, magnetometer, orientation meter and gyroscope have an error that is substantially constant within predetermined tolerances and that essentially causes the displacement to be underestimated with respect to the real one or anyway with respect to the one that would be determined by a GPS sensor.

This is shown in figure 6 by the fact that the point B′ has a given distance from point B.

In this case, the invention provides to apply to the estimated signals a constant multiplicative factor that “stretches” the estimated path such to reduce the error and to have a more true reconstruction of the path.

Said multiplicative factor can be determined one time on the device during the initial set-up phase or it can be modified and updated over time.

Said multiplicative factor can be determined later after the detection by setting it depending on the device used and therefore it can be inserted in the following detections in order to refine the algorithm.

A method to calculate the multiplicative factor consists in comparing the length A-B′ and the length A-B. Therefore by the division (A-B)/(A-B′) the multiplicative factor to be applied to the distance calculated instant by instant is determined.

For example if the segment A-B′ is 10m long and the segment A-B is 12m long a multiplicative factor of the value of 12/10=1,2 would be provided.

Figure 2 shows a functional block diagram of the device comprising an accelerometer 1, a gyroscope 2, an orientation meter 3, a magnetometer 4.

The accelerometer 1 preferably is a linear accelerometer.

There is provided a processing unit 5 connected to the sensors for estimating the position of the device instant by instant on the basis of the signals generated by the sensors. The processing unit 5 comprises a sub-unit 50 comparing the change of the signal generated by the orientation meter 3 and/or magnetometer 4 in two subsequent instants with a predetermined value. When the change exceeds such predetermined value, the processing unit 5 carries out a correction of the signal generated by the orientation meter 3 and/or magnetometer 4 on the basis of the signal generated by the gyroscope 2.

The device comprises a GPS detector 6 connected to the processing unit 5 and the processing unit 5 comprises a sub-unit 51 monitoring the GPS detector. Upon losing the GPS signal, as detected by the monitoring sub-unit 51, the processing unit 5 automatically starts to carry out an estimate of the position of the device instant by instant on the basis of the signals generated by the sensors, and when the GPS signal is regained, the processing unit 5 automatically stops such estimate.

The position detected by the GPS detector upon losing the signal is used by the processing unit 5 as the starting position for tracking the path. The position detected by the GPS detector 6 when the GPS signal is regained is used as the final position by the processing unit 5. The processing unit 5 corrects backwards the tracked path, such that the final calculated position coincides with the final position detected by the GPS detector 6.

The device is preferably composed of a tablet, smartphone or the like, and it is provided with water-resistant means, such to be used during a dive.

The water-resistant means can be for example an underwater case.

Therefore the device comprises a touchscreen 7, by means of which it is possible for example to display in real-time its own position and/or consult its own position with respect to previous recorded paths.

The device can advantageously integrate all functionalities currently known for tablets, for example having the access to GIS functionalities, collecting photos and videos with geotags and filling in data collecting tables defined by the user by geolocating in real-time such detections. The device further comprises a wi-fi unit, and therefore it is able to communicate through short-distance wi-fi with external sensors, to record received data as well as to integrate them in the computational process calculating the position instant by instant.

Figures 3 ans 4 show two views of the device supporting a tablet, smartphone or the like, that can be mounted on a underwater sea scooter 9, which underwater sea scooter 9 is schematically shown in figure 4.

The supporting device has a base resting on the sea scooter 9 and a seat removably housing the tablet.

The supporting device comprises two elements 80 shaped in the same manner to each other and spaced from each other by spacing elements 81, preferably three tubular spacing elements.

Each element 80 has a side resting on the sea scooter 83, such that the two rest sides 83 of the two elements 80 are said rest base.

Each element 80 further has one inclined side 84 provided with a recess 82, such that the two recesses 82 of the two elements 80 are said housing seat.

The housing seat advantageously has dimensions corresponding to those of the tablet and it has such a shape that the tablet is kept with an inclination lower than 60° with respect to the plane defined by the sea scooter.

The supporting device comprises means for fastening to the sea scooter and means for coupling the tablet in the housing seat.

In the example shown in the figures, such means comprise through slits 85 and 86 in the elements 80. The slits fastening to the sea scooter 86 are placed at the sides resting on the sea scooter 83. In such slits 86 it is possible to pass for example a belt removably fastening the supporting device to the sea scooter. On the contrary the slits coupling the tablet 85 are placed at the recesses 82, that is near the housing seat. Similarly in such slits 85 it is possible to pass a belt or an elastic element holding the tablet within the housing seat.

