(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 279 689 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
24.06.2020 Bulletin 2020/26

(21) Application number: **17173373.6**

(22) Date of filing: **30.05.2017**

(51) Int Cl.:
G01S 13/87 *(2006.01)* ***G01S 13/93*** *(2020.01)*

(54) MOBILE NAVIGATION METHOD AND SYSTEM

MOBILNAVIGATIONSVERFAHREN UND -SYSTEM

PROCÉDÉ ET SYSTÈME DE NAVIGATION MOBILE

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **01.08.2016 TW 105124361**

(43) Date of publication of application:
07.02.2018 Bulletin 2018/06

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EP 3 279 689 B1

Printed by Jouve, 75001 PARIS (FR)

Description

FIELD OF THE INVENTION

[0001] The present invention relates to navigation means, and more particularly to mobile navigation method and system.

BACKGROUND OF THE INVENTION

[0002] Generally, an electronic radar positioning process is conducted by emitting an electromagnetic wave from an emitter and calculating relative distance and speed of a target object according information of a reflected electromagnetic wave, which is reflected from the target object back to the emitter. For example, US Patent Publication No. 2005/0088335 A1 discloses a positioning system including a passive, isotropic reflecting landmark at a fixed position for positioning a device. The device transmits an electromagnetic pulse having a circular polarization and receives a return signal over a period of time, which is referred to for positioning. In practice, not only the target object but also other objects might reflect the electromagnetic wave. When the electromagnetically positioning process is performed in such an environment, detection errors are likely to occur since more than one reflected electromagnetic wave might be received. For example, if the radar positioning is implemented with a frequency-modulated continuous wave (FMCW), the scattering behavior of objects might happen to form multi-directional reflected waves, and different reflective paths would result in a multi-path electromagnetic wave. In the FMCW radar positioning method, electromagnetic waves in different paths would show different distances, so the multi-path electromagnetic wave would make the detection of the position of the target object unreliable.

SUMMARY OF THE INVENTION

[0003] Therefore, the present invention provides mobile navigation system and method for electromagnetically positioning a target zone and precisely guiding a vehicle toward the target zone, as set forth in the independent claims. Embodiments of the invention are claimed in the dependent claims.

[0004] In an aspect of the present invention, a mobile navigation system for guiding a vehicle, comprises: a radar antenna carried by the vehicle, emitting a first sensing beam at a first time point and emitting a second sensing beam at a second time point; a first retro-directive antenna disposed at a first position; a second retro-directive antenna disposed at a second position, which is a specific distance from the first position; and a processing device electrically coupled to the radar antenna. The first retro-directive antenna and the second retro-directive antenna respectively return a first retro wave and a second retro wave corresponding to a direction of the first sensing beam. The first retro-directive antenna and the second retro-directive antenna respectively return a third retro wave and a fourth retro wave corresponding to a direction of the second sensing beam. The processing device receives the first, second, third and fourth retro waves, and determines a moving direction of the vehicle according to the first, second, third and fourth retro waves and the specific distance.

[0005] In another aspect of the present invention, a mobile navigation method is adapted for guiding a moving vehicle toward a target point, wherein the moving vehicle carries an omnidirectional antenna, and a first retro-directive antenna and a second retro-directive antenna are arranged at opposite sides of the target point and have a specific distance from each other. The mobile navigation method comprises: emitting a first sensing beam from the moving vehicle at a first time point; calculating a first distance that a first retro wave travels and a second distance that a second retro wave travels, wherein the first retro wave and the second retro wave are transmitted back corresponding to the first sensing beam; emitting a second sensing beam from the moving vehicle at a second time point, which is a period of time after the first time point; calculating a third distance that a third retro wave travels and a fourth distance that a fourth retro wave travels, wherein the third retro wave and the fourth retro wave are transmitted back corresponding to the second sensing beam; and determining whether a current moving direction of the moving vehicle needs to be adjusted or not according to the first, second, third and/or fourth distances and the specific distance.

[0006] In a further aspect of the present invention, a mobile navigation method is adapted for guiding a moving vehicle toward a target point, wherein the moving vehicle carries a directive beamforming antenna, and a first retro-directive antenna and a second retro-directive antenna are each arranged at a specific distance from the target point. The mobile navigation method comprises: emitting a first sensing beam from the moving vehicle at a first time point; receiving a first retro wave in response to the first sensing beam, wherein the first retro wave is emitted or reflected by one of the first retro-directive antenna and the second retro-directive antenna; emitting a second sensing beam from the moving vehicle at a second time point; receiving a second retro wave in response to the second sensing beam, wherein the second retro wave is emitted or reflected by the other of the first retro-directive antenna and the second retro-directive antenna; realizing a first emission angle of the first sensing beam and calculating a first distance that the first retro wave travels; realizing a second emission angle of the second sensing beam and calculating a second distance that the second retro wave travels; and determine whether a current moving direction of the moving vehicle needs to be adjusted or not according to the first distance, the second distance, the first emission angle and the second emission angle.

[0007] In a still further aspect of the present invention, a mobile navigation system for guiding a vehicle, com-

prises: a radar antenna carried by the vehicle, emitting a first sensing beam at a first time point and emitting a second sensing beam at a second time point; a first specific reflecting object disposed at a first position; a second specific reflecting object disposed at a second position, which is a specific distance from the first position; and a processing device electrically coupled to the radar antenna. The first specific reflecting object and the second specific reflecting object respectively return a first retro wave and a second retro wave corresponding to a direction of the first sensing beam. The first specific reflecting object and the second specific reflecting object respectively return a third retro wave and a fourth retro wave corresponding to a direction of the second sensing beam. The processing device receives the first, second, third and fourth retro waves, and determines a moving direction of the vehicle according to the first, second, third and fourth retro waves and the specific distance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The invention will become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed description and accompanying drawings, in which:

FIG. 1 is a schematic diagram illustrating a mobile navigation system according to an embodiment of the present invention;
FIG. 2 is a schematic flowchart illustrating a mobile navigation method according to an embodiment of the present invention;
FIG. 3A is a schematic flowchart exemplifying details of the mobile navigation method as illustrated in FIG. 2, particularly regarding Step S240;
FIG. 3B is a scheme illustrating a relationship among the first through fourth distances and the specific distance d;
FIG. 4A is a schematic flowchart exemplifying details of the mobile navigation method as illustrated in FIG. 3A, particularly regarding Step S330;
FIG. 4B is a scheme exemplifying a relationship among associated azimuths according to an embodiment of the present invention;
FIG. 4C is a scheme exemplifying a relationship among associated azimuths according to another embodiment of the present invention;
FIG. 5 is a schematic flowchart illustrating a mobile navigation method according to another embodiment of the present invention; and
FIG. 6 is a schematic flowchart exemplifying details of the mobile navigation method as illustrated in FIG. 5, particularly regarding Step S530.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0009] The invention will now be described more specifically with reference to the following embodiments. It is to be noted that the following descriptions of preferred embodiments of this invention are presented herein for purpose of illustration and description only. It is not intended to be exhaustive or to be limited to the precise form disclosed.

[0010] Referring to FIG. 1, an embodiment of a mobile navigation system for guiding a vehicle according to the present invention is schematically illustrated. In this embodiment, the mobile navigation system 10 includes a radar antenna 100, a first retro-directive antenna 110, a second retro-directive antenna 120, and a processing device 130. The radar antenna 100 is carried by a vehicle 105 and sequentially emits sensing beams continuously or periodically at different time points. For example, the radar antenna 100 may be an omnidirectional antenna (OMNI antenna), or a beamforming antenna. The first retro-directive antenna 110 is disposed at a first position, and the second retro-directive antenna 120 is disposed at a second position. There is a specific distance d between the second position and the first position. The processing device 130 is electrically coupled to the radar antenna 100 for receiving data from the radar antenna 100. In an embodiment, the processing device 130 is disposed at and moves with the vehicle 105, and electrically coupled to the radar antenna 100 in either wireless or wiring manner. Alternatively, the processing device 130 may be disposed separately from the vehicle 105 provided that the vehicle 105 or the vehicle driver can communicate with the processing device 130 to guide the vehicle 105 along a desirable direction. For example, the processing device 130 may be disposed at a network node. The operating principle of the present invention will be described hereinafter, using the system, the flowchart, and the scheme as shown in FIGS. 1, 2, 3A and 3B as examples.

[0011] In an embodiment of mobile navigation system illustrated in FIG. 1, the radar antenna 100 emits a first sensing beam at a first time point, and then emits a second sensing beam in a second direction at a second time point. The first retro-directive antenna 110 is an antenna that transmits a signal back to where the first sensing beam is emitted, and similarly, the second retro-directive antenna 120 is an antenna that transmits a signal back to where the second sensing beam is emitted. The first retro-directive antenna 110 receives the first sensing beam, and returns a corresponding wave in response to the received first sensing beam. The returned corresponding wave is so called as a first retro wave. The second retro-directive antenna 120 also receives the first sensing beam, and returns a corresponding wave, which is so called as a second retro wave, in response to the received first sensing beam. Likewise, the first retro-directive antenna 110 receives the second sensing beam, and in response to the received second sensing beam, returns a corresponding wave, which is so called as a third retro wave. The second retro-directive antenna 120 also receives the second sensing beam, and in response

to the received second sensing beam, returns a corresponding wave, which is so called as a fourth retro wave. The radar antenna 100 receives the first through fourth retro waves from the retro-directive antennas 110 and 120, and the processing device 130 receives the first through fourth retro waves from the radar antenna 100. According to the information of the first through fourth retro waves and the specific distance d between the positions of the first and second retro-directive antennas 110 and 120, the processing device 130 determines the direction where the vehicle 105 should be guided subsequently. For example, the vehicle 105 initially moves in a direction M, and the moving direction optionally changes in response to a control command issued by the processing device 130.

[0012] In an embodiment of mobile navigation method illustrated in FIG. 2, an OMNI antenna is used as an example of the radar antenna 100, and disposed on a vehicle to be guided. First of all, the radar antenna 100 emits a first sensing beam at a first time point (Step 200). After receiving the first sensing beam, the first retro-directive antenna 110 transmits a first retro wave back, and the second retro-directive antenna 120 transmits a second retro wave back. Meanwhile, a first distance that the first retro wave travels and a second distance that the second retro wave travels are calculated (Step S205). The first and second distance information is then conveyed to the processing device 130 (Step S210). After the first sensing beam is emitted in Step S200, the radar antenna 100 carried by and moving with the vehicle 105 in the direction M further emits a second sensing beam at a second time point (Step S220). After receiving the second sensing beam, the first retro-directive antenna 110 returns a third retro wave, and the second retro-directive antenna 120 returns a fourth retro wave. Meanwhile, a third distance that the third retro wave travels and a fourth distance that the fourth retro wave travels are calculated (Step S225). The third and fourth distance information is then conveyed to the processing device 130 (Step S230). Afterwards, in Step S240, the processing device 130 determines whether and how the moving direction should be adjusted based on the first, second, third and fourth distances, the default specific distance d between the positions of the first retro-directive antenna 110 and the second retro-directive antenna 120, and a shift of the vehicle 105 in the direction M within a time period from the first time point to the second time point.

