Positioning Method, Device and System for Transmitting Device, and Storage Medium and Electronic Device

Cross Reference

This application is a National Stage Filing of the PCT International Application No. PCT/CN2021/093459 filed on May 12, 2021, which claims priority to Chinese patent application No. 202010615392.8 filed on June 30, 2020, the entirety of which is herein incorporated by reference.

Technical Field

Embodiments of the present disclosure relate to the field of communications, in particular to a positioning method, device and system for a transmitting device, and a storage medium and an electronic device.

Background

Traditional estimation methods for Direction of Arrival (DOA) of an array beam include Multiple Signal Classification (MUSIC), Estimating Signal parameter via Rotation Invariance Techniques (ESPRIT), etc., a foundation of which lies in an independent measurement function (for example, an arrival phase measurement function) of an array element. However, for a beam-adjustable meta-surface (also called meta-surface or reconfigurable meta-surface), the addition of such a measuring function will reduce reflection efficiency and increase cost. Therefore, the meta-surface is not usually associated with a phase measuring function of an independent electromagnetic unit, which makes the traditional estimation methods for DOA of the array not available in the meta-surface.

Traditional Non-Line-Of-Sight (NLOS) positioning methods include a Line-Of-Sight (LOS) reconstruction positioning method, an NLOS weighted positioning method, a Time of Arrival (TOA) positioning method based on a combination of line-of-sight reconstruction and smoothing, and a positioning method based on inequality constraints. In these methods, the NLOS is converted into the LOS according to a mirror principle, or influences of NLOS components are reduced through stochastic methods by the coordination between multiple base stations. Moreover, fingerprint maps or positioning methods based on a Global Positioning System (GPS) in the related art require the deployment of another positioning system and related accessories, which increases the cost and limits the implementation in some scenarios. It can be seen that in the related art, the use of multiple systems and the support from other related technologies are required during positioning, and a terminal cannot be positioned by means of the characteristics of a meta-surface.

For the technical problem in the related art that a terminal cannot be positioned by means of characteristics of a meta-surface, no effective technical solution is available so far.

Summary

In the above embodiment, the signal measurement result may be signal quality, signal strength level or signal received power.

The execution sequences of S304 and S306 are interchangeable, that is, S306 may be executed first and then S304.

In an exemplary embodiment, the operation that the control information is determined by the receiving device includes that the control information is determined according to a target area. The operation that the control information is determined according to the target area includes that: multiple pieces of preset direction information are determined according to multiple sub-areas obtained by dividing the target area, and multiple target time periods are determined according to the multiple pieces of preset direction information. The multiple pieces of preset direction information are in one-to-one correspondence with the multiple sub-areas. The temporal information includes the multiple target time periods. The multiple target time periods are in one-to-one correspondence with the multiple pieces of preset direction information. Alternatively, multiple preset directions pointing to the target area are determined, each piece of preset direction information among multiple pieces of preset direction information is determined as a respective one of the multiple preset directions, and the temporal information is determined according to the multiple pieces of preset direction information. The temporal information includes the multiple target time periods, and the multiple target time periods are in one-to-one correspondence with the multiple pieces of preset direction information.

In the above embodiment, the target area may be divided into multiple sub-areas by the receiving device. For example, the target area is divided into sub-area 1, sub-area 2, sub-area 3, etc., and the preset direction information corresponding to each sub-area is determined according to the multiple sub-areas, such as preset direction information 1, preset direction information 2, and preset direction information 3. The preset direction information is used for instructing the meta-surface control unit to adjust a reflection coefficient of each electromagnetic unit of the meta-surface, so that the reflected beam formed on the meta-surface points to the sub-area corresponding to the preset direction information. The reflected beam is the reflected beam (also called virtual reflected beam) formed on the meta-surface by the beam in the direction from the receiving device to the meta-surface. Therefore, by controlling the meta-surface to make the reflected beam point to the sub-areas of the target area in turn, the receiving device can scan the target area. In an exemplary embodiment, the receiving device may determine the preset direction information corresponding to each sub-area according to an order of scanning the sub-areas of the target area, and determine the temporal information according to the preset direction information determined (that is, determine multiple target time periods, each of which has the corresponding preset direction information). For

by the receiving device measuring a received target pilot signal. The target pilot signal is received by the receiving device after reflected by the meta-surface whose reflection coefficient is adjusted to the target reflection coefficient. The pilot signals transmitted by the transmitting device include the target pilot signal.