From what described above it is clear that the invention is not limited to the embodiments described and shown by way of non-limitative example but is can be widely changed and modified, as a whole and as regards individual details, depending on specific needs and on manufacturing and use advantages, above all as regards construction and within the technical and functional equivalents, without for this reason departing from the teaching principle mentioned above and claimed below.

CLAIMS

1. Method for tracking the path of an object, comprising the following steps:

a) detecting an acceleration signal from at least one accelerometer;

b) calculating the displacement of said object starting from said acceleration signal;

c) detecting an orientation signal from at least one magnetometer and/or a further device determining the orientation, so called orientation meter;

d) estimating the position of the object instant by instant on the basis of the signals generated by said sensors starting from a position detected by a GPS sensor at an instant immediately preceding the loss of said signal of the GPS sensor;

characterized in that

it comprises the following further steps:

e) detecting a rotation signal from at least one gyroscope;

f) comparing the change of the orientation signal in two subsequent instants with a predetermined value;

g) when the change exceeds such predetermined value, correcting the orientation signal on the basis of the signal generated by the gyroscope.

2. Method according to claim 1, wherein for correcting the signal an orientation value is generated starting from the rotation signal, and the time-corresponding value of the orientation signal is modified by calculating the mean of the orientation

signal and of said orientation value generated starting from the rotation signal.

3. Method according to one or more of the preceding claims, further providing the following steps:

Determining a first orientation signal by said magnetometer;

Contemporaneously determining a second orientation signal, by a further different device detecting the orientation so called orientation meter which produces orientation signals on the basis of a diversity of the physical and/or structural type and/or as regards the algorithm and/or the processing software;

Comparing said first and said second orientation signal and determining the difference between said first and second comparison signal

When said difference exceeds a predetermined value correcting the first orientation signal on the basis of the second orientation signal and using the first corrected orientation signal as the estimate of the object position.

4. Method according to one or more of the preceding claims, wherein the estimate of the position of the object instant by instant on the basis of the signals generated by said sensors is automatically carried out starting from the loss in the signal of a GPS detector.

5. Method according to claim 4, wherein the position detected by the GPS detector in the instant of the loss in GPS signal is used as the starting position

for estimating the position of the object instant by instant on the basis of the signals generated by said sensors.

6. Method according to claim 5, wherein in the moment when the GPS signal is regained, the estimate of the position of the object instant by instant on the basis of the signals generated by said sensors is automatically stopped.

7. Method according to claim 6, wherein the position detected by the GPS detector in the moment when the GPS signal is regained is used as the final position, and the tracked path is corrected backwards such that the final calculated position coincides with the final position detected by the GPS detector, the starting position detected by the GPS in the moment immediately preceding the loss in the GPS signal and the position of arrival detected by the GPS signal upon recovering the reception of the GPS signal by the GPS sensor being considered as the correct starting position and position of arrival respectively and a curve connecting said starting and arrival positions being generated which is calculated by means of a progressive and incremental change of the position of each point on the estimated path, which points coincide with a displacement step or with each acquisition of the orientation and displacement signals of the sequence of acquisition of said signals, said progressive position change being applied in the direction of the vector connecting the estimated point of arrival and the point of arrival determined by the

GPS sensor.

8. Method according to claim 7, wherein the change in the position of each point along the estimated path corresponding to a step of the acquisition of the displacement and/or orientation signals of the sequence of acquisition steps is determined according to the following steps:

determining the distance between the estimated point of arrival and the point of arrival determined by the GPS sensor;

determining an incremental step of the change in the position of each point which step is defined by dividing the distance between the estimated point of arrival and the point of arrival detected by the GPS sensor by the number of steps of acquisition of the orientation and displacement signals provided in said acquisition sequence;

progressively applying a multiple of said incremental step of the change in the position which multiplicative factor of such multiple is determined by the order number of the estimated point on the path correspondingly to the acquisition sequence.

9. Method according to claims 7 and 8, characterized in that it comprises the following steps:

determining a number of detections of displacement and/or orientation signals during the displacement of an object which detections are carried out by displacement and/or orientation sensors;

defining a starting point by the GPS sensor;

estimating a point of arrival of the displacement by means of sensors different from the GPS sensor;

detecting the point of arrival by the GPS sensor;

determining the distance and direction between the estimated point of arrival and the point of arrival detected by the GPS sensor;

dividing the distance between the estimated point of arrival and the point of arrival detected by the GPS sensor by the number of detections of displacement and/or orientation signals during the displacement of an object;

defining along the estimated path between the starting point and the point of arrival a number of points corresponding to the position where the acquisitions have been carried out or dividing the estimated path in a number of points along said path corresponding to the number of said detections;

moving each point along the same direction of the difference in the position between estimated point of arrival and point of arrival detected by the GPS sensor for a distance corresponding to said distance divided by the number of said detections, multiplied by the number of order of said point along the estimated path starting from the starting position detected by the GPS;

possibly connecting said displaced points by a curve.

