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Method for installing radio wave sensor, radio wave sensor, and adjustment device

Abstract

A method for installing a radio wave sensor configured to radiate a radio wave to a range including a target area that is set for detection of an object. The method includes: a step of installing a reference object; and a step of adjusting a radio wave radiation direction of the radio wave sensor, using the reference object as a reference. The reference object is installed at a first position outside the target area.

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Background/Summary

TECHNICAL FIELD
(1) The present disclosure relates to a method for installing a radio wave sensor, a radio wave sensor, and an adjustment device. This application claims priority on Japanese Patent Application No. 2019-223080 filed on Dec. 10, 2019, the entire content of which is incorporated herein by reference.
BACKGROUND ART
(2) PATENT LITERATURE 1 discloses a radio wave sensor that radiates a radio wave to a target area that is set so as to include a pedestrian crossing, and that detects an object. PATENT

LITERATURE 2 discloses measuring the direction of a reference object installed in a target area that is set so as to include a pedestrian crossing, thereby recognizing deviation of the orientation of a radio wave sensor.
CITATION LIST
Patent Literature
(3) PATENT LITERATURE 1: Japanese Laid-Open Patent Publication No. 2017-90138 PATENT LITERATURE 2: Japanese Laid-Open Patent Publication No. 2018-162977
SUMMARY OF THE INVENTION
(4) An aspect of the present disclosure is a method for installing a radio wave sensor. The method of the disclosure is for installing a radio wave sensor configured to radiate a radio wave to a range including a target area that is set for detection of an object. The method includes: a step of installing a reference object; and a step of adjusting a radio wave radiation direction of the radio wave sensor, using the reference object as a reference. The reference object is installed at a first position outside the target area.
(5) Another aspect of the present disclosure is a radio wave sensor. The radio wave sensor of the disclosure is configured to radiate a radio wave to a range including a target area that is set for detection of an object. The radio wave sensor includes a sighting device having a sighting direction that has an angle with respect to a radio wave radiation direction of the radio wave sensor. The sighting direction is a direction extending from the radio wave sensor toward a position outside the target area, when the radio wave radiation direction is directed to the target area.
(6) A radio wave sensor of the disclosure is configured to radiate a radio wave to an inside and an outside of a target area that is set for detection of an object. The radio wave sensor includes: a display configured to display a screen including a first image that indicates a radio wave reflection position of a reference object installed outside the target area and that is to be used for adjustment of a radio wave radiation direction of the radio wave sensor, and a second image indicating an adjustment direction; and a controller configured to execute an operation of setting the adjustment direction. The adjustment direction is a direction that has a first angle with respect to the radio wave radiation direction. The first angle is an angle identical to a second angle between a reference direction extending from the radio wave sensor toward the reference object and a target direction extending from the radio wave sensor toward a second position in the target area.
(7) Another aspect of the present disclosure is an adjustment device. The adjustment device of the disclosure is for a radio wave radiation direction of a radio wave sensor configured to radiate a radio wave to an inside and an outside of a target area that is set for detection of an object. The adjustment device includes: a display configured to display a screen including a first image that indicates a radio wave reflection position of a reference object installed outside the target area and that is to be used for adjustment of the radio wave radiation direction, and a second image indicating an adjustment direction; and a controller configured to execute an operation of setting the adjustment direction. The adjustment direction is a direction that has a first angle with respect to the radio wave radiation direction. The first angle is an angle identical to a second angle between a reference direction extending from the radio wave sensor toward the reference object and a target direction extending from the radio wave sensor toward a second position in the target area.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) FIG. **1** is a perspective view of a radio wave sensor.
(2) FIG. **2** is a hardware configuration diagram of the radio wave sensor.
(3) FIG. **3** is a flow chart showing a sensor installation procedure.
(4) FIG. **4** illustrates a target area, a reference object installation position, a base position in the