Through the present disclosure, control information is determined by a receiving device, wherein the control information includes temporal information and control direction information; the control direction information is used for instructing a meta-surface control unit to adjust a reflection coefficient of a meta-surface to a target reflection coefficient corresponding to a preset direction, so that a beam in a direction from the receiving device to the meta-surface forms on the meta-surface a reflected beam in the preset direction; the preset direction is a direction indicated by preset direction information corresponding to a target time period, and the preset direction points to a target area; the temporal information includes the target time period; and the control direction information includes the preset direction information. A pilot signal is transmitted to the meta-surface by a transmitting device, wherein the transmitting device is located in the target area. The control information is sent to the meta-surface control unit by the receiving device, wherein the control information is used for instructing the meta-surface control unit to adjust the reflection coefficient of the meta-surface to the target reflection coefficient corresponding to the preset direction within the target time period. A signal measurement result corresponding to the preset direction is determined, and the transmitting device is positioned according to the preset direction and the signal measurement result, wherein the signal measurement result is a measurement result obtained by the receiving device measuring a received target pilot signal; the target pilot signal is received by the receiving device after reflected by the meta-surface whose reflection coefficient is adjusted to the target reflection coefficient; and the pilot signals transmitted by the transmitting device include the target pilot signal. Therefore, the technical problem in the related art that a terminal cannot be positioned by means of characteristics of a meta-surface can be solved, thereby achieving the effect of using the characteristics of a meta-surface to position a terminal.

It is to be noted that the positioning node may be the receiving device or other positioning devices in the network.

In an exemplary embodiment, the receiving device is further configured to determine the control information according to the target area. The receiving device is configured to determine the control information in a following manner. Multiple pieces of preset direction information are determined according to multiple sub-areas obtained by dividing the target area, and multiple target time periods are determined according to the multiple pieces of preset direction information. The multiple pieces of preset direction information are in one-to-one correspondence

What is claimed is:

1. A positioning method for a transmitting device, comprising:

determining control information by a receiving device, wherein the control information comprises temporal information and control direction information; the control direction information is used for instructing a meta-surface control unit to adjust a reflection coefficient of a meta-surface to a target reflection coefficient corresponding to a preset direction, so that a beam in a direction from the receiving device to the meta-surface forms on the meta-surface a reflected beam in the preset direction; the preset direction is a direction indicated by preset direction information corresponding to a target time period, and the preset direction points to a target area; the temporal information comprises the target time period; and the control direction information comprises the preset direction information;

transmitting a pilot signal to the meta-surface by a transmitting device, wherein the transmitting device is located in the target area;

sending the control information to the meta-surface control unit by the receiving device, wherein the control information is used for instructing the meta-surface control unit to adjust the reflection coefficient of the meta-surface to the target reflection coefficient corresponding to the preset direction within the target time period; and

determining a signal measurement result corresponding to the preset direction, and positioning the transmitting device according to the preset direction and the signal measurement result, wherein the signal measurement result is a measurement result obtained by the receiving device measuring a received target pilot signal; the target pilot signal is received by the receiving device after reflected by the meta-surface whose reflection coefficient is adjusted to the target reflection coefficient; and the pilot signal transmitted by the transmitting device comprises the target pilot signal.

2. The method according to claim 1, wherein determining the control information by the receiving device comprises determining the control information according to a target area;

determining the control information according to the target area comprises:

determining multiple pieces of preset direction information according to multiple sub-areas obtained by dividing the target area, and determining multiple target time periods according to the multiple pieces of preset direction information, wherein the multiple pieces of preset direction information are in one-to-one correspondence with the multiple sub-areas, the temporal information comprises the multiple target time periods, and the multiple target time periods are in one-to-one

correspondence with the multiple pieces of preset direction information; or, determining multiple preset directions pointing to the target area, determining each piece of preset direction information among multiple pieces of preset direction information as a respective one of the multiple preset directions, and determining multiple target time periods according to the multiple pieces of preset direction information, wherein the temporal information comprises the multiple target time periods, and the multiple target time periods are in one-to-one correspondence with the multiple pieces of preset direction information.

3. The method according to claim 1, wherein after sending the control information to the meta-surface control unit by the receiving device, the method further comprises:

determining the target reflection coefficient by the meta-surface control unit according to the preset direction information; and

adjusting a reflection coefficient of each electromagnetic unit of the meta-surface to the target reflection coefficient by the meta-surface control unit within the target time period, so as to adjust the reflection coefficient of the meta-surface to the target reflection coefficient;

wherein the reflection coefficient of each electromagnetic unit comprises at least one of amplitude, phase and polarization.