10. Device for tracking a path, comprising at least one accelerometer (1), at least one gyroscope (2), at least one orientation meter (4) and/or magnetometer (3) and a processing unit (5) connected to

said sensors (1, 2, 3, 4) for estimating the position of the device instant by instant on the basis of the signals generated by said sensors (1, 2, 3, 4),

characterized in that

the processing unit (5) comprises a sub-unit (50) comparing the change of the signal generated by the orientation meter (4) and/or magnetometer (3) in two subsequent instants with a predetermined value, such that when the change exceeds such predetermined value, the processing unit (5) carries out a correction of the signal generated by the orientation meter (4) and/or magnetometer (3) on the basis of the signal generated by the gyroscope (2).

11. Device according to claim 10, characterized in that is comprises a GPS detector (6) connected to said processing unit (5), and the processing unit (5) comprises a sub-unit monitoring the GPS detector (6), such that upon the loss of the GPS signal, the processing unit (5) automatically starts to carry out the estimate of the position of the device instant by instant on the basis of the signals generated by said sensors (1, 2, 3, 4) and in the moment when the GPS signal is regained, the processing unit (5) automatically stops the estimate of the position of the object instant by instant on the basis of the signals generated by said sensors (1, 2, 3, 4).

12. Device according to claim 11, wherein the position detected by the GPS detector (6) in the instant of the signal loss is used by the processing unit (5) as the starting position for tracking the

path.

13. Device according to claim 12, wherein the position detected by the GPS detector (6) in the moment when the GPS signal is regained, is used as the final position by the processing unit (5), which processing unit (5) corrects backwards the tracked path such that the final calculated position coincides with the final position detected by the GPS detector (6).

14. Device according to one or more of the claims 10 to 13, wherein said accelerometer (1) is a linear accelerometer.

15. Device according to one or more of the claims 10 to 14, wherein there are provided water-resistant means, such that the device is intended to be used underwater.

16. Device according to one or more of the claims 10 to 15, characterized in that it is composed of a tablet, a smartphone or a computer of the handheld type.

17. Device for supporting a tablet, smartphone or the like, for an underwater sea scooter (9),

characterized in that

it has a base resting on said sea scooter (9), and a seat removably housing said tablet, which housing seat has the dimensions corresponding to those of the tablet and it is shaped such that the tablet is kept with an inclination lower than 60° with respect to the plane defined by the sea scooter (9).

18. Device according to claim 17, wherein there are provided two elements (80) shaped in the same

manner to each other and spaced from each other by spacing elements (81), each element having a side (83) resting on the sea scooter (9), such that the two rest sides (83) of the two elements (80) are said rest base, and at least one inclined side (84) provided with a recess (82), such that the two recesses (82) of the two elements (80) are said housing seat.