target area, and a radio wave sensor installation position.
(5) FIG. **5** shows a state in which a radio wave sensor before the orientation thereof is adjusted is mounted at the radio wave sensor installation position.
(6) FIG. **6** is a flow chart showing an orientation adjustment procedure of the radio wave sensor.
(7) FIG. **7** shows a screen displayed on a display of an adjustment device.
(8) FIG. **8** shows the radio wave sensor of which the orientation has been adjusted.
(9) FIG. **9** is a flow chart showing another example of the orientation adjustment procedure of the radio wave sensor.
(10) FIG. **10** is a perspective view showing another example of the radio wave sensor.
(11) FIG. **11** shows a state where the radio wave sensor before the orientation thereof is adjusted is mounted at the radio wave sensor installation position.
(12) FIG. **12** shows a state where the front face direction of the radio wave sensor is directed to a reference direction.
(13) FIG. **13** shows the radio wave sensor of which the orientation has been adjusted.

DETAILED DESCRIPTION

Description of Embodiment of the Present Disclosure

(14) When the radio wave radiation direction of a radio wave sensor is inaccurate, the original ability of the radio wave sensor is impaired. For example, when the radio wave radiation direction of a radio wave sensor is inaccurate, decrease of reflection intensity of the radio wave is caused. When the radio wave radiation direction of a radio wave sensor is inaccurate, there is also a case where a part of the target area is positioned outside the detectable range of the radio wave sensor.
(15) As described in PATENT LITERATURE 2, when a reference object is used, the radio wave radiation direction can be accurately directed to the target area. Therefore, use of a reference object is advantageous for adjustment of the radio wave radiation direction. However, there are cases where a reference object is difficult to be installed in the target area. For example, when a target area is to be set in a road for vehicle traveling, work of installing a reference object on the road is required. When a worker in charge of installing the reference object is to install the reference object on a road on which vehicles travel, it is necessary to close the road, and this causes difficulty in the work of installing the reference object.
(16) Therefore, even in a case where a target area of a radio wave sensor is set in a place that is not easy for the worker to enter, it is desired that the radio wave radiation direction of the radio wave sensor can be easily adjusted.
(17) (1) A method according to an embodiment is a method for installing a radio wave sensor configured to radiate a radio wave to a range including a target area that is set for detection of an object. The method for installing the radio wave sensor includes a step of installing a reference object; and a step of adjusting a radio wave radiation direction of the radio wave sensor, using the reference object as a reference. Here, the radio wave radiation direction denotes the direction in which a radio wave radiated with directivity advances. For example, when the face from which a radio wave is radiated in a radio wave sensor is defined as the front face of the radio wave sensor, the radio wave radiation direction corresponds to the front face direction of the radio wave sensor. The reference object is installed at a first position outside the target area. Since the reference object is installed outside the target area, there is no need for a worker to enter the target area in order to install the reference object. Therefore, even in a case where the target area is set in a place that is not easy for the worker to enter, installation of the reference object is easy. As a result, adjustment of the radio wave radiation direction of the radio wave sensor is facilitated.
(18) (2) Preferably, a first distance from the radio wave sensor to the first position is a distance identical to a second distance from the radio wave sensor to a second position in the target area. In this case, the distance from the radio wave sensor to the reference object is substantially the same as the distance from the radio wave sensor to the target area, whereby the position of the reference object becomes appropriate. The second position may be any position in the target area. However,