[0013] Further referring to FIG. 3A and FIG. 3B, more exemplified details are given for facilitating understanding of the invention. The flowchart illustrated in FIG. 3A shows the details of Step S240, and the scheme illustrated in FIG. 3B shows the relationship among the first, second, third and fourth distances, and the specific distance d between the positions of the first retro-directive antenna 110 and the second retro-directive antenna 120. After Step S210 and S230, the processing device receives information associated with the first, second, third and fourth distances. Then in Step S302, the processing device 130 configures a circle, hereinafter a first defined circle, with the position where the radar antenna 100 is at the first time point treated as a center and the first distance treated as a radius. Then in Step S304, the processing device 130 configures another circle, hereinafter a second defined circle, with the position where the radar antenna 100 is at the first time point treated as a center and the second distance treated as a radius. Likewise, in Step S306, the processing device 130 configures another circle, hereinafter a third defined circle, with the position where the radar antenna 100 is at the second time point treated as a center and the third distance treated as a radius. Then in Step S308, the processing device 130 configures another circle, hereinafter a fourth defined circle, with the position where the radar antenna 100 is at the second time point treated as a center and the fourth distance treated as a radius.

[0014] The first defined circle and the third defined circle have at least a first intersection point, and the second defined circle and the fourth defined circle have at least a second intersection point. Subsequently in Step S310, at least the first intersection point and at least the second intersection point are located. Depending on practical conditions, one or two intersection points may be located between each pair of defined circles, e.g. the first defined circle and the third defined circle, or the second and the fourth defined circle. In the example as shown in FIG. 3B, the first defined circle and the third defined circle intersect at two points T_1 and T_3, and the second defined circle and the fourth defined circle intersect at a point T_2. One of the intersection points T_1 and T_3 is supposed to be the position of the first or second retro-directive antennas, and the intersection point T_2 is supposed to be the position of the other retro-directive antenna. Therefore, take the intersection points T_1 or T_3 as a first hypothetical position, i.e. one antenna location, and take the intersection point T_2 as a second hypothetical position, i.e. the other antenna location (Step S310). Then in Step S320, a distance between the first hypothetical position and the second hypothetical position is calculated and compared with the specific distance d. If the distance is substantially equal to the specific distance d, it is determined that that the first and second hypothetical positions are the positions of the first and second retro-directive antennas 110 and 120. The direction where the vehicle will be guided can be determined accordingly (Step S330). On the contrary, if the distance is inconsistent with the specific distance d, additional procedures will be executed for locating the first and second retro-directive antennas 110 and 120.

[0015] Step S330 will be described in more detail as follows. Once the positions of the first and second retro-directive antennas 110 and 120 are determined, a first triangle can be configured with the position P_1 of the radar antenna 100 on the vehicle 105, the position of the first hypothetical position, e.g. T_1, and the position of the second hypothetical position, e.g. T_2, at the first time point. Likewise, a second triangle can be configured with the

position P_2 of the radar antenna 100 on the vehicle 105, the position of the first hypothetical position, e.g. T_1, and the position of the second hypothetical position, e.g. T_2, at the second time point. Based on the angle at the vertex P_1 of the first triangle and the angle at the vertex P_2 of the second triangle, whether the vehicle 105 is approaching the middle of the points P_1 and P_2 can be determined. If the angle at the apex P_1 of the first triangle is greater than the angle at the apex P_2 of the second triangle, it is inferred that the vehicle 106 is moving away from the middle of the points P_1 and P_2. The current moving direction M of the vehicle 105 will be adjusted. In contrast, if the angle at the apex P_1 of the first triangle is less than the angle at the apex P_2 of the second triangle, it is inferred that the vehicle 106 is moving toward the middle of the points P_1 and P_2. The vehicle 105 continues to move in the direction M.

[0016] As described above, if the distance between the two hypothetical positions is inconsistent with the specific distance d, i.e. Step S320 indicates a result "NO", additional procedures will be executed for locating the first and second retro-directive antennas 110 and 120, i.e. proceed to Step S340. The first defined circle and the fourth defined circle have at least a third intersection point. The second defined circle and the third defined circle have at least a fourth intersection point. In Step S340, at least the third intersection point and at least the fourth intersection point are located and assumed to be the locations of a third hypothetical position and a fourth hypothetical position of the first and second retro-directive antennas 110 and 120. Depending on practical conditions, one or two intersection points may be located between two defined circles. According to the correlation of vertex angles of two triangles configured with the positions of the radar antenna 100 on the vehicle 105, and according to the positions of the third hypothetical position and the positions of the fourth hypothetical position respectively at two different time points, whether the current moving direction of the vehicle 105 needs to be modified can be determined (Step S350). In an alternative embodiment, whether a distance between the third and fourth hypothetical positions is consistent to the specific distance d between the first and second retro-directive antennas 110 and 120 is optionally determined first for confirming the positions of the first and second retro-directive antennas 110 and 120 before Step S350. If the result indicates "YES", Step S350 is executed, and otherwise, the process returns to Step S200 to start over. In an alternative example, the above discriminating procedure may be omitted, and Step S350 is directly executed after the third and fourth hypothetical positions are determined according to a proper algorithm. It is understood that the discriminating step for confirmation enhances reliability of the mobile navigation method.

[0017] In another embodiment, the second distance may be treated as the radius of the first defined circle, and the first distance may be treated as the radius of the second defined circle. On the other hand, the third distance and the fourth distance may still be treated as the radii of the third defined circle and the fourth defined circle, respectively. Since an OMNI antenna emits a sensing beam in a radial manner toward the surrounding, each of the defined circles represents a probable position of an object which may reflect the sensing beam, and the radius of the defined circle represents a distance between the object and the OMNI antenna. In other words, the first defined circle realized at the first time point represents a set of positions where a beam-reflecting object may be present, and the second defined circle realized at the first time point represents a set of positions where another beam-reflecting object maybe present. The terms "first" and "second" used herein do not mean any sequence, but mean distinction. Likewise, the third defined circle realized at the second time point represents a set of positions where the beam-reflecting object resulting one of the first and second defined circles may be present, and the fourth defined circle realized at the second time point represents a set of positions where the beam-reflecting object resulting the other of the first and second defined circles may be present.

[0018] For example, referring to FIG. 3B, assume that the vehicle 105, as well as the radar antenna 100, is positioned at the point P_1 at the first time point, and moves along the direction M for a period of time. At the second time point, it arrives at the position indicated by the point P_2. The distances r_{11} and r_{12} are respective distances between the two beam-reflecting objects and the radar antenna at the point P_1, and the distances r_{21} and r_{22} are respective distances between the two beam-reflecting objects and the radar antenna at the point P_2. Under this circumstance, the defined circle C_{11} is configured with the point P_1 as a center and the distance r_{11} as a radius; the defined circle C_{12} is configured with the point P_1 as a center and the distance r_{12} as a radius; the defined circle C_{21} is configured with the point P_2 as a center and the distance r_{21} as a radius; and the defined circle C_{22} is configured with the point P2 as a center and the distance r_{22} as a radius. The defined circles C_{11} and C_{21} intersect at the points T_1 and T_3, the defined circles C_{12} and C_{22} intersect at the points T_2, and the defined circles C_{11} and C_{22} intersect at the points F_1 and F_2.

[0019] In an example, assuming that the defined circle C_{11} is the first defined circle, the defined circle C_{12} is the second defined circle, the defined circle C_{21} is the third defined circle, and the defined circle C_{22} is the fourth defined circle, then the positions of the points T_1 and T_3 are candidates of the first hypothetical position, the position of the point T_2 is a candidate of the second hypothetical position, and the positions of the points F_1 and F_2 are candidates of the third hypothetical position. In this example, there is no intersection between the defined circles C_{12} and C_{21}, so the fourth hypothetical position does not exist. If the distance between one of first hypothetical positions, e.g. the point T_1, and the second hypothetical position, e.g. the point T_2, is substantially equal to the specific distance d, it can be inferred that there are

retro-directive antennas respectively positioned at the points T_1 and T_2. The information can be referred to for guiding the vehicle 105.

[0020] In another example, it is assumed that the defined circle C_{12} is the first defined circle, the defined circle C_{11} is the second defined circle, the defined circle C_{21} is the third defined circle, and the defined circle C_{22} is the fourth defined circle. Since the defined circles C_{12} and C_{21} have no intersection, the first hypothetical point does not exist. In this case, the positions of the points F_1 and F_2 are candidates of the second hypothetical position, the position of the point T_2 is a candidate of the third hypothetical position, and the positions of the points T_1 and T_3 are candidates of the fourth hypothetical position. Accordingly, in Step S320 shown in FIG. 3A, the result would be "NO" as no first hypothetical position is existent, and the process proceeds to Step S340. Furthermore, it is understood from the above descriptions that a retro-directive antenna is inherently disposed at the point T_2, and there are two candidates, e.g. the points T_1 and T_3, of the position of another retro-directive antenna. Therefore, by comparing the distance between the points T_1 and T_2 with the specific distance d, and also comparing the distance between the points T_3 and T_2 with the specific distance d, as in Step S320, the one of the points T_1 and T_3 having a distance from the point T_2 substantially equal to the specific distance d would be the position of the another retro-directive antenna. Based on the obtained information, how the vehicle is guided is determined in Step S350. Step S350 may be executed in a manner similar to Step S330 or by suitably modifying Step S330.

[0021] In an example that a connecting line between the point P_1 and the point P_2 passes the point T_2, both the distance from the point T_2 to the point T_1 and the distance from the point T_2 to the point T_3 will be substantially equal to the specific distance d. Therefore, the compared result in Step S320 is "YES", and Step S330 will be executed. In this example, Step S330 is executed by determining the moving direction of the vehicle, i.e. from P_1 toward P_2 or from P_2 toward P_1, with the triangles at first. Then, the vehicle moves, depending on the determined moving direction, toward the point T_1 or the point T_3, and continues to move for a while. By monitoring respective energy variations of reflected waves from the points T_1 and T_3, the position of the retro-directive antenna can be determined, i.e. at the point T_1 or the point T_3. Meanwhile, according to the intensities of the retro waves received at the first time point and the second time point, whether and how the moving direction should be adjusted can be determined.