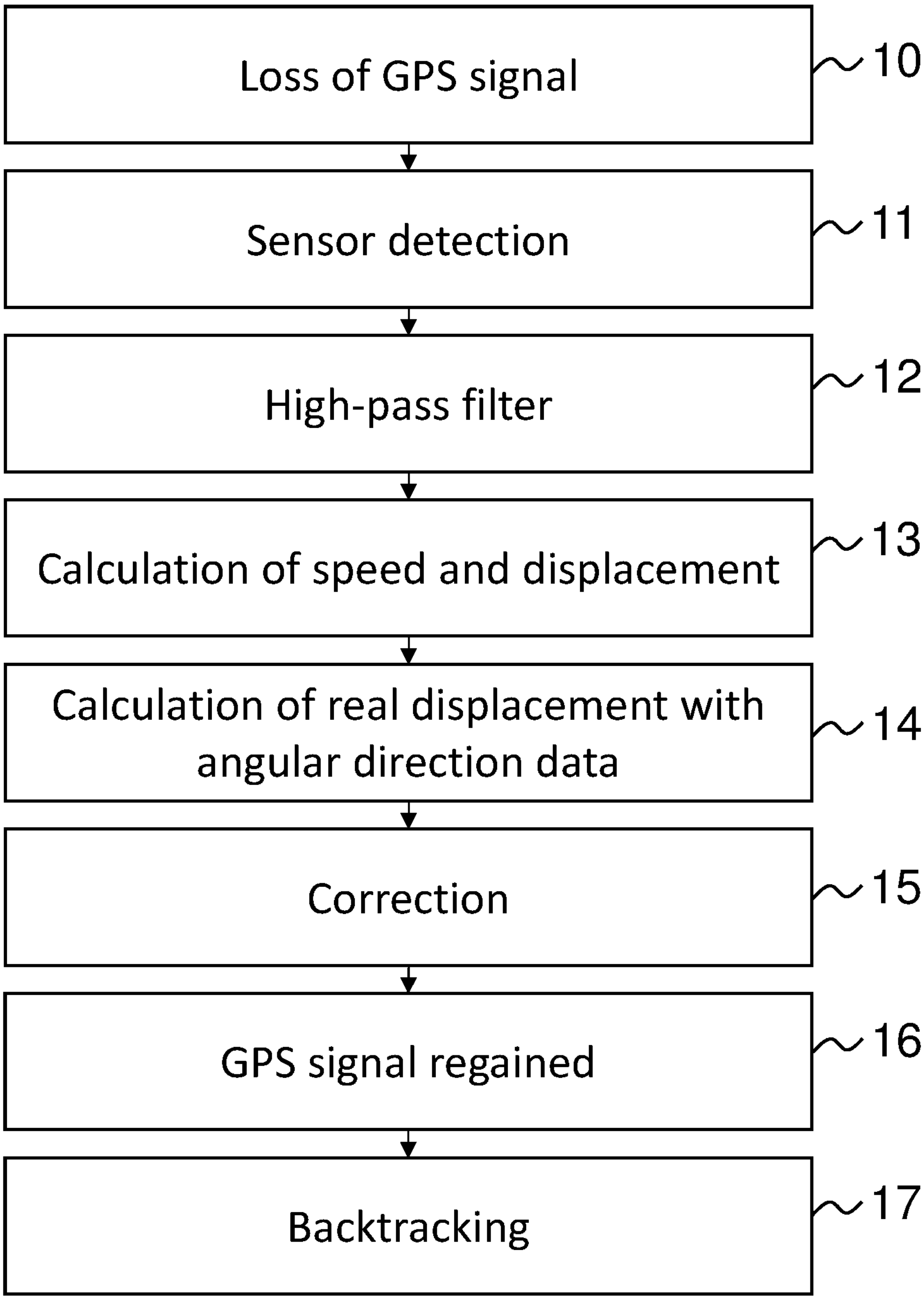
Loss of GPS signal
10
Sensor detection
11
High-pass filter
12
Calculation of speed and displacement
13
Calculation of real displacement with angular direction data
14
Correction
15
GPS signal regained
16
Backtracking
17