when a predetermined position (e.g., a base position described later) for determining the radio wave radiation direction of the radio wave sensor is present in the target area, the second position is preferably the predetermined position.
(19) (3) Preferably, the step of adjusting the radio wave radiation direction includes adjusting an elevation angle of the radio wave sensor on the basis of a radio wave reflection power from the reference object. In this case, the elevation angle of the radio wave sensor is made appropriate. When the first distance and the second distance are set to be identical with each other, the radio wave reflection power from an object in the target area is increased by adjusting the elevation angle of the radio wave sensor on the basis of the radio wave reflection power from the reference object outside the target area.
(20) (4) The step of adjusting the radio wave radiation direction can include aligning an adjustment direction having a first angle with respect to the radio wave radiation direction, with a reference direction extending from the radio wave sensor toward the reference object. Although depending on the directivity of the radio wave sensor, the radio wave radiation direction is, in general, the front face direction of the radio wave sensor. Preferably, the first angle is identical to a second angle between the reference direction and a target direction extending from the radio wave sensor toward the second position in the target area. In this case, when the adjustment direction is aligned with the reference direction, the radio wave radiation direction can be aligned with the target direction. Preferably, the first position is a position at which the radio wave sensor can detect the radio wave reflection position of the reference object when the adjustment direction is aligned with the reference direction.
(21) (5) Preferably, the step of adjusting the radio wave radiation direction further includes displaying, on a screen, a radio wave reflection position of the reference object and the adjustment direction. In this case, with reference to the screen, whether or not the radio wave reflection position and the adjustment direction match each other can be confirmed.
(22) (6) Preferably, the step of adjusting the radio wave radiation direction further includes outputting, performed by a device configured to calculate a difference between the adjustment direction and a direction of a radio wave reflection position of the reference object, information regarding the difference via a user interface. In this case, the difference can be easily understood. The output of the information regarding the difference may be a display on the screen, or may be a display of a lamp or an output of sound.
(23) (7) The aligning of the adjustment direction with the reference direction can include aligning a sight of a sighting device provided to the radio wave sensor, with the reference object. Preferably, the adjustment direction is identical to a sighting direction of the sighting device. In this case, when the sighting direction is directed to the reference object, the adjustment direction can be aligned with the reference direction.
(24) (8) The step of adjusting the radio wave radiation direction can include: aligning the radio wave radiation direction with the reference direction extending from the radio wave sensor toward the reference object; and rotating the radio wave radiation direction after having aligned the radio wave radiation direction with the reference direction, thereby aligning the radio wave radiation direction with the target direction extending from the radio wave sensor toward the second position. Preferably, a rotation angle when rotating the radio wave radiation direction has a magnitude that corresponds to an angle between the reference direction and the target direction. In this case as well, the radio wave radiation direction can be aligned with the target direction.
(25) (9) Preferably, the target area is set in a range including a lane for vehicle traveling. Preferably, the reference object is installed outside the lane in which the target area is set. In this case, there is no need for a worker to enter the lane in which the target area is set, in order to install the reference object. The “outside the lane” may be “outside the road”, or may be “in the road but in a range of a lane other than the lane in which the target area is set”.
(26) (10) Preferably, the target area is set in a range including a road for vehicle traveling.