[0022] In other examples, the first, second, third and fourth defined circles may be the circles C_{11}, C_{12}, C_{22} and C_{21}, respectively, or the circles C_{12}, C_{11}, C_{22} and C_{21}, respectively. The locating methods of the hypothetical positions and the retro-directive antennas, as well as the determination and adjustment of the moving direction can be executed as in the above-described embodiments and examples, and will not be redundantly described herein.

[0023] Hereinafter, Step S330 will be described in more detail with reference to the flowchart of FIG. 4A. Subsequent to Step S320, a base line connecting the first hypothetical position and the second hypothetical position is located (Step S400). Meanwhile, a first angle (azimuth) between a base line and a line connecting the OMNI antenna and the first hypothetical position at a first time point is calculated (Step S412), and a second angle (azimuth) between the base line and a line connecting the OMNI antenna and the second hypothetical position at the first time point is also calculated (Step S414). Then, a third angle (azimuth) between the base line and a line connecting the OMNI antenna and the first hypothetical position at a second time point is calculated (Step S416), and a fourth angle (azimuth) between the base line and a line connecting the OMNI antenna and the second hypothetical position at the second time point is also calculated (Step S418). Subsequently in Step S420, whether the first azimuth is greater than the second azimuth is determined. If positive, whether the third azimuth is greater than the first azimuth is determined (Step S430). and if negative, whether the fourth azimuth is greater than the second azimuth is determined (Step S460). If the comparing result indicates "YES" in either Step S430 or Step S460, proceed to Step S440 to adjust the moving direction. Otherwise, proceed to Step S450, i.e. the vehicle continues to move along the current moving direction.

[0024] In this embodiment, whether the moving direction should be changed is determined by executing the steps of the flowchart shown in FIG. 4A with the first, second, third and fourth azimuths. Nevertheless, the azimuths may be applied to alternative algorithms as long as the object for guiding the vehicle can be achieved.

[0025] Hereinafter, FIG. 4B is referred to for further elaborating the mobile navigation method illustrated in the flowchart of FIG. 4A. FIG. 4B exemplifies a relationship among the associated azimuths. In this example, the mobile navigation system aims to guide the vehicle with the OMNI antenna disposed thereon to arrive at a target point DET. It is assumed that currently, the OMNI antenna is moving from the point P_1 to the point P_2 along the direction M. The first retro-directive antenna 110 and the second retro-directive antenna 120 are located in any of the previously described ways. The base line is the line segment connecting the first retro-directive antenna 110 and the second retro-directive antenna 120, and the target point DET is the midpoint of the line section between the first and second retro-directive antennas 110 and 120. The first azimuth is the azimuth a_1, the second azimuth is the azimuth a_2, the third azimuth is the azimuth a_3, and the fourth azimuth is the azimuth a_4, and in this example, the first azimuth is larger than the second azimuth, and the third azimuth is smaller than the first azimuth. Therefore, according to the mobile navigation method illustrated by the flowchart of FIG. 4A, Step S420,

S430 and S450 are sequentially executed so that the moving direction is not going to be adjusted. In other words, the vehicle 105 carrying the OMNI antenna is approaching the target point DET if continuing to move along the direction M.

[0026] FIG. 4C exemplifies another relationship among the associated azimuths. In this example, the mobile navigation system also aims to guide the vehicle with the OMNI antenna disposed thereon to arrive at a target point DET. Likewise, it is assumed that currently, the OMNI antenna is moving from the point P_1 to the point P_2 along the direction M. The first retro-directive antenna 110 and the second retro-directive antenna 120 are located in any of the previously described ways. The base line is the section line connecting the first retro-directive antenna 110 and the second retro-directive antenna 120, and the target point DET is the midpoint of the line section between the first and second retro-directive antennas 110 and 120. The first azimuth is the azimuth a_1, the second azimuth is the azimuth a_2, the third azimuth is the azimuth a_3, and the fourth azimuth is the azimuth a_4. In this example, the first azimuth is larger than the second azimuth, and the third azimuth is larger than the first azimuth. Therefore, according to the mobile navigation method illustrated by the flowchart of FIG. 4A, Step S420, S430 and S440 are sequentially executed so that the moving direction is going to be adjusted.

[0027] Once the moving direction of a vehicle is determined to be adjusted according to the present invention, there may be a variety of ways to adjust the moving direction, depending on practical requirements. For example, it is preferred to dynamically adjust the moving direction to have the vehicle gradually approach the target position. Concretely, with the dynamic adjustment of the moving direction, the first azimuth a_1 would be decreasing.

[0028] It is to be noted that the target position DET need not be the midpoint of the section line between the first and second retro-directive antennas 110 and 120. Actually, as long as the target position has a constant or derivable correlation to the position of the first retro-directive antenna 110 and the second retro-directive antenna 120, the mobile navigation system 10 according to the present invention can work with a suitable navigation application to guide the vehicle 105 to the target position DET based on a previously inputted correlation of positions.

[0029] Although the above embodiments and examples are described with an OMNI antenna serving as the radar antenna of the present invention, it is understood that the radar antenna may alternatively be a directive beamforming antenna, and the corresponding navigation method implemented with the directive beamforming antenna can be realized by modifying the above-described embodiments and examples without departing from the scope of the present invention.

[0030] FIG. 5 is a flowchart embodying a mobile navigation method executed by the mobile navigation system 10 illustrated in FIG. 1, in which a directive beamforming antenna is used as the radar antenna 100 and carried by the vehicle 105. In this embodiment, a first sensing beam is emitted at a first time point by the directive beamforming antenna 100 to detect whether a retro-directive antenna, e.g. the first retro-directive antenna 110 or the second retro-directive antenna 120, is present in a specified area (Step S500). If a first retro wave is returned in response to the first sensing beam by the first retro-directive antenna 110 or a second retro wave is returned in response to the first sensing beam by the second retro-directive antenna 120, and the first or second retro wave is received by the directive beamforming antenna 100 (Step S510), it can be determined that a retro-directive antenna is present in the sensing area of the sensing beam. Since every sensing beam emitted by the directive beamforming antenna 100 has a specific emission angle, a first emission angle of the first sensing beam can be realized when receiving the first or second retro wave. Furthermore, a first distance that the first retro wave travels can be calculated according to the travel time of the first retro wave, for example, when a pulse radar is used (Step S512). Alternatively, the first distance that the first retro wave travels can be calculated according to the frequency difference of the first retro wave from the sensing beam, for example, when a frequency modulated continuous waveform (FMCW) radar is used. The directive beamforming antenna 100 used in the present invention may be an antenna whose emission angle can be shifted, or an antenna whose emission angle is fixed.

[0031] After the first sensing beam is emitted at the first time point by the directive beamforming antenna 100, a second sensing beam is emitted at a second time point by the directive beamforming antenna 100 (Step S520). Likewise, whether a retro-directive antenna, e.g. the first retro-directive antenna 110 or the second retro-directive antenna 120, is present in a specified area is determined (Step S520). If a third retro wave is returned in response to the second sensing beam by the first retro-directive antenna 110 or a fourth retro wave is returned in response to the second sensing beam by the second retro-directive antenna 120, and the third or fourth retro wave is received by the directive beamforming antenna 100 (Step S522), it can be determined that a retro-directive antenna, other than the retro-directive antenna generating the first retro wave, is present in the sensing area of the second sensing beam. A second emission angle of the second sensing beam is realized when receiving the third or fourth retro wave, and then a second distance that the second retro wave travels can be calculated according to the travel time of the second retro wave (Step S524).

[0032] Subsequently, proceed to Step S530. According to several parameters, for example, including the first distance, the second distance, the first emission angle and the second emission angle, whether and how the moving direction of the vehicle 105 should be adjusted can be determined.

[0033] Further referring to FIG. 6, which exemplifies

details of the mobile navigation method as illustrated in FIG. 5, particularly regarding Step S530. After Step S512 and S524, the aforementioned parameters are obtained. Then, a probable position of an object which may emit or reflect the first or second retro wave can be calculated according to the first distance and the first emission angle (Step S600), and is referred to as a first position. Likewise, a probable position of an object which may emit or reflect the third or fourth retro wave can be calculated according to the second distance and the second emission angle (Step S610), and is referred to as a second position. Subsequently, in Step S620, whether the moving direction needs to be adjusted is determined according to a relationship among the first position, the second position and the current moving direction, e.g. the direction M. A variety of algorithms may be adopted for adjusting the moving direction, if necessary. The object of the present invention can be achieved no matter which algorithm is adopted. For example, when the vehicle 105 moving in the current direction, e.g. the direction M, is actually being away from both the first position and the second position, the moving direction should be adjusted to have the vehicle move toward one of the first and second positions, which is farther. The movement of the vehicle toward the first or second position may be achieved by gradually approaching, or by turning to somewhere between the first and second positions.

[0034] Compared with the embodiments described above with reference to FIGS. 3A-3B and FIG. 4A-4C, the mobile navigation method as illustrated in FIG. 6 would be simpler in arithmetical operation. Since every sensing beam emitted by the directive beamforming antenna 100 has a specific emission angle, so the orientation of the object, which reflects the sensing beam into a corresponding retro wave, relative to the directive beamforming antenna, which receives the corresponding retro wave, can be directly derived from the emission angle of the sensing beam. Furthermore, according to the time difference from the emission of the sensing beam to the receiving of the retro wave, the distance between the directive beamforming antenna and the beam-reflecting object can be directly obtained. In other words, the azimuth and distance information required for guiding the vehicle can be readily obtained, and no complicated operation is involved.

[0035] In a case that the mobile navigation is conducted in an area where multi-path reflection is not an issue, e.g. an open space, two specific beam-reflecting objects can be used in lieu of the retro-directive antennas to accomplish the guidance of the vehicle. The omission of the retro-directive antennas facilitates reduction of the cost of the navigation system.

[0036] To sum up, by disposing a radar antenna on a vehicle and arranging two retro-directive antennas or specific beam-reflecting objects around the target point, the target area can be dynamically located to adaptively adjust the moving direction of the vehicle. Furthermore, by monitoring the travel speed and travel time of the radar wave, the moving speed of the vehicle and the orientation and distance of the target area relative to the radar antenna can be calculated so as to estimate the arrival time.

Claims

1. A mobile navigation system for guiding a moving vehicle toward a target point, comprising:

   a radar antenna (100) carried by the moving vehicle (105), emitting a first sensing beam at a first time point and emitting a second sensing beam at a second time point later than the first time point; and
   a processing device (130) electrically coupled to the radar antenna (100);
   characterized in further comprising:

   a first retro-directive antenna (110) disposed at a first position; and
   a second retro-directive antenna (120) disposed at a second position, which is at a side of the target point opposite to the first position, and has a specific distance from the first position;
   wherein the first retro-directive antenna (110) and the second retro-directive antenna (120) being configured to respectively receive the first sensing beam and return a first retro wave and a second retro wave corresponding to a direction of the first sensing beam;
   the first retro-directive antenna (110) and the second retro-directive antenna (120) being configured to respectively receive the second sensing beam and return a third retro wave and a fourth retro wave corresponding to a direction of the second sensing beam, and
   the processing device (130) being configured to receive the first, second, third and fourth retro waves, and determining whether a moving direction of the vehicle (105) needs to be adjusted or does not according to first, second, third and/or fourth distances that the first, second, third and fourth retro waves travel, respectively, and the specific distance between the positions of the first retro-directive antenna (110) and the second retro-directive antenna (120).