4. The method according to claim 1, wherein in a case where the preset direction information is an input parameter corresponding to the preset direction, after sending the control information to the meta-surface control unit by the receiving device, the method further comprises:

determining the target reflection coefficient by the meta-surface control unit according to the input parameter; and

adjusting a reflection coefficient of each electromagnetic unit of the meta-surface to the target reflection coefficient by the meta-surface control unit within the target time period, so as to adjust the reflection coefficient of the meta-surface to the target reflection coefficient; or

in a case where the preset direction information is the target reflection coefficient corresponding to the preset direction, after sending the control information to the meta-surface control unit by the receiving device, the method further comprises:

adjusting a reflection coefficient of each electromagnetic unit of the meta-surface to the target reflection coefficient by the meta-surface control unit within the target time period, so as to adjust the reflection coefficient of the meta-surface to the target reflection coefficient.

5. The method according to claim 1, wherein the control information further comprises at least one of following information:

beam control start time for instructing the meta-surface control unit to start controlling a reflection coefficient of each electromagnetic unit of the meta-surface at the beam control start time; and

beam control end time for instructing the meta-surface control unit to end up controlling the reflection coefficient of each electromagnetic unit of the meta-surface at the beam control end time.

6. The method according to claim 1, wherein determining the signal measurement result corresponding to the preset direction comprises:

determining the target time period corresponding to each signal measurement result in a signal measurement result set, wherein the signal measurement result set comprises the signal measurement result corresponding to the preset direction; and

according to the target time period, determining the preset direction indicated by the preset direction information corresponding to the target time period, and determining the signal measurement result corresponding to the target time period as the signal measurement result corresponding to the preset direction.

7. The method according to claim 1, wherein positioning the transmitting device according to the preset direction and the signal measurement result comprises:

according to the preset direction and a position and height of the meta-surface, determining position coordinates (xi, yi) of the reflected beam corresponding to each preset direction in the target area, and determining a value of the signal measurement result corresponding to the preset direction as a z-coordinate zi corresponding to the position coordinates (xi, yi), wherein i is an identifier of the reflected beam corresponding to the preset direction; and

performing Gaussian function fitting according to a coordinate range of the target area, the position coordinates (xi, yi) and the corresponding z-coordinate zi to obtain a fitted Gaussian function, and determining a positioning result of positioning the transmitting device according to coordinates corresponding to a vertex of the fitted Gaussian function.

8. The method according to claim 7, wherein performing Gaussian function fitting according to the coordinate range of the target area, the position coordinates (xi, yi) and the corresponding z-coordinate zi to obtain the fitted Gaussian function, and determining the positioning result of positioning the transmitting device according to the coordinates corresponding to the vertex of the

fitted Gaussian function comprises:

sampling an x-coordinate range and a y-coordinate range of the target area respectively according to a preset coordinate interval to obtain an x-coordinate set and a y-coordinate set after sampling;

determining a z-coordinate zw corresponding to each x-coordinate xw in the x-coordinate set from the z-coordinate zi corresponding to the position coordinates (xi, yi), and determining a z-coordinate zp corresponding to each y-coordinate yp in the y-coordinate set from the z-coordinate zi corresponding to the position coordinates (xi, yi), wherein both the w and p are positive integers in an interval [1, n], and n is the number of samples sampled;

performing one-dimensional Gaussian function fitting according to a coordinate set (xw, zw) composed of the x-coordinate set and the z-coordinate zw corresponding to each x-coordinate xw in the x-coordinate set to obtain a fitted first Gaussian function; and performing one-dimensional Gaussian function fitting according to a coordinate set (yp, zp) composed of the y-coordinate set and the z-coordinate zp corresponding to each y-coordinate yp in the y-coordinate set to obtain a fitted second Gaussian function; and

determining a first coordinate xt corresponding to a vertex of the first Gaussian function and a second coordinate yt corresponding to a vertex of the second Gaussian function, and determining xt and yt respectively as an x-coordinate and a y-coordinate of the positioning result, wherein xt is an x-coordinate within the x-coordinate range, and yt is a y-coordinate within the y-coordinate range.