Preferably, the reference object is installed outside the road. In this case, there is no need for the worker to enter the road on which vehicles travel, in order to install the reference object.
(27) (11) Preferably, the radio wave sensor is installed on one outer side out of both outer sides at left and right of the road. In this case, there is no need for the worker to enter the road in order to install the radio wave sensor. Preferably, the reference object is installed on the one outer side. In this case, since the reference object and the radio wave sensor are installed on the same side out of both outer sides at the left and right of the road, there is no need for the worker to cross the road.
(28) (12) A radio wave sensor according to the embodiment is used in order to radiate a radio wave to a range including a target area that is set for detection of an object. Preferably, the radio wave sensor includes a sighting device having a sighting direction that has an angle with respect to a radio wave radiation direction of the radio wave sensor. Preferably, the sighting direction is a direction extending from the radio wave sensor toward a position outside the target area, when the radio wave radiation direction is directed to the target area. In this case, the sight of the sighting device can be aligned with the reference object installed outside the target area. The sighting device can have one or a plurality of sighting directions. When the sighting device has a plurality of sighting directions, it is sufficient that at least one sighting direction is a direction toward the outside of the target area.
(29) (13) A radio wave sensor according to the embodiment is used in order to radiate a radio wave to an inside and an outside of a target area that is set for detection of an object. The radio wave sensor can include: a display configured to display a screen including a first image that indicates a radio wave reflection position of a reference object installed outside the target area and that is to be used for adjustment of a radio wave radiation direction of the radio wave sensor, and a second image indicating an adjustment direction; and a controller configured to execute an operation of setting the adjustment direction. Preferably, the adjustment direction is a direction that has a first angle with respect to the radio wave radiation direction. Preferably, the first angle is an angle identical to a second angle between a reference direction extending from the radio wave sensor toward the reference object and a target direction extending from the radio wave sensor toward a second position in the target area.
(30) (14) Preferably, the controller is configured to calculate a difference between the adjustment direction and a direction of the radio wave reflection position and to output the difference.
(31) (15) An adjustment device according to the embodiment is used for adjustment of a radio wave radiation direction of a radio wave sensor configured to radiate a radio wave to an inside and an outside of a target area that is set for detection of an object. The adjustment device can include: a display configured to display a screen including a first image that indicates a radio wave reflection position of a reference object installed outside the target area and that is to be used for adjustment of the radio wave radiation direction, and a second image indicating an adjustment direction; and a controller configured to execute an operation of setting the adjustment direction. Preferably, the adjustment direction is a direction that has a first angle with respect to the radio wave radiation direction. Preferably, the first angle is an angle identical to a second angle between a reference direction extending from the radio wave sensor toward the reference object and a target direction extending from the radio wave sensor toward a second position in the target area.
(32) (16) Preferably, the controller is configured to calculate a difference between the adjustment direction and a direction of the radio wave reflection position, and to output the difference.
(33) A computer program according to the embodiment includes commands for causing a computer to operate as the controller. The computer program is stored in a computer-readable non-transitory storage medium. The computer program is read and executed by a processor of the computer.
(34) According to the present disclosure, adjustment of the radio wave radiation direction of the radio wave sensor is facilitated.

Details of Embodiment of the Present Disclosure

(35) FIG. **1** and FIG. **2** each show a radio wave sensor **10** according to an embodiment. The radio

wave sensor **10** radiates a radio wave, and receives a reflected wave from an object, thereby detecting the object. The radio wave sensor **10** of the embodiment is a millimeter-wave radar. The radio wave sensor **10** of the embodiment is used in order to detect a vehicle traveling on a road. The detection result of the vehicle is used for traffic flow measurement or vehicle traveling support, for example.

(36) The radio wave sensor **10** includes a radio wave sensor body **20** covered by a housing **26**. In the housing **26**, a transmission antenna **21**, a reception antenna **22**, a transmission/reception circuit **23**, a signal processing circuit **24**, and an interface **25** are provided.

(37) The housing **26** has a front face **27** at which transmission/reception of a radio wave **600** is performed. In FIG. **1**, the front face **27** is present on the farther side of the housing **26**. The transmission antenna **21** is disposed inside the housing **26** so as to radiate the radio wave **600** in a direction (forward of the radio wave sensor **10**) D**12** orthogonal to the front face **27** of the housing **26**. Therefore, in the embodiment, the front face direction D**12** of the housing **26** is the radio wave radiation direction. The reception antenna **22** is disposed inside the housing **26** so as to receive a reflected wave at the front face **27**.

(38) The transmission antenna **21** includes a plurality of antenna elements **21**A, **21**B. In FIG. **2**, the number of antenna elements **21**A, **21**B forming the transmission antenna **21** is two, for example. The plurality of antenna elements **21**A, **21**B are arranged in the horizontal direction.

(39) A radio wave radiated from the transmission antenna **21** is reflected at an object. The reception antenna **22** receives a reflected wave from the object. The reception antenna **22** includes a plurality of antenna elements **22**A, **22**B, **22**C, **22**D. In FIG. **2**, the number of antenna elements **22**A, **22**B, **22**C, **22**D forming the reception antenna **22** is four, for example. The plurality of antenna elements **22**A, **22**B, **22**C, **22**D are arranged in the horizontal direction.