Fig. 1

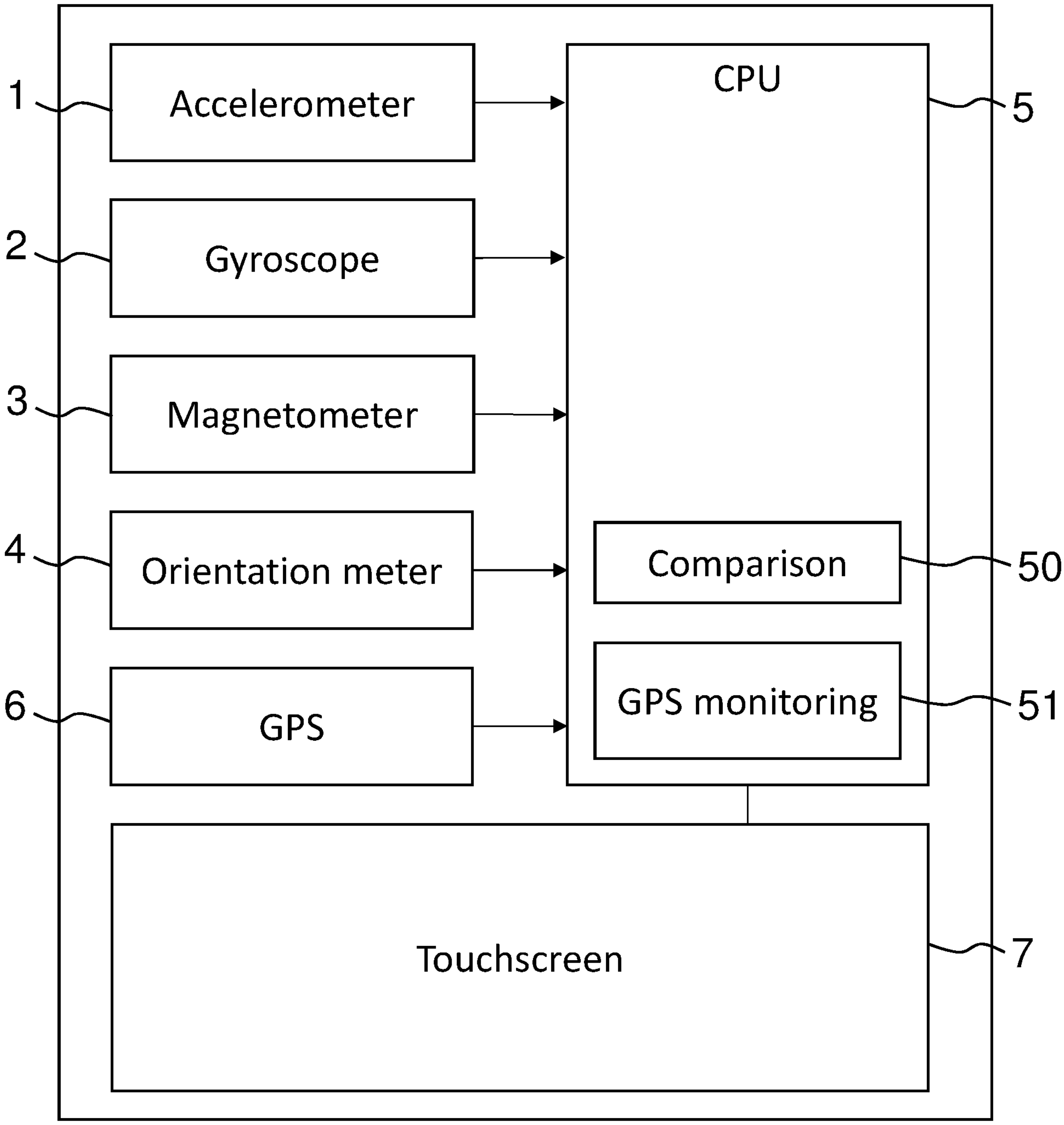
CPU
Accelerometer
Gyroscope
Magnetometer
Orientation meter
GPS
Comparison
GPS monitoring
Touchscreen
1
2
3
4
6
5
50
51
7