2. The system according to claim 1, wherein the radar antenna (100) is an omnidirectional antenna or a directive beamforming antenna.

3. A mobile navigation method for guiding a moving vehicle toward a target point, comprising:

emitting a first sensing beam from the moving vehicle (105) at a first time point; and
emitting a second sensing beam from the moving vehicle (105) at a second time point later than the first time point;
characterized by
arranging a radar antenna (100) on the moving vehicle, and arranging a first retro-directive antenna (110) and a second retro-directive antenna (120) at opposite sides of the target point, wherein the first retro-directive antenna (110) and the second retro-directive antenna (120) have a specific distance from each other;
calculating a first distance that a first retro wave travels and a second distance that a second retro wave travels, wherein the first retro wave and the second retro wave are returned waves from the first retro-directive antenna (110) and the second retro-directive antenna (120), respectively, in response to the first sensing beam;
calculating a third distance that a third retro wave travels and a fourth distance that a fourth retro wave travels, wherein the third retro wave and the fourth retro wave are returned waves from the first retro-directive antenna (110) and the second retro-directive antenna (120), respectively, in response to the second sensing beam; and
determining whether a current moving direction of the moving vehicle (105) needs to be adjusted or not according to the first, second, third and/or fourth distances and the specific distance between the positions of the first retro-directive antenna (110) and the second retro-directive antenna (120).

4. The mobile navigation method according to claim 3, wherein the radar antenna (100) is an omnidirectional antenna, and the step of determining whether the current moving direction of the moving vehicle (105) needs to be adjusted or not includes:

defining a first circle with a position of the omnidirectional antenna at the first time point as a center of the first defined circle and the first distance as a radius of the first defined circle;
defining a second circle with a position of the omnidirectional antenna at the first time point as a center of the second defined circle and the second distance as a radius of the second defined circle;
defining a third circle with a position of the omnidirectional antenna at the second time point as a center of the third defined circle and the third distance as a radius of the third defined circle;
defining a fourth circle with a position of the omnidirectional antenna at the second time point as a center of the fourth defined circle and the fourth distance as a radius of the fourth defined circle;
using an intersection point of the first defined circle and the third defined circle as a first hypothetical position, using an intersection point of the second defined circle and the fourth defined circle as a second hypothetical position, and determining whether a distance between the first hypothetical position and the second hypothetical position is equal to the specific distance or not;
if the distance between the first hypothetical position and the second hypothetical position is substantially equal to the specific distance, determining whether the current moving direction of the moving vehicle (105) needs to be adjusted or not according to the first hypothetical position and the second hypothetical position; and
if the distance between the first hypothetical position and the second hypothetical position is not equal to the specific distance, determining whether the current moving direction of the moving vehicle (105) needs to be adjusted or not according to a third hypothetical position and a fourth hypothetical position, wherein an intersection point of the first defined circle and the fourth defined circle is used as the third hypothetical position, and an intersection point of the second defined circle and the third defined circle is used as the fourth hypothetical position.

5. The mobile navigation method according to claim 4, wherein whether the current moving direction of the moving vehicle (105) needs to be adjusted or not is determined according to the first, second, third and/or fourth distances, the specific distance, and intensities of the first, second, third and/or fourth retro waves.

6. The mobile navigation method according to claim 4, wherein the step of determining whether the current moving direction of the moving vehicle (105) needs to be adjusted or not includes:

connecting the first hypothetical position and the second hypothetical position as a base line, wherein a first azimuth exists between the base line and a line connecting the omnidirectional antenna and the first hypothetical position at the first time point, a second azimuth exists between the base line and a line connecting the omnidirectional antenna and the second hypothetical position at the first time point, a third azimuth exists between the base line and a line connecting the omnidirectional antenna and the first hypothetical position at the second time point, and a fourth azimuth exists between the base line

and a line connecting the omnidirectional antenna and the second hypothetical position at the second time point; and
comparing the first, second, third and/or fourth azimuths to determine whether the current moving direction of the moving vehicle (105) needs to be adjusted or not.

7. The mobile navigation method according to claim 6, wherein the step of determining whether the current moving direction of the moving vehicle (105) needs to be adjusted or not includes:

comparing the first azimuth and the second azimuth;
comparing the third azimuth and the first azimuth if the first azimuth is not smaller than the second azimuth; and
determining that the current moving direction of the moving vehicle (105) needs to be adjusted if the third azimuth is larger than the first azimuth.

8. The mobile navigation method according to claim 7, further comprising a step of adjusting the current moving direction of the moving vehicle (105) to have the first azimuth gradually decrease if it is determined that the current moving direction of the moving vehicle (105) needs to be adjusted.

9. The mobile navigation method according to claim 6, wherein the step of determining whether the current moving direction of the moving vehicle (105) needs to be adjusted or does not include:

comparing the first azimuth and the second azimuth;
comparing the fourth azimuth and the second azimuth if the first azimuth is not larger than the second azimuth; and
determining that the current moving direction of the moving vehicle (105) needs to be adjusted if the fourth azimuth is larger than the second azimuth.

Patentansprüche

1. Mobilnavigationssystem zum Leiten eines sich bewegenden Fahrzeugs in Richtung eines Zielpunkts, umfassend:

eine von dem sich bewegenden Fahrzeug (105) getragene Radarantenne (100), die einen ersten Abtaststrahl an einem ersten Zeitpunkt ausstrahlt und einen zweiten Abtaststrahl an einem zweiten Zeitpunkt, der später als der erste Zeitpunkt ist, ausstrahlt; und
eine Verarbeitungsvorrichtung (130), die elektrisch mit der Radarantenne (100) gekoppelt ist; **dadurch gekennzeichnet, dass** es ferner Folgendes umfasst:

eine erste rückwärtsgerichtete Antenne (110), die an einer ersten Position angeordnet ist; und
eine zweite rückwärtsgerichtete Antenne (120), die an einer zweiten Position angeordnet ist, die sich an einer Seite des Zielpunkts gegenüber der ersten Position befindet und einen spezifischen Abstand von der ersten Position aufweist;
wobei die erste rückwärtsgerichtete Antenne (110) und die zweite rückwärtsgerichtete Antenne (120) dazu konfiguriert sind, jeweils den ersten Abtaststrahl zu empfangen und eine erste Rückwelle und eine zweite Rückwelle entsprechend einer Richtung des ersten Abtaststrahls zurückzugeben;
die erste rückwärtsgerichtete Antenne (110) und die zweite rückwärtsgerichtete Antenne (120) dazu konfiguriert sind, jeweils den zweiten Abtaststrahl zu empfangen und eine dritte Rückwelle und eine vierte Rückwelle entsprechend einer Richtung des zweiten Abtaststrahls zurückzugeben, und
die Verarbeitungsvorrichtung (130) dazu konfiguriert ist, die erste, zweite, dritte und vierte Rückwelle zu empfangen und zu bestimmen, ob gemäß einem ersten, zweiten, dritten und/oder vierten Abstand, den die erste, zweite, dritte beziehungsweise vierte Rückwelle zurücklegt, und dem spezifischen Abstand zwischen den Positionen der ersten rückwärtsgerichteten Antenne (110) und der zweiten rückwärtsgerichteten Antenne (120) eine Bewegungsrichtung des Fahrzeugs (105) angepasst werden muss oder nicht.

2. System nach Anspruch 1, wobei die Radarantenne (100) eine Rundstrahlantenne oder eine gerichtete Strahlformungsantenne ist.

3. Mobilnavigationsverfahren zum Leiten eines sich bewegenden Fahrzeugs in Richtung eines Zielpunkts, umfassend:

Ausstrahlen eines ersten Abtaststrahls von dem sich bewegenden Fahrzeug (105) an einem ersten Zeitpunkt; und
Ausstrahlen eines zweiten Abtaststrahls von dem sich bewegenden Fahrzeug (105) an einem zweiten Zeitpunkt, der später als der erste Zeitpunkt ist;
gekennzeichnet durch

Anordnen einer Radarantenne (100) an dem sich bewegenden Fahrzeug und Anordnen einer ersten rückwärtsgerichteten Antenne (110) und einer zweiten rückwärtsgerichteten Antenne (120) auf gegenüberliegenden Seiten des Zielpunktes, wobei die erste rückwärtsgerichtete Antenne (110) und die zweite rückwärtsgerichtete Antenne (120) einen spezifischen Abstand voneinander aufweisen;

Berechnen eines ersten Abstands, den eine erste Rückwelle zurücklegt, und eines zweiten Abstands, den eine zweite Rückwelle zurücklegt, wobei die erste Rückwelle und die zweite Rückwelle von der ersten rückwärtsgerichteten Antenne (110) beziehungsweise der zweiten rückwärtsgerichteten Antenne (120) als Reaktion auf den ersten Abtaststrahl zurückgegebene Wellen sind;

Berechnen eines dritten Abstands, den eine dritte Rückwelle zurücklegt, und eines vierten Abstands, den eine vierte Rückwelle zurücklegt, wobei die dritte Rückwelle und die vierte Rückwelle von der ersten rückwärtsgerichteten Antenne (110) beziehungsweise der zweiten rückwärtsgerichteten Antenne (120) als Reaktion auf den zweiten Abtaststrahl zurückgegebene Wellen sind; und

Bestimmen, ob gemäß dem ersten, zweiten, dritten und/oder vierten Abstand und dem spezifischen Abstand zwischen den Positionen der ersten rückwärtsgerichteten Antenne (110) und der zweiten rückwärtsgerichteten Antenne (120) eine aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) angepasst werden muss oder nicht.