(40) The transmission antenna **21** and the reception antenna **22** are connected to the transmission/reception circuit **23**. The transmission/reception circuit **23** outputs, to the transmission antenna **21**, a signal that is radiated as a radio wave. The signal radiated as a radio wave is a frequency modulated continuous wave (FMCW), for example. The transmission/reception circuit **23** outputs, to the signal processing circuit **24**, a signal of the reflected wave received by the reception antenna **22**.

(41) The signal processing circuit **24** detects the distance to, and the direction, the speed, and the like of the object, from the reflected-wave signal. The detection result including the distance to, and the direction, the speed, and the like of the object can be outputted to the outside of the radio wave sensor body **20** via the interface **25**. The interface **25** is used for providing connection with an external device such as an adjustment device **30** described later.

(42) The radio wave sensor **10** according to the embodiment further includes the adjustment device **30**. The adjustment device **30** is used by being connected to the interface **25** of the radio wave sensor body **20**, when the radio wave sensor body **20** is to be installed. The adjustment device **30** is used in order to adjust the radio wave radiation direction by adjusting the orientation of the radio wave sensor body **20**. In order to adjust the orientation of the radio wave sensor body **20**, the adjustment device **30** receives the detection result of the object from the radio wave sensor body **20**. It should be noted that, after the radio wave sensor body **20** has been installed, the adjustment device **30** is disconnected from the radio wave sensor body **20**. The connection between the radio wave sensor body **20** and the adjustment device **30** may be wired connection using a cable **40**, or may be wireless connection.

(43) The adjustment device **30** is implemented by a computer that includes a processor **31** and a memory **32** connected to the processor **31**. The processor **31** operates as a controller regarding orientation adjustment of the radio wave sensor body **20**. The memory **32** has stored therein a computer program that includes commands for causing the processor **31** to execute an operation for orientation adjustment of the radio wave sensor body **20**. The processor **31** reads out the computer program from the memory **32** and executes the computer program, thereby operating as the