9. The method according to claim 1, wherein positioning the transmitting device according to the preset direction and the signal measurement result comprises:

according to the preset direction and a position and height of the meta-surface, determining position coordinates (xi, yi) of the reflected beam corresponding to each preset direction in the target area, and determining a value of the signal measurement result corresponding to the preset direction as a z-coordinate zi corresponding to the position coordinates (xi, yi), wherein i is an identifier of the reflected beam corresponding to the preset direction;

performing two-dimensional Gaussian function fitting according to a coordinate set (xi, yi, zi) composed of the position coordinates (xi, yi) and the z-coordinate zi to obtain a fitted two-dimensional Gaussian function; and

determining coordinates (xt, yt) corresponding to a vertex of the two-dimensional Gaussian function, and determining the coordinates (xt, yt) as a positioning result of positioning the

transmitting device, wherein xt is an x-coordinate within an x-coordinate range of the target area, and yt is a y-coordinate within a y-coordinate range of the target area.

10. The method according to claim 1, wherein after determining the signal measurement result corresponding to the preset direction, and positioning the transmitting device according to the preset direction and the signal measurement result, the method further comprises:

determining target direction information according to a positioning result of positioning the transmitting device, wherein the target direction information is used for instructing the meta-surface control unit to control a reflection coefficient of each electromagnetic unit of the meta-surface according to the target direction information, so that the reflected beam formed on the meta-surface by a radio signal transmitted by the receiving device points to the transmitting device.

11. A positioning device for a transmitting device, comprising:

a determining module, configured to determine control information by a receiving device, wherein the control information comprises temporal information and control direction information; the control direction information is used for instructing a meta-surface control unit to adjust a reflection coefficient of a meta-surface to a target reflection coefficient corresponding to a preset direction, so that a beam in a direction from the receiving device to the meta-surface forms on the meta-surface a reflected beam in the preset direction; the preset direction is a direction indicated by preset direction information corresponding to a target time period, and the preset direction points to a target area; the temporal information comprises the target time period; and the control direction information comprises the preset direction information;

a transmitting module, configured to transmit a pilot signal to the meta-surface by a transmitting device, wherein the transmitting device is located in the target area;

a controlling module, configured to send the control information to the meta-surface control unit by the receiving device, wherein the control information is used for instructing the meta-surface control unit to adjust the reflection coefficient of the meta-surface to the target reflection coefficient corresponding to the preset direction within the target time period; and

a positioning module, configured to determine a signal measurement result corresponding to the preset direction, and position the transmitting device according to the preset direction and the signal measurement result, wherein the signal measurement result is a measurement result obtained by the receiving device measuring a received target pilot signal; the target pilot signal is received by the receiving device after reflected by the meta-surface whose reflection coefficient is adjusted to the target reflection coefficient; and the pilot signal transmitted by the transmitting device

comprises the target pilot signal.

12. A positioning system for a transmitting device, comprising: a transmitting device, a receiving device, a meta-surface control unit, a meta-surface and a positioning node;

the receiving device is configured to determine control information, wherein the control information comprises temporal information and control direction information; the control direction information is used for instructing a meta-surface control unit to adjust a reflection coefficient of a meta-surface to a target reflection coefficient corresponding to a preset direction, so that a beam in a direction from the receiving device to the meta-surface forms on the meta-surface a reflected beam in the preset direction; the preset direction is a direction indicated by preset direction information corresponding to a target time period, and the preset direction points to a target area; the temporal information comprises the target time period; and the control direction information comprises the preset direction information;

the transmitting device is configured to transmit a pilot signal to the meta-surface, wherein the transmitting device is located in the target area;

the receiving device is further configured to send the control information to the meta-surface control unit, wherein the control information is used for instructing the meta-surface control unit to adjust the reflection coefficient of the meta-surface to the target reflection coefficient corresponding to the preset direction within the target time period;

the receiving device is further configured to determine a signal measurement result corresponding to the preset direction; and

the positioning node is configured to position the transmitting device according to the preset direction and the signal measurement result, wherein the signal measurement result is a measurement result obtained by the receiving device measuring a received target pilot signal; the target pilot signal is received by the receiving device after reflected by the meta-surface whose reflection coefficient is adjusted to the target reflection coefficient; and the pilot signal transmitted by the transmitting device comprises the target pilot signal.

13. The system according to claim 12, wherein the receiving device is further configured to determine the control information according to a target area;

the receiving device is configured to determine the control information in a following manner:

determining multiple pieces of preset direction information according to multiple sub-areas obtained by dividing the target area, and determining multiple target time periods according to the

multiple pieces of preset direction information, wherein the multiple pieces of preset direction information are in one-to-one correspondence with the multiple sub-areas, the temporal information comprises the multiple target time periods, and the multiple target time periods are in one-to-one correspondence with the multiple pieces of preset direction information; or, determining multiple preset directions pointing to the target area, and determining each piece of preset direction information among multiple pieces of preset direction information as a respective one of the multiple preset directions, and determining multiple target time periods according to the multiple pieces of preset direction information, wherein the temporal information comprises the multiple target time periods, and the multiple target time periods are in one-to-one correspondence with the multiple pieces of preset direction information.