Fig. 2

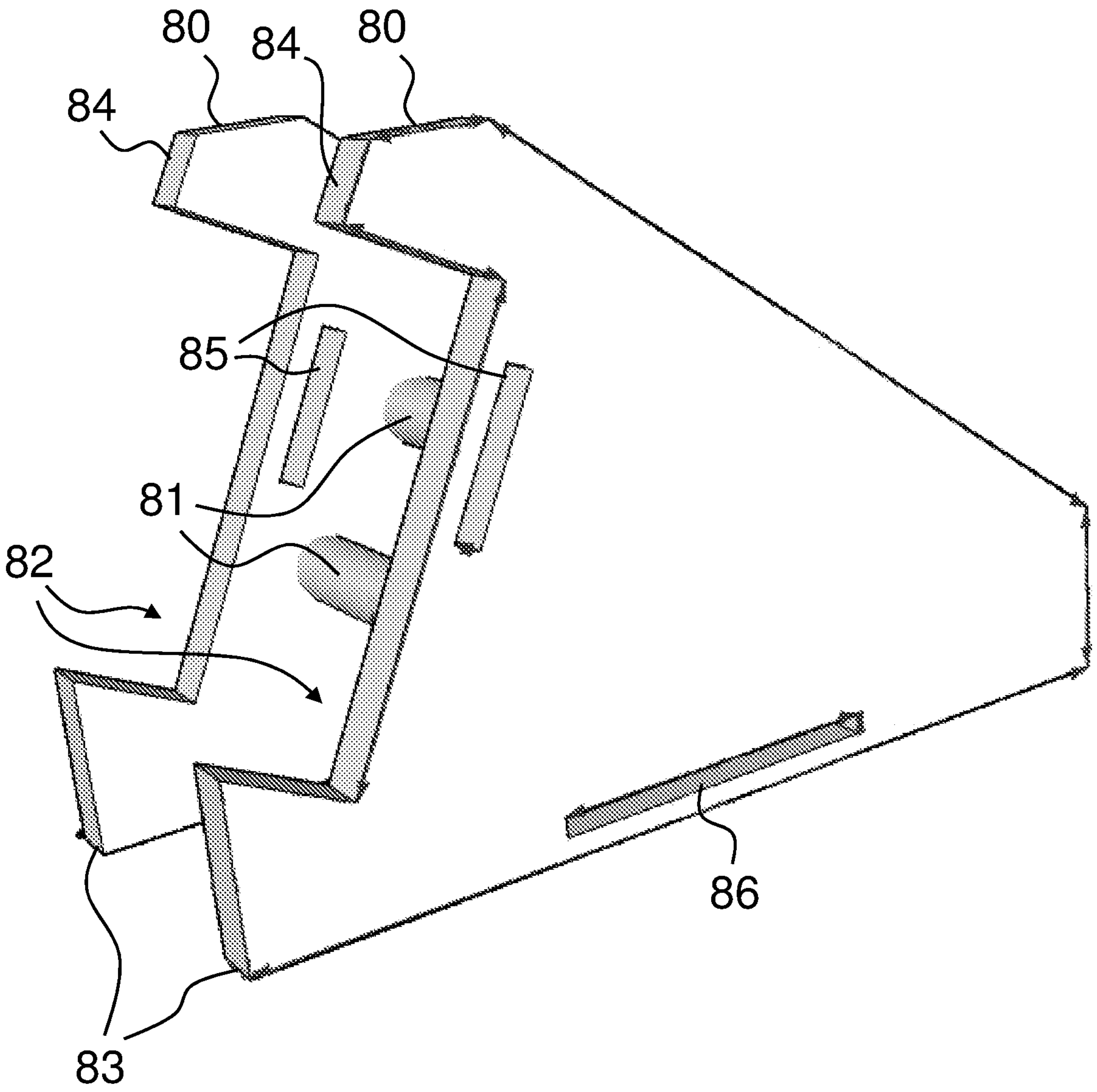

Fig. 3