controller regarding the orientation adjustment of the radio wave sensor body **20**. The operation of the controller includes an operation of setting an adjustment direction D**11** (described later).
(44) The adjustment device **30** includes a display **33**. The display **33** displays a screen to be used for adjustment of the orientation of the radio wave sensor body **20**. The display content of the display **33** is controlled by the processor **31** functioning as the controller.
(45) The radio wave sensor body **20** includes a sighting device **45** to be used for adjustment of the orientation of the radio wave sensor body **20**. The sighting device **45** is used in order to visually align the orientation of the radio wave sensor body **20** with a predetermined sighting direction D**31**, D**32**, D**33**. The sighting device **45** shown in FIG. **1** includes a single rear sight **46**, and front sights **47**, **48**, **49**. The sighting device **45** shown in FIG. **1** includes the plurality of front sights **47**, **48**, **49** in order to obtain the plurality of sighting directions D**31**, D**32**, D**33**. The plurality of front sights **47**, **48**, **49** include a first front sight **47**, a second front sight **48**, and a third front sight **49**.
(46) When the rear sight **46** and the first front sight **47** are used, the sight can be visually set on the first sighting direction D**31**. When the rear sight **46** and the second front sight **48** are used, the sight can be set on the second sighting direction D**32**. When the rear sight **46** and the third front sight **49** are used, the sight can be set on the third sighting direction D**33**.
(47) The plurality of sighting directions D**31**, D**32**, D**33** are directions that are respectively different in, for example, a horizontal plane, and each have an angle with respect to the front face direction (radio wave radiation direction) D**12** of the radio wave sensor body **20**. Here, the horizontal plane is the XY plane shown in FIG. **1**. The Z direction in FIG. **1** is the vertical direction. In FIG. **1**, the angle (first angle θ**1**) of the first sighting direction D**31** with respect to the front face direction (radio wave radiation direction) D**12** is 10°. The angle (first angle θ**1**) of the second sighting direction D**32** with respect to the front face direction (radio wave radiation direction) D**12** is 20°. The angle (first angle θ**1**) of the third sighting direction D**33** with respect to the front face direction (radio wave radiation direction) D**12** is 30°. Here, the first angle θ**1** is an angle in the horizontal plane. All or at least one of the plurality of sighting directions D**31**, D**32**, D**33** is a direction toward a reference object **200** described later that is installed outside a target area **100** for object detection, when the front face direction (radio wave radiation direction) D**12** of the radio wave sensor **10** is directed to the target area **100**. More specifically, all or at least one of the plurality of sighting directions D**31**, D**32**, D**33** is a direction toward the reference object **200** installed outside the target area **100**, when the front face direction (radio wave radiation direction) D**12** of the radio wave sensor **10** is directed to a position P**2** described later. It should be noted that specific directions of the sighting directions D**31**, D**32**, D**33** are not limited in particular.
(48) In order to obtain a plurality of sighting directions, a plurality of rear sights and a single front sight may be used. In order to obtain a plurality of sighting directions, a mechanism that changes a sighting direction formed by a single rear sight and a single front sight may be used. As the mechanism that changes the sighting direction, a function that rotates a set of a rear sight and a front sight with respect to the housing **26** is adopted, for example.
(49) FIG. **3** shows an installation procedure of the radio wave sensor **10** (the radio wave sensor body **20**). First, in step S**11**, a target area **100** is set. The target area **100** is set on a road **300** on which a vehicle as a detection target object travels, for example (see FIG. **4**). The place and range in which the target area **100** is to be set are described in a specification document regarding installation of the radio wave sensor **10**, for example.
(50) When the target area **100** is to be set, the adjustment device **30** causes the display **33** to display a map of a region including the road **300** where the target area **100** is to be set. An operator of the adjustment device **30** performs, on the adjustment device **30**, an operation of specifying the target area **100** on the map. The adjustment device **30** receives the operation of specifying the target area **100**, and stores data regarding the target area **100** into the memory **32**.
(51) In the embodiment, the target area **100** is set in a range including the road **300** for vehicle traveling. The road **300** is a highway, for example. The road **300** includes one or a plurality of lanes

301, **302** for vehicle traveling. The target area **100** may be set in a range including all of the plurality of lanes **301**, **302**, or may be set only in a range including the lane **301** being a part of the plurality of lanes **301**, **302**. In FIG. **4**, the target area **100** is set in a range including one lane **301** only, out of the two lanes **301**, **302**.

(52) In step S**12**, an installation position P**3** of the radio wave sensor **10** is determined (see FIG. **4**). The installation position P**3** is set in the vicinity of the target area **100** such that an object in the target area **100** can be detected by the radio wave sensor **10**.

(53) The operator of the adjustment device **30** refers to the aforementioned map on which the target area **100** has been set, and performs, on the adjustment device **30**, an operation of specifying the installation position P**3** of the radio wave sensor **10**. The adjustment device **30** receives the operation of specifying the installation position P**3**, and stores data regarding the installation position P**3** into the memory **32**.

(54) In the embodiment, the installation position P**3** is set on an outer side **311**, **312** of the road **300**. More specifically, the radio wave sensor **10** is installed on the outer side **311**, which is one of both outer sides **311**, **312** at the left and right of the road **300**. Since the installation position P**3** of the radio wave sensor **10** is set on the outer side **311**, **312** of the road **300**, there is no need for a worker to enter the road **300** for installation work of the radio wave sensor **10**. In addition, there is no need to close the road **300** for the installation work of the radio wave sensor **10**.