4. Mobilnavigationsverfahren nach Anspruch 3, wobei die Radarantenne (100) eine Rundstrahlantenne ist, und der Schritt des Bestimmens, ob die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) angepasst werden muss oder nicht, Folgendes umfasst:

Definieren eines ersten Kreises mit einer Position der Rundstrahlantenne an dem ersten Zeitpunkt als ein Mittelpunkt des ersten definierten Kreises und des ersten Abstands als ein Radius des ersten definierten Kreises;

Definieren eines zweiten Kreises mit einer Position der Rundstrahlantenne an dem ersten Zeitpunkt als ein Mittelpunkt des zweiten definierten Kreises und des zweiten Abstands als ein Radius des zweiten definierten Kreises;

Definieren eines dritten Kreises mit einer Position der Rundstrahlantenne an dem zweiten Zeitpunkt als ein Mittelpunkt des dritten definierten Kreises und des dritten Abstands als ein Radius des dritten definierten Kreises;

Definieren eines vierten Kreises mit einer Position der Rundstrahlantenne an dem zweiten Zeitpunkt als ein Mittelpunkt des vierten definierten Kreises und des vierten Abstands als ein Radius des vierten definierten Kreises;

Verwenden eines Schnittpunkts des ersten definierten Kreises und des dritten definierten Kreises als eine erste hypothetische Position, Verwenden eines Schnittpunktes des zweiten definierten Kreises und des vierten definierten Kreises als eine zweite hypothetische Position, und Bestimmen, ob ein Abstand zwischen der ersten hypothetischen Position und der zweiten hypothetischen Position gleich dem spezifischen Abstand ist oder nicht;

falls der Abstand zwischen der ersten hypothetischen Position und der zweiten hypothetischen Position im Wesentlichen gleich dem spezifischen Abstand ist, Bestimmen, ob die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) gemäß der ersten hypothetischen Position und der zweiten hypothetischen Position angepasst werden muss oder nicht; und

falls der Abstand zwischen der ersten hypothetischen Position und der zweiten hypothetischen Position nicht gleich dem spezifischen Abstand ist, Bestimmen, ob die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) gemäß einer dritten hypothetischen Position und einer vierten hypothetischen Position angepasst werden muss oder nicht, wobei ein Schnittpunkt des ersten definierten Kreises und des vierten definierten Kreises als die dritte hypothetische Position verwendet wird, und ein Schnittpunkt des zweiten definierten Kreises und des dritten definierten Kreises als die vierte hypothetische Position verwendet wird.

5. Mobilnavigationsverfahren nach Anspruch 4, wobei gemäß dem ersten, zweiten, dritten und/oder vierten Abstand, dem spezifischen Abstand und Intensitäten der ersten, zweiten, dritten und/oder vierten Rückwelle bestimmt wird, ob die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) angepasst werden muss oder nicht.

6. Mobilnavigationsverfahren nach Anspruch 4, wobei der Schritt des Bestimmens, ob die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) angepasst werden muss oder nicht, Folgendes umfasst:

Verbinden der ersten hypothetischen Position und der zweiten hypothetischen Position als eine Grundlinie, wobei ein erster Azimut zwischen der Grundlinie und einer Linie, die die Rundstrahlantenne und die erste hypothetische Po-

sition an dem ersten Zeitpunkt verbindet, besteht, ein zweiter Azimut zwischen der Grundlinie und einer Linie, die die Rundstrahlantenne und die zweite hypothetische Position an dem ersten Zeitpunkt verbindet, besteht, ein dritter Azimut zwischen der Grundlinie und einer Linie, die die Rundstrahlantenne und die erste hypothetische Position an dem zweiten Zeitpunkt verbindet, besteht, und ein vierter Azimut zwischen der Grundlinie und einer Linie, die die Rundstrahlantenne und die zweite hypothetische Position an dem zweiten Zeitpunkt verbindet, besteht; und

Vergleichen des ersten, zweiten, dritten und/oder vierten Azimuts, um zu bestimmen, ob die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) angepasst werden muss oder nicht.

7. Mobilnavigationsverfahren nach Anspruch 6, wobei der Schritt des Bestimmens, ob die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) angepasst werden muss oder nicht, Folgendes umfasst:

Vergleichen des ersten Azimuts und des zweiten Azimuts;

Vergleichen des dritten Azimuts und des ersten Azimuts, falls der erste Azimut nicht kleiner als der zweite Azimut ist; und

Bestimmen, dass die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) angepasst werden muss, falls der dritte Azimut größer als der erste Azimut ist.

8. Mobilnavigationsverfahren nach Anspruch 7, ferner umfassend einen Schritt des Anpassens der aktuellen Bewegungsrichtung des sich bewegenden Fahrzeugs (105), so dass der erste Azimut schrittweise verkleinert wird, wenn bestimmt wird, dass die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) angepasst werden muss.

9. Mobilnavigationsverfahren nach Anspruch 6, wobei der Schritt des Bestimmens, ob die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) angepasst werden muss oder nicht, Folgendes umfasst:

Vergleichen des ersten Azimuts und des zweiten Azimuts;

Vergleichen des vierten Azimuts und des zweiten Azimuts, falls der erste Azimut nicht größer als der zweite Azimut ist; und

Bestimmen, dass die aktuelle Bewegungsrichtung des sich bewegenden Fahrzeugs (105) angepasst werden muss, falls der vierte Azimut größer als der zweite Azimut ist.

Revendications

1. Système de navigation mobile pour guider un véhicule en déplacement vers un point cible, comprenant :

une antenne radar (100) portée par le véhicule en déplacement (105), émettant un premier faisceau de détection à un premier instant et émettant un second faisceau de détection à un second instant ultérieur au premier instant ; et
un dispositif de traitement (130) couplé électriquement à l'antenne radar (100) ;
caractérisé en ce qu'il comprend en outre :

une première antenne à rayonnement rétro-directif (110) disposée à une première position ; et
une seconde antenne à rayonnement rétro-directif (120) disposée à une seconde position, qui est au niveau d'un côté du point cible opposé à la première position, et a une distance spécifique par rapport à la première position ;
dans lequel la première antenne à rayonnement rétro-directif (110) et la seconde antenne à rayonnement rétro-directif (120) sont configurées pour recevoir respectivement le premier faisceau de détection et renvoyer une première rétro-onde et une deuxième rétro-onde correspondant à une direction du premier faisceau de détection ;
la première antenne à rayonnement rétro-directif (110) et la seconde antenne à rayonnement rétro-directif (120) sont configurées pour recevoir respectivement le second faisceau de détection et renvoyer une troisième rétro-onde et une quatrième rétro-onde correspondant à une direction du second faisceau de détection, et
le dispositif de traitement (130) est configuré pour recevoir les première, deuxième, troisième et quatrième rétro-ondes, et déterminer si une direction de déplacement du véhicule (105) doit être ajustée ou non selon des première, deuxième, troisième et/ou quatrième distances que les première, deuxième, troisième et quatrième rétro-ondes parcourent, respectivement, et la distance spécifique entre les positions de la première antenne à rayonnement rétro-directif (110) et de la seconde antenne à rayonnement rétro-directif (120).

2. Système selon la revendication 1, dans lequel l'antenne radar (100) est une antenne omnidirectionnelle ou une antenne de formation de faisceau directive.

3. Procédé de navigation mobile pour guider un véhicule en déplacement vers un point cible, comprenant :

l'émission d'un premier faisceau de détection depuis le véhicule en déplacement (105) à un premier instant ; et
l'émission d'un second faisceau de détection depuis le véhicule en déplacement (105) à un second instant ultérieur au premier instant ;
caractérisé par
l'agencement d'une antenne radar (100) sur le véhicule en déplacement, et l'agencement d'une première antenne à rayonnement rétro-directif (110) et d'une seconde antenne à rayonnement rétro-directif (120) au niveau de côtés opposés du point cible, dans lequel la première antenne à rayonnement rétro-directif (110) et la seconde antenne à rayonnement rétro-directif (120) ont une distance spécifique l'une par rapport à l'autre ;
le calcul d'une première distance qu'une première rétro-onde parcourt et d'une deuxième distance qu'une deuxième rétro-onde parcourt, dans lequel la première rétro-onde et la deuxième rétro-onde sont des ondes renvoyées depuis la première antenne à rayonnement rétro-directif (110) et la seconde antenne à rayonnement rétro-directif (120), respectivement, en réponse au premier faisceau de détection ;
le calcul d'une troisième distance qu'une troisième rétro-onde parcourt et d'une quatrième distance qu'une quatrième rétro-onde parcourt, dans lequel la troisième rétro-onde et la quatrième rétro-onde sont des ondes renvoyées depuis la première antenne à rayonnement rétro-directif (110) et la seconde antenne à rayonnement rétro-directif (120), respectivement, en réponse au second faisceau de détection ; et
la détermination pour savoir si une direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée ou non selon les première, deuxième, troisième et/ou quatrième distances et la distance spécifique entre les positions de la première antenne à rayonnement rétro-directif (110) et de la seconde antenne à rayonnement rétro-directif (120).

4. Procédé de navigation mobile selon la revendication 3, dans lequel l'antenne radar (100) est une antenne omnidirectionnelle, et l'étape de détermination pour savoir si la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée ou non comporte :

la définition d'un premier cercle avec une position de l'antenne omnidirectionnelle au premier instant en tant que centre du premier cercle défini et la première distance en tant que rayon du premier cercle défini ;
la définition d'un deuxième cercle avec une position de l'antenne omnidirectionnelle au premier instant en tant que centre du deuxième cercle défini et la deuxième distance en tant que rayon du deuxième cercle défini ;
la définition d'un troisième cercle avec une position de l'antenne omnidirectionnelle au second instant en tant que centre du troisième cercle défini et la troisième distance en tant que rayon du troisième cercle défini ;
la définition d'un quatrième cercle avec une position de l'antenne omnidirectionnelle au second instant en tant que centre du quatrième cercle défini et la quatrième distance en tant que rayon du quatrième cercle défini ;
l'utilisation d'un point d'intersection du premier cercle défini et du troisième cercle défini en tant que première position hypothétique, l'utilisation d'un point d'intersection du deuxième cercle défini et du quatrième cercle défini en tant que deuxième position hypothétique, et la détermination pour savoir si une distance entre la première position hypothétique et la deuxième position hypothétique est égale à la distance spécifique ou non ;
si la distance entre la première position hypothétique et la deuxième position hypothétique est sensiblement égale à la distance spécifique, la détermination pour savoir si la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée ou non selon la première position hypothétique et la deuxième position hypothétique ; et
si la distance entre la première position hypothétique et la deuxième position hypothétique n'est pas égale à la distance spécifique, la détermination pour savoir si la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée ou non selon une troisième position hypothétique et une quatrième position hypothétique, dans lequel un point d'intersection du premier cercle défini et du quatrième cercle défini est utilisé en tant que troisième position hypothétique, et un point d'intersection du deuxième cercle défini et du troisième cercle défini est utilisé en tant que quatrième position hypothétique.

5. Procédé de navigation mobile selon la revendication 4, dans lequel le fait de savoir si la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée ou non est déterminé selon les première, deuxième, troisième et/ou quatrième distances, la distance spécifique, et des intensités des première, deuxième, troisième et/ou quatrième rétro-ondes.