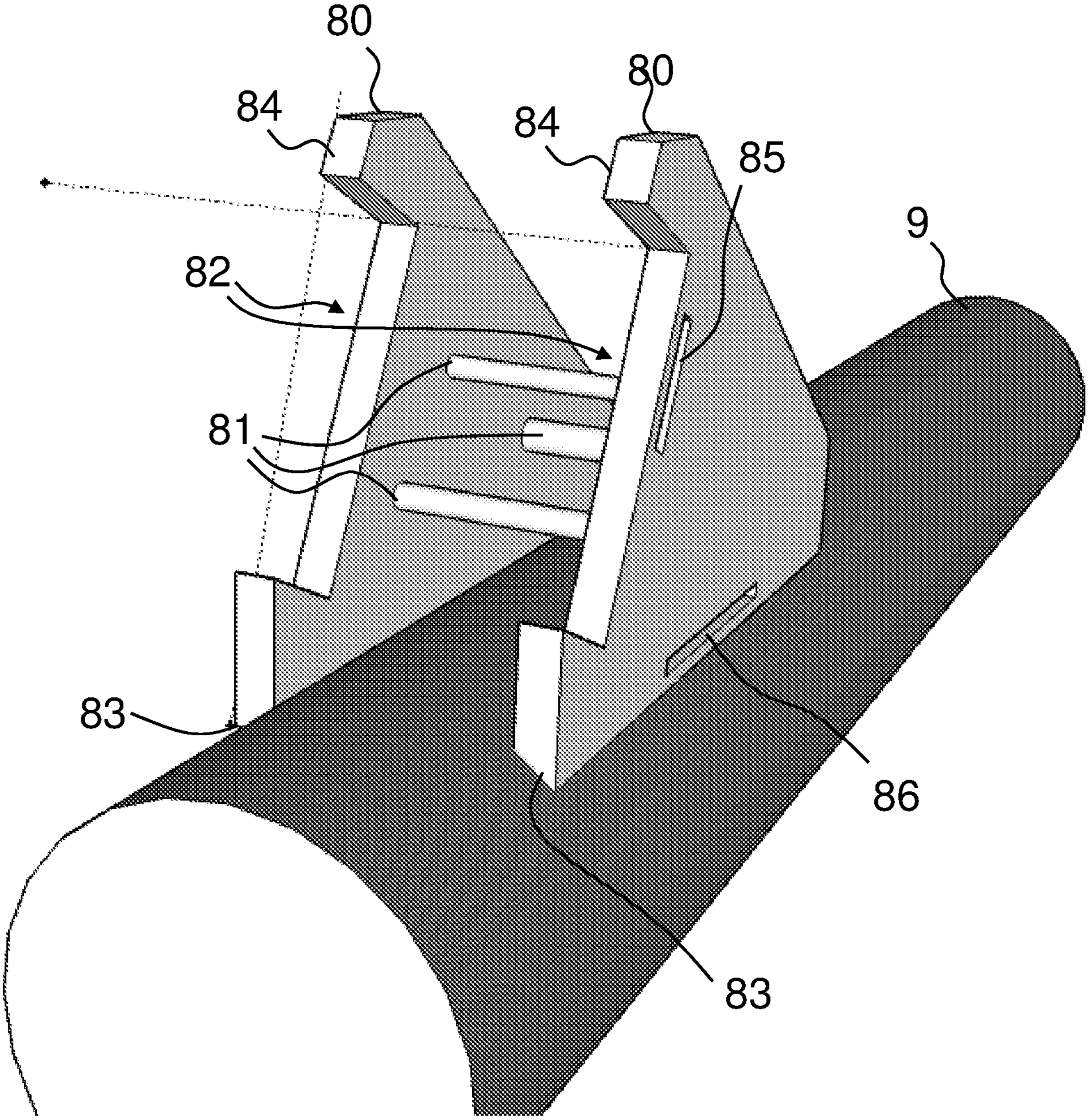

Fig. 4

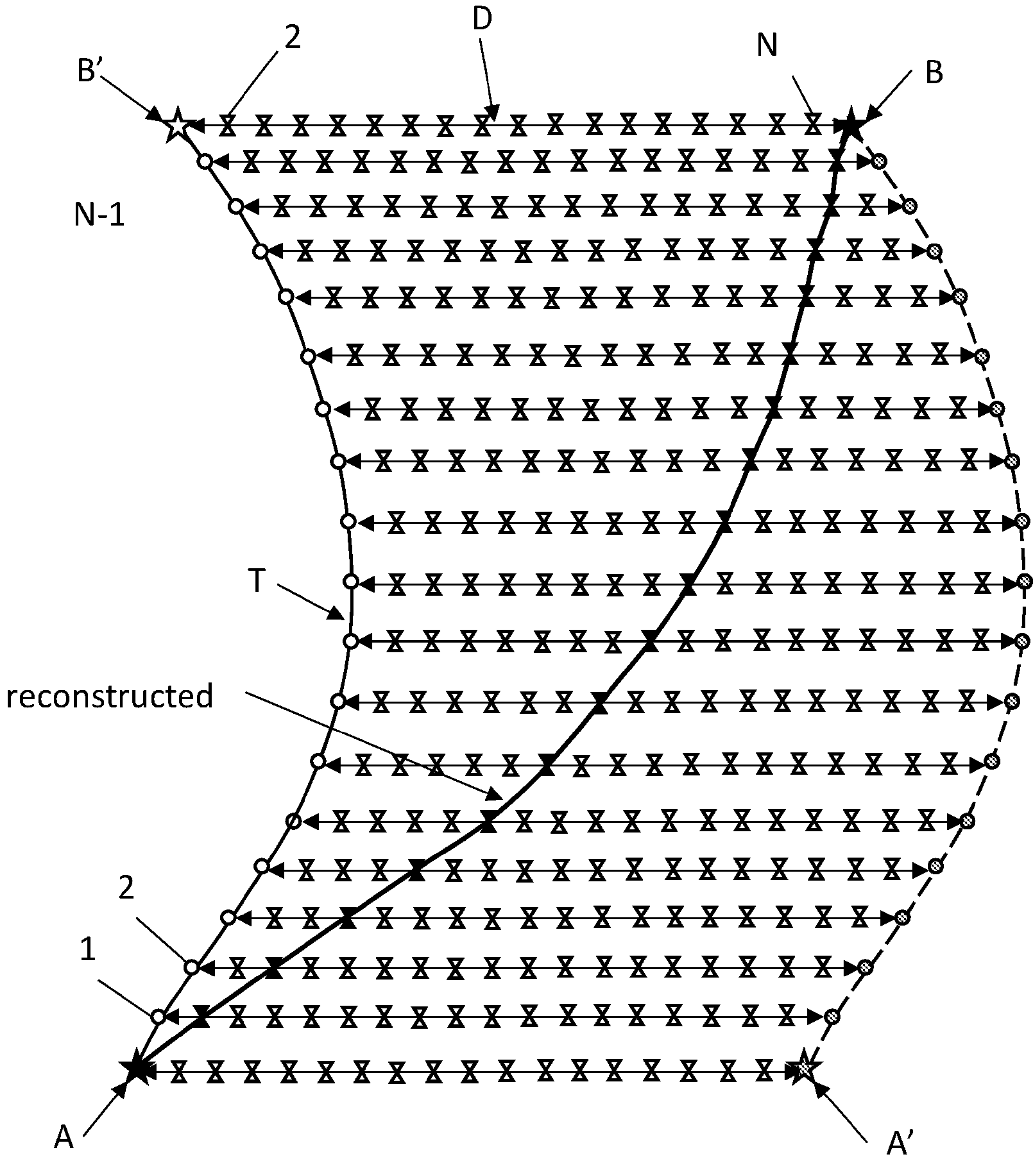