14. The system according to claim 12, wherein the meta-surface control unit is configured to:

determine the target reflection coefficient according to the preset direction information; and

adjust a reflection coefficient of each electromagnetic unit of the meta-surface to the target reflection coefficient within the target time period, so as to adjust the reflection coefficient of the meta-surface to the target reflection coefficient;

wherein the reflection coefficient of each electromagnetic unit comprises at least one of amplitude, phase and polarization.

15. The system according to claim 12, wherein the receiving device is further configured to:

determine the target time period corresponding to each signal measurement result in a signal measurement result set, wherein the signal measurement result set comprises the signal measurement result corresponding to the preset direction; and

according to the target time period, determine the preset direction indicated by the preset direction information corresponding to the target time period, and determine the signal measurement result corresponding to the target time period as the signal measurement result corresponding to the preset direction.

16. The system according to claim 12, wherein the positioning node is further configured to:

according to the preset direction and a position and height of the meta-surface, determine position coordinates (xi, yi) of the reflected beam corresponding to each preset direction in the target area, and determine a value of the signal measurement result corresponding to the preset direction as a z-coordinate zi corresponding to the position coordinates (xi, yi), wherein i is an identifier of the reflected beam corresponding to the preset direction; and

perform Gaussian function fitting according to a coordinate range of the target area, the position coordinates (xi, yi) and the corresponding z-coordinate zi to obtain a fitted Gaussian function, and determine a positioning result of positioning the transmitting device according to coordinates corresponding to a vertex of the fitted Gaussian function.

17. The system according to claim 16, wherein the positioning node is further configured to:

sample an x-coordinate range and a y-coordinate range of the target area respectively according to a preset coordinate interval to obtain an x-coordinate set and a y-coordinate set after sampling;

determine a z-coordinate zw corresponding to each x-coordinate xw in the x-coordinate set from the z-coordinate zi corresponding to the position coordinates (xi, yi), and determine a z-coordinate zp corresponding to each y-coordinate yp in the y-coordinate set from the z-coordinate zi corresponding to the position coordinates (xi, yi), wherein both the w and p are positive integers in an interval [1, n], and n is the number of samples sampled;

perform one-dimensional Gaussian function fitting according to a coordinate set (xw, zw) composed of the x-coordinate set and the z-coordinate zw corresponding to each x-coordinate xw in the x-coordinate set to obtain a fitted first Gaussian function; and perform one-dimensional Gaussian function fitting according to a coordinate set (yp, zp) composed of the y-coordinate set and the z-coordinate zp corresponding to each y-coordinate yp in the y-coordinate set to obtain a fitted second Gaussian function;

determine a first coordinate xt corresponding to a vertex of the first Gaussian function and a second coordinate yt corresponding to a vertex of the second Gaussian function, and determine xt and yt respectively as an x-coordinate and a y-coordinate of the positioning result, wherein xt is an x-coordinate within the x-coordinate range, and yt is a y-coordinate within the y-coordinate range.

18. The system according to claim 12, wherein the positioning node is further configured to:

according to the preset direction and a position and height of the meta-surface, determine position coordinates (xi, yi) of the reflected beam corresponding to each preset direction in the target area, and determine a value of the signal measurement result corresponding to the preset direction as a z-coordinate zi corresponding to the position coordinates (xi, yi), wherein i is an identifier of the reflected beam corresponding to the preset direction;

perform two-dimensional Gaussian function fitting according to a coordinate set (xi, yi, zi) composed of the position coordinates (xi, yi) and the z-coordinate zi to obtain a fitted

two-dimensional Gaussian function; and

determine coordinates (xt, yt) corresponding to a vertex of the two-dimensional Gaussian function, and determine the coordinates (xt, yt) as a positioning result of positioning the transmitting device, wherein xt is an x-coordinate within the x-coordinate range of the target area, and yt is a y-coordinate within the y-coordinate range of the target area.

19. A computer-readable storage medium, in which a computer program is stored, wherein the computer program is configured to execute, when running, the method according to any one of claims 1 to 10.

20. An electronic device, comprising a memory and a processor, wherein the memory stores a computer program, and the processor is configured to run the computer program, so as to perform the method according to any one of claims 1 to 10.