(55) In step S**13**, a base position P**2** in the target area **100** is determined (see FIG. **4**). The base position P**2** is determined as an appropriate position in the target area **100**. The base position P**2** is a position to which the radio wave radiation direction (front face direction) D**12** of the radio wave sensor **10** is to be directed. The base position P**2** is set such that the entirety of the target area **100** is within the detectable range of the radio wave sensor **10**, for example. The base position P**2** is determined as a position at which the reflection power from the target area **100** becomes high as a whole of the target area **100**, on the basis of the directivity of the radio wave sensor **10** and the installation position P**3**, for example. The base position P**2** may be calculated by the adjustment device **30** on the basis of the directivity of the radio wave sensor **10** and the installation position P**3**, or may be determined and inputted by the operator to the adjustment device **30**. The adjustment device **30** stores data regarding the base position P**2** into the memory **32**.

(56) When the base position P**2** has been determined, a direction extending from the installation position P**3** toward the base position P**2** is naturally determined as a target direction (base direction) D**22**. The adjustment device **30** stores data regarding the target direction D**22** into the memory **32**. The target direction D**22** is the direction in which the radio wave radiation direction (front face direction) D**12** of the radio wave sensor **10** is to be directed.

(57) In step S**14**, an installation position P**1** of the reference object **200** is determined (see FIG. **4**). The reference object **200** is an object to serve as a reference for determining the orientation of the radio wave sensor **10**. The reference object **200** functions as a reflector that reflects the radio wave radiated from the radio wave sensor **10**, at the time of orientation adjustment of the radio wave sensor **10**. The reference object **200** functions as a target on which the sight is set by the sighting device **45**, at the time of orientation adjustment of the radio wave sensor **10**.

(58) In the embodiment, the installation position P**1** of the reference object **200** is set outside the target area **100**. In FIG. **4**, the installation position P**1** of the reference object **200** is set outside the target area **100** and outside the road **300**. Since the installation position P**1** of the reference object **200** is set outside the road **300** for vehicle traveling, there is no need for an installation worker of the reference object **200** to enter the road **300**. In addition, there is no need to close the road **300** for the installation work of the reference object **200**.

(59) In FIG. **4**, the installation position P**1** of the reference object **200** is set on the same side **311** as the installation position P**3** of the radio wave sensor **10**, out of both outer sides **311**, **312** at the left and right of the road **300**. Since the installation position P**1** of the reference object **200** and the installation position P**3** of the radio wave sensor **10** are set on the same side **311** out of both outer

sides **311**, **312** at the left and right of the road **300**, the worker can perform installation work of the reference object **200** and the radio wave sensor **10** only on the single side **311** of the road **300**. Therefore, there is no need for the worker to cross the road **300**.

(60) It should be noted that it is possible to install the radio wave sensor **10** on one outer side **311** of the road **300**, and to install the reference object **200** on the other outer side **312** of the road **300**. However, in this case, the worker needs to cross the road **300** in order to install the reference object **200** and the radio wave sensor **10**.

(61) The installation position P**1** of the reference object **200** may be inside the road **300** as long as the installation position P**1** is outside the target area **100**. For example, the installation position P**1** of the reference object **200** may be set on the lane **302** being outside the lane **301** where the target area **100** is set. In this case, if only the lane **302** is closed without closing the lane **301** where the target area **100** is set, the reference object **200** can be installed.

(62) Preferably, the installation position (first position) P**1** of the reference object **200** is set at a distance identical to the distance from the installation position P**3** of the radio wave sensor **10** to the base position (second position) P**2** in the target area **100**. That is, preferably, a distance L**1** from the position P**3** to the position P**1** is identical to a distance L**2** from the position P**3** to the position P**2**. When the distance L**1** and the distance L**2** are an identical distance, the elevation angle of the radio wave sensor **10** can be appropriately adjusted. This will be described later.

(63) The operator of the adjustment device **30** refers to the aforementioned map on which the target area **100**, the base position P**2** in the target area, and the radio wave sensor installation position P**3** have been set, and performs, on the adjustment device **30**, an operation of specifying the installation position P**1** of the reference object **200**. The adjustment device **30** receives the operation of specifying the installation position P**1**, and stores data regarding the installation position P**1** into the memory **32**. The data regarding the installation position P**1** includes data indicating the distance L**1**.