Fig. 5

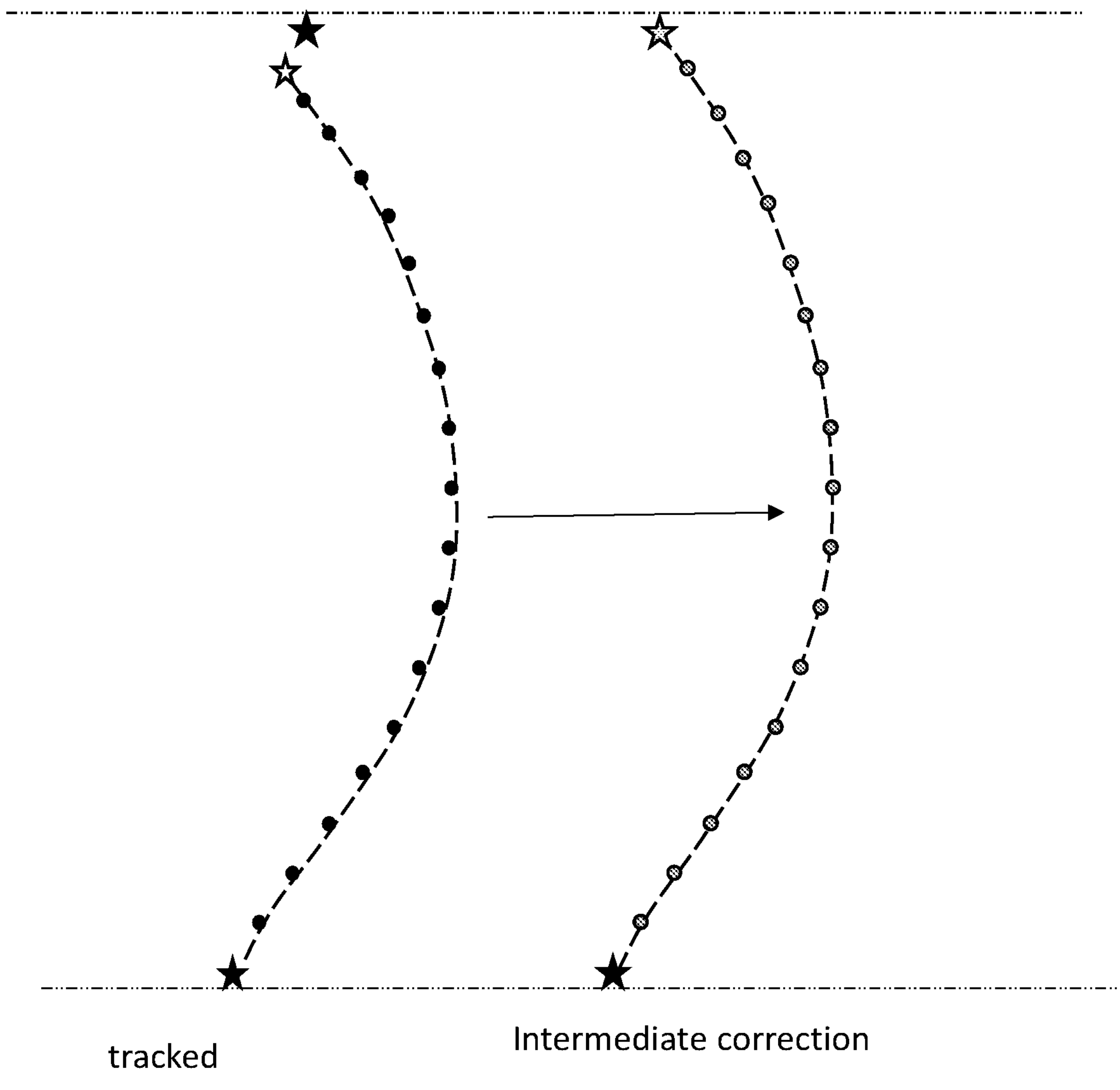

Fig. 6