6. Procédé de navigation mobile selon la revendication 4, dans lequel l'étape de détermination pour savoir si la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée ou non comporte :

la liaison de la première position hypothétique et de la deuxième position hypothétique en tant que ligne de base, dans lequel un premier azimut existe entre la ligne de base et une ligne reliant l'antenne omnidirectionnelle et la première position hypothétique au premier instant, un deuxième azimut existe entre la ligne de base et une ligne reliant l'antenne omnidirectionnelle et la deuxième position hypothétique au premier instant, un troisième azimut existe entre la ligne de base et une ligne reliant l'antenne omnidirectionnelle et la première position hypothétique au second instant, et un quatrième azimut existe entre la ligne de base et une ligne reliant l'antenne omnidirectionnelle et la deuxième position hypothétique au second instant ; et
la comparaison des premier, deuxième, troisième et/ou quatrième azimuts pour déterminer si la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée ou non.

7. Procédé de navigation mobile selon la revendication 6, dans lequel l'étape de détermination pour savoir si la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée ou non comporte :

la comparaison du premier azimut et du deuxième azimut ;
la comparaison du troisième azimut et du premier azimut si le premier azimut n'est pas inférieur au deuxième azimut ; et
la détermination que la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée si le troisième azimut est supérieur au premier azimut.

8. Procédé de navigation mobile selon la revendication 7, comprenant en outre une étape d'ajustement de la direction de déplacement actuelle du véhicule en déplacement (105) pour avoir le premier azimut diminuer progressivement s'il est déterminé que la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée.

9. Procédé de navigation mobile selon la revendication 6, dans lequel l'étape de détermination pour savoir si la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée ou non comporte :

la comparaison du premier azimut et du deuxième azimut ;
la comparaison du quatrième azimut et du deuxième azimut si le premier azimut n'est pas supérieur au deuxième azimut ; et
la détermination que la direction de déplacement actuelle du véhicule en déplacement (105) doit être ajustée si le quatrième azimut est supérieur au deuxième azimut.

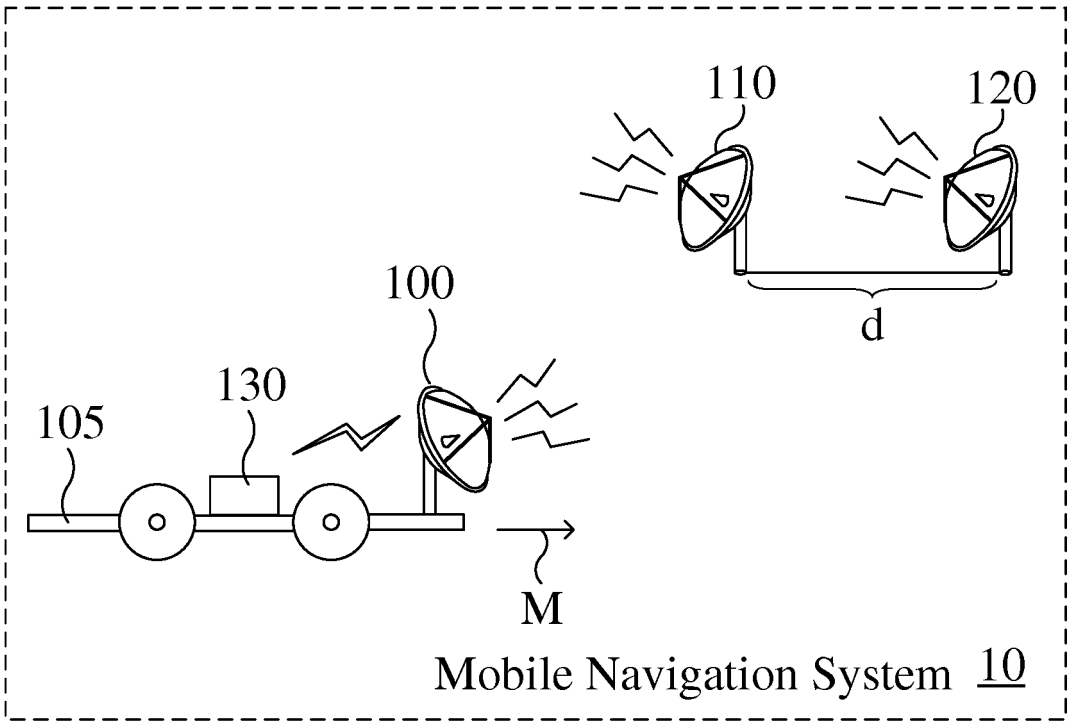

FIG. 1

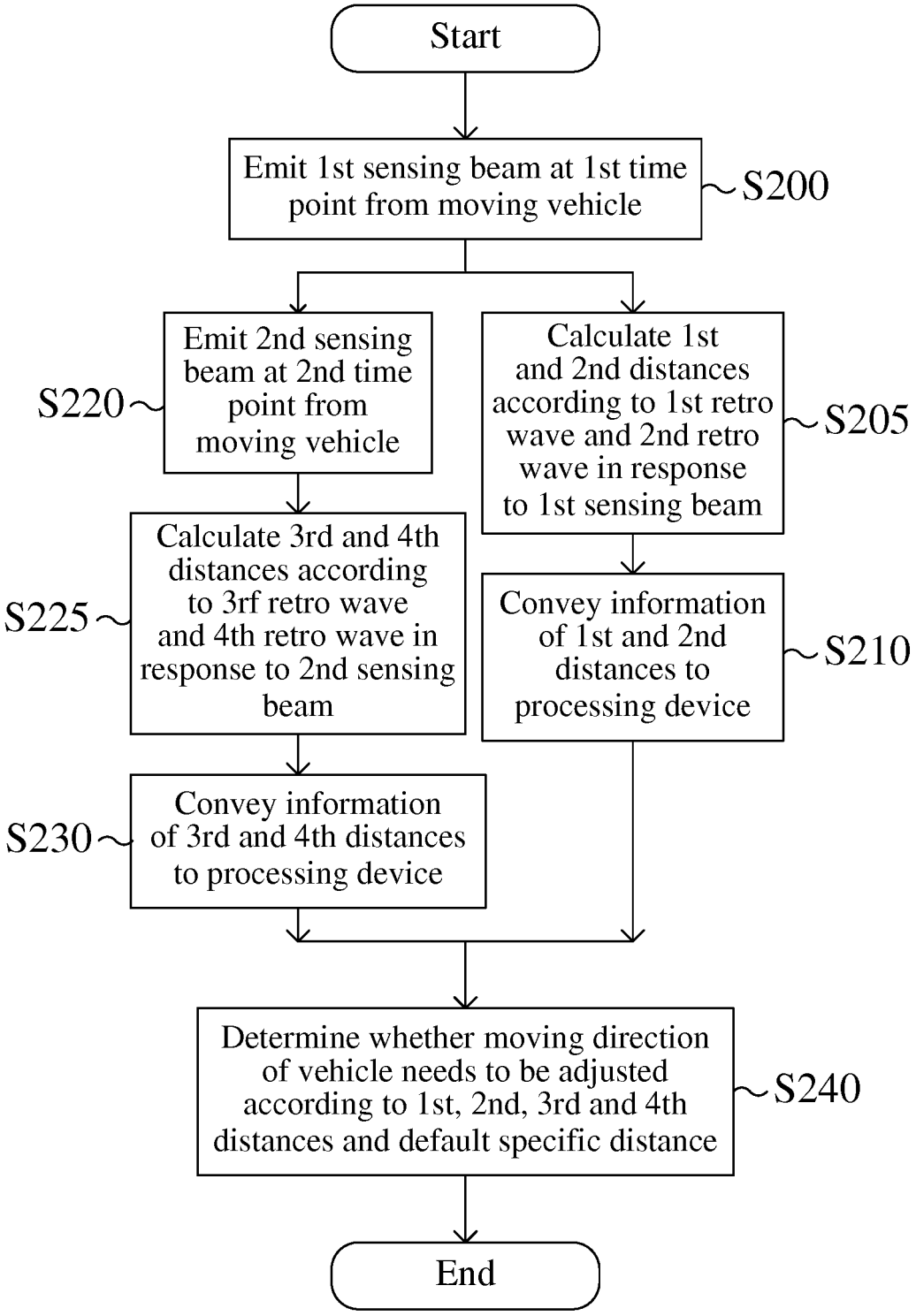
Start
Emit 1st sensing beam at 1st time point from moving vehicle
S200
Emit 2nd sensing beam at 2nd time point from moving vehicle
S220
Calculate 1st and 2nd distances according to 1st retro wave and 2nd retro wave in response to 1st sensing beam
S205
Calculate 3rd and 4th distances according to 3rf retro wave and 4th retro wave in response to 2nd sensing beam
S225
Convey information of 1st and 2nd distances to processing device
S210
Convey information of 3rd and 4th distances to processing device
S230
Determine whether moving direction of vehicle needs to be adjusted according to 1st, 2nd, 3rd and 4th distances and default specific distance
S240
End

FIG. 2

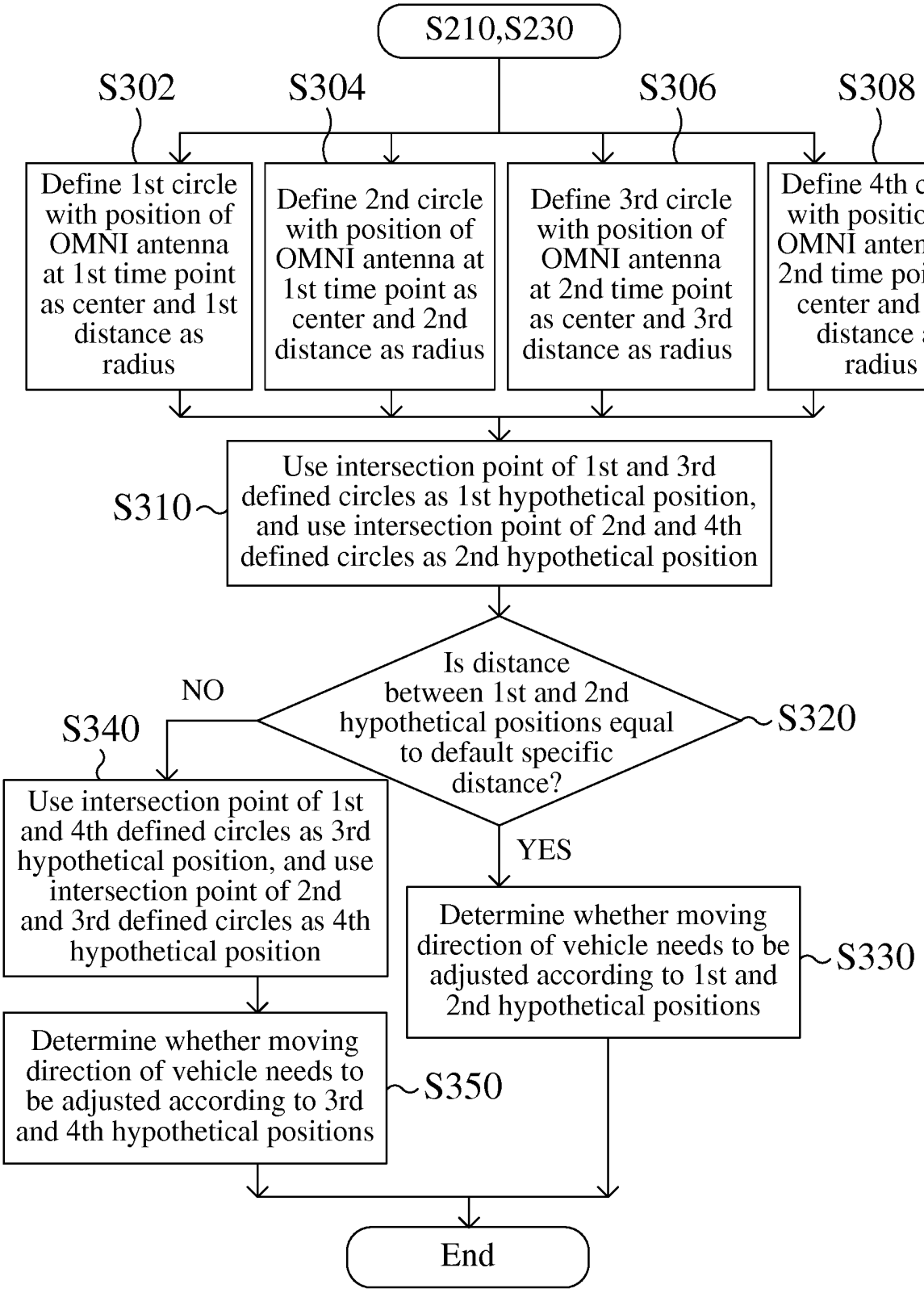
S210,S230
S302
S304
S306
S308
Define 1st circle with position of OMNI antenna at 1st time point as center and 1st distance as radius
Define 2nd circle with position of OMNI antenna at 1st time point as center and 2nd distance as radius
Define 3rd circle with position of OMNI antenna at 2nd time point as center and 3rd distance as radius
Define 4th circle with position of OMNI antenna at 2nd time point as center and 4th distance as radius
S310
Use intersection point of 1st and 3rd defined circles as 1st hypothetical position, and use intersection point of 2nd and 4th defined circles as 2nd hypothetical position
Is distance between 1st and 2nd hypothetical positions equal to default specific distance?
S320
NO
S340
YES
Use intersection point of 1st and 4th defined circles as 3rd hypothetical position, and use intersection point of 2nd and 3rd defined circles as 4th hypothetical position
Determine whether moving direction of vehicle needs to be adjusted according to 1st and 2nd hypothetical positions
S330
Determine whether moving direction of vehicle needs to be adjusted according to 3rd and 4th hypothetical positions
S350
End

FIG. 3A

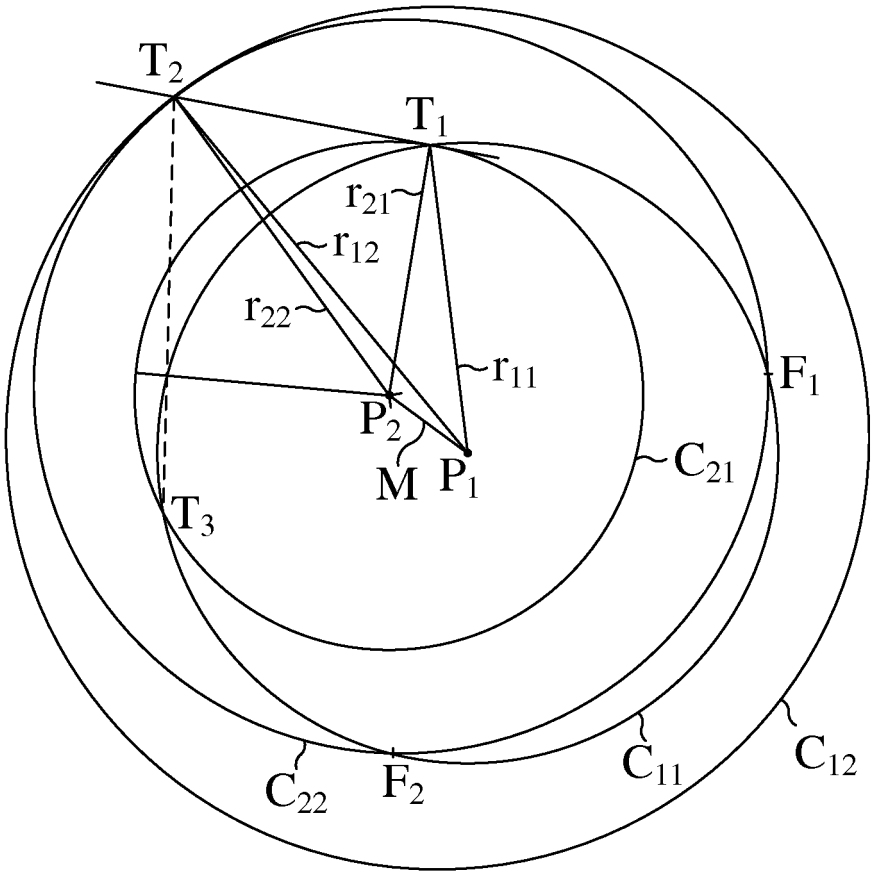

FIG. 3B

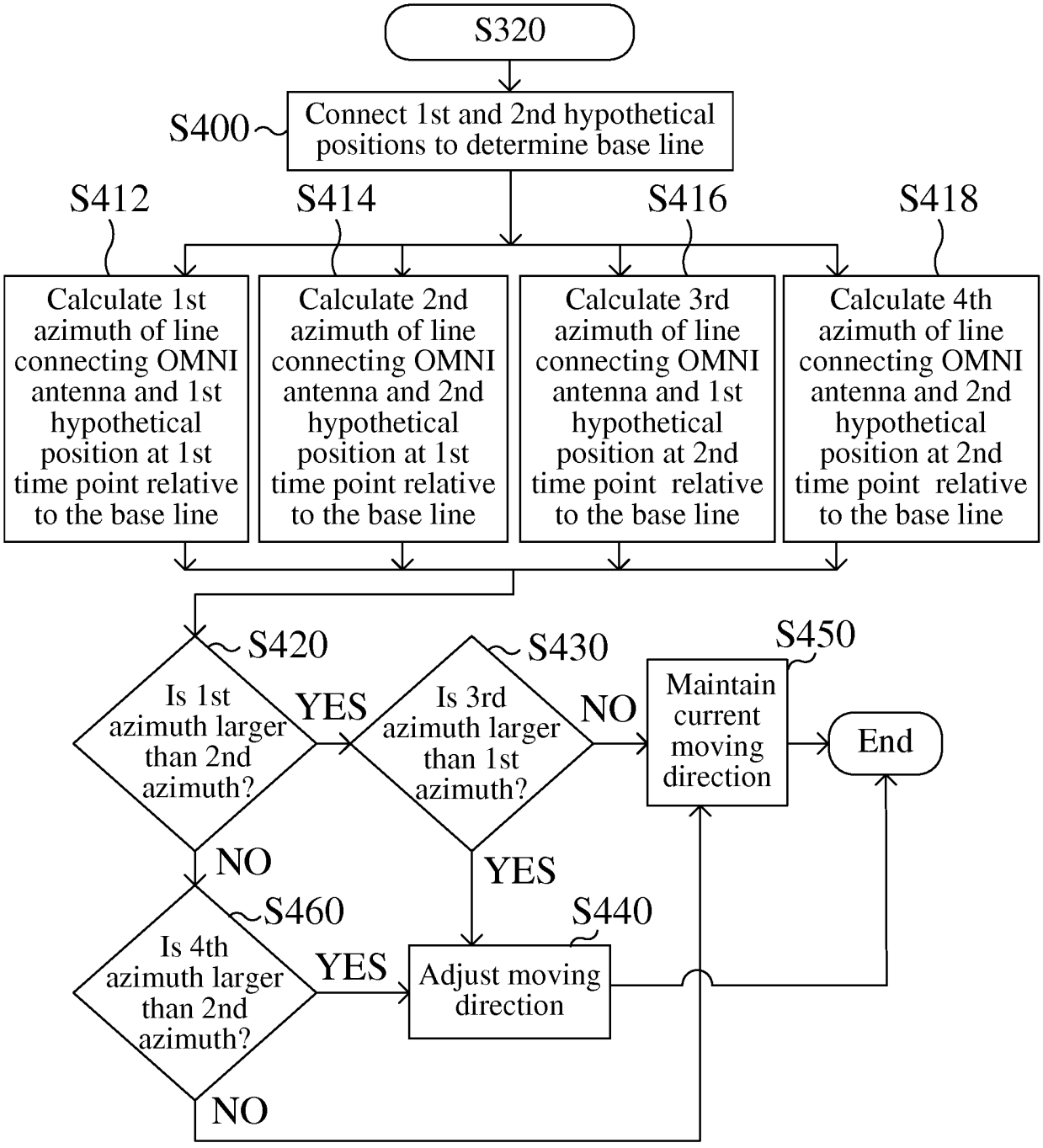
S320
S400
Connect 1st and 2nd hypothetical positions to determine base line
S412
S414
S416
S418
Calculate 1st azimuth of line connecting OMNI antenna and 1st hypothetical position at 1st time point relative to the base line
Calculate 2nd azimuth of line connecting OMNI antenna and 2nd hypothetical position at 1st time point relative to the base line
Calculate 3rd azimuth of line connecting OMNI antenna and 1st hypothetical position at 2nd time point relative to the base line
Calculate 4th azimuth of line connecting OMNI antenna and 2nd hypothetical position at 2nd time point relative to the base line
S420
Is 1st azimuth larger than 2nd azimuth?
YES
S430
Is 3rd azimuth larger than 1st azimuth?
NO
S450
Maintain current moving direction
End
NO
YES
S460
Is 4th azimuth larger than 2nd azimuth?
YES
S440
Adjust moving direction
NO

FIG. 4A

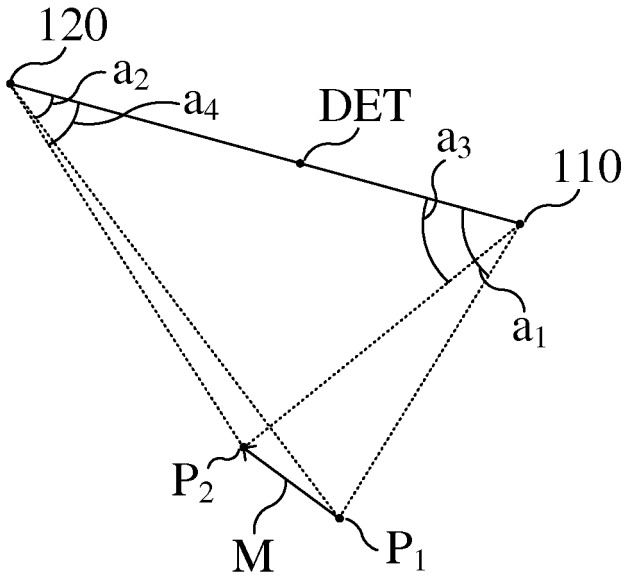

FIG. 4B

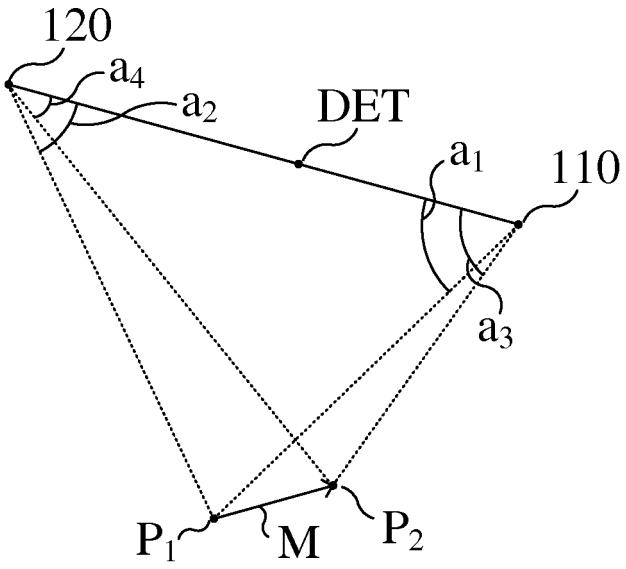

FIG. 4C

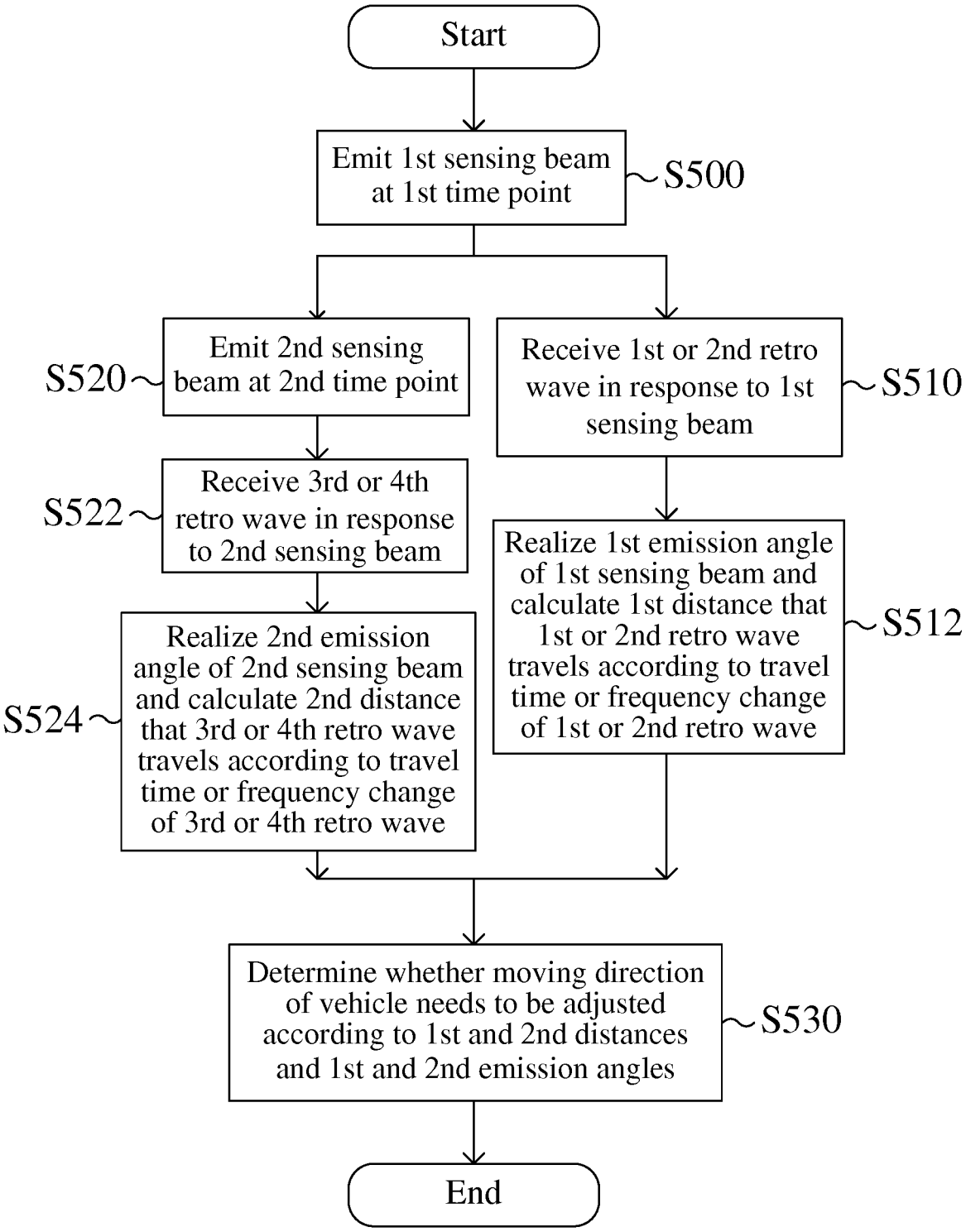
Start
Emit 1st sensing beam at 1st time point
S500
Emit 2nd sensing beam at 2nd time point
S520
Receive 1st or 2nd retro wave in response to 1st sensing beam
S510
Receive 3rd or 4th retro wave in response to 2nd sensing beam
S522
Realize 1st emission angle of 1st sensing beam and calculate 1st distance that 1st or 2nd retro wave travels according to travel time or frequency change of 1st or 2nd retro wave
S512
Realize 2nd emission angle of 2nd sensing beam and calculate 2nd distance that 3rd or 4th retro wave travels according to travel time or frequency change of 3rd or 4th retro wave
S524
Determine whether moving direction of vehicle needs to be adjusted according to 1st and 2nd distances and 1st and 2nd emission angles
S530
End

FIG. 5

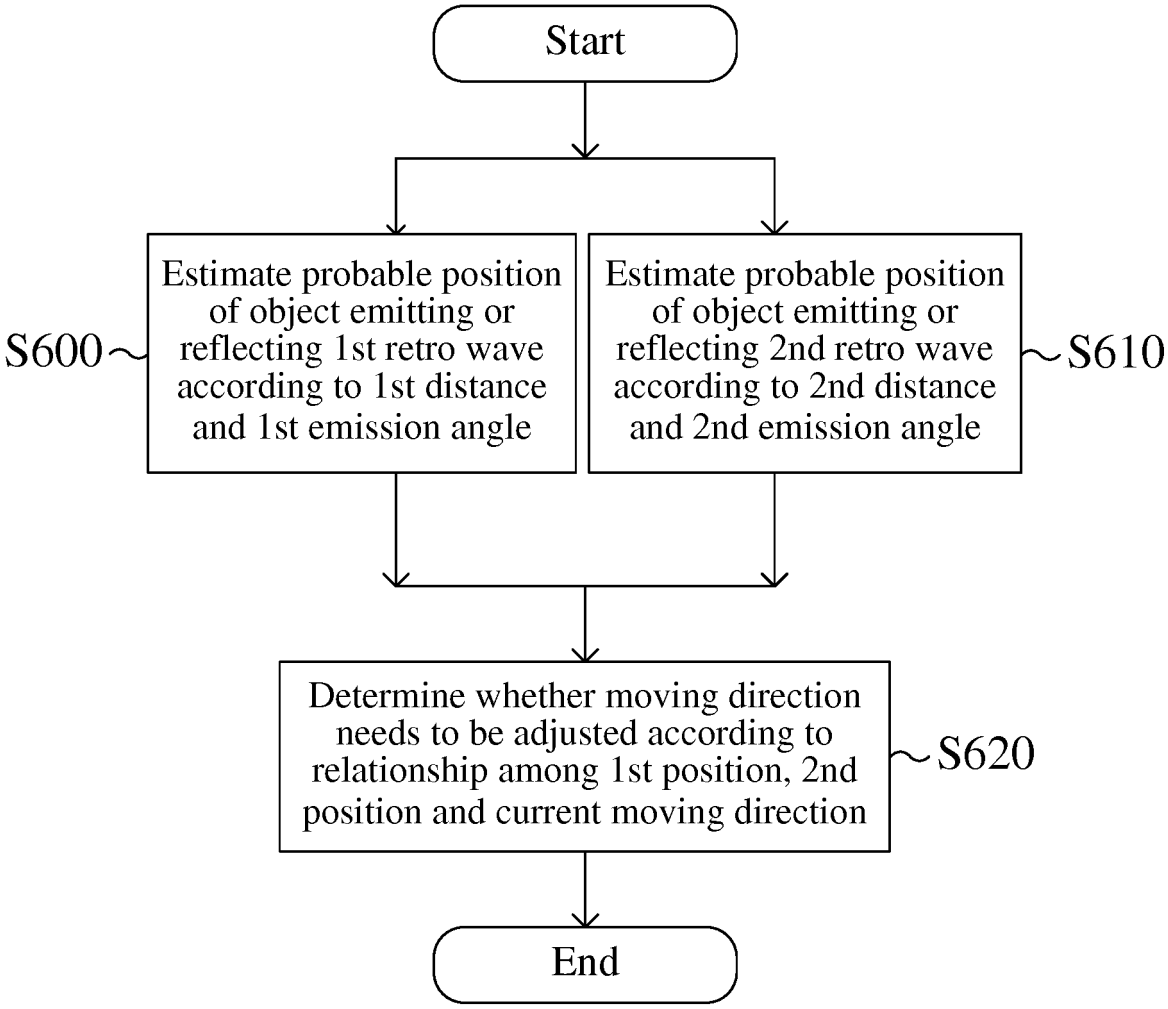
Start
Estimate probable position of object emitting or reflecting 1st retro wave according to 1st distance and 1st emission angle
S600
Estimate probable position of object emitting or reflecting 2nd retro wave according to 2nd distance and 2nd emission angle
S610
Determine whether moving direction needs to be adjusted according to relationship among 1st position, 2nd position and current moving direction
S620
End

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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