(64) The adjustment device **30** displays, on the display **33**, one or a plurality of candidates for the installation position P**1** of the reference object **200**. Each candidate for the installation position P**1** is displayed on the aforementioned map, for example. The candidate for the installation position P**1** may be indicated by a dot or by a line. The dot indicating the candidate for the installation position P**1** is indicated as one or a plurality of dots having a predetermined angle (e.g., 10°, 20°, or 30°) with respect to the direction D**22** from P**3** toward P**2**, on an arc **350** having a radius L**2** about the position P**3**, for example. A line indicating the candidate for the installation position P**1** is expressed as a circle or the arc **350** about the position P**3** and having the radius L**2**, for example.

(65) The operator of the adjustment device **30** refers to the one or plurality of candidates for the installation position P**1** that have been displayed on the map, and can determine the installation position P**1** of the reference object **200** in consideration of geographical features and the like.

(66) When the installation position P**1** has been determined, a direction extending from the installation position P**3** toward the installation position P**1** is determined as a reference direction (quasi-base direction) D**21**. The reference direction D**21** is a direction that has a predetermined angle (second angle) θ**2** with respect to the target direction D**22**. Here, the second angle θ**2** is an angle in the horizontal plane. On the basis of the operation of specifying the installation position P**1** performed by the operator, the adjustment device **30** obtains the reference direction D**21** and the second angle θ**2**, and stores data regarding the reference direction D**21** and the second angle θ**2** into the memory **32**.

(67) In step S**15**, the worker mounts the radio wave sensor **10** to a support **50** or the like provided at the installation position P**3** (see FIG. **5**). At this time point, the front face direction D**12** of the radio wave sensor **10** need not be directed to the target area **100**. As shown in FIG. **5**, the radio wave sensor **10** has a detectable range **500**. The detectable range **500** is a range in which an object can be detected by the radio wave sensor **10**. In step S**16**, the worker installs the reference object **200** at the installation position P**1** (see FIG. **5**). The operator of the adjustment device **30**, and the

installation worker of the radio wave sensor **10** and the reference object **200** may be different persons, or may be the same person.

(68) In the subsequent step S**17**, work of adjusting the orientation of the radio wave sensor **10** is performed, using the reference object **200** as a reference. FIG. **6** shows details of step S**17**. In the adjustment work shown in FIG. **6**, the sighting device **45** is not used. Adjustment work that uses the sighting device **45** will be described with reference to FIG. **9**.

(69) In the adjustment work shown in FIG. **6**, the orientation of the radio wave sensor **10** is adjusted by using the adjustment device **30** connected to the radio wave sensor body **20**. In step S**181** in FIG. **6**, the adjustment device **30** sets the adjustment direction D**11** (see FIG. **5**). The adjustment direction D**11** is a direction that has an angle (first angle) θ**1** with respect to the radio wave radiation direction D**12** of the radio wave sensor **10**. The first angle θ**1** is set to be an angle identical to the second angle θ**2**. The adjustment device **30** determines the adjustment direction D**11** on the basis of the radio wave radiation direction D**12** set in advance in the adjustment device **30** and the previously-obtained second angle θ**2**, and stores data regarding the adjustment direction D**11** into the memory **32**.

(70) The radio wave sensor body **20** installed at the installation position P**3** is set to be in a state of being capable of detecting an object by transmitting/receiving a radio wave. The detection result is obtained by the adjustment device **30** connected to the radio wave sensor body **20** (step S**182**), and is displayed on the display **33** (step S**183**). As shown in FIG. **7**, the adjustment device **30** outputs, on the display **33**, a mark (first image) **35** indicating a radio wave reflection position of the reference object **200**, a mark (second image) **37** indicating the adjustment direction D**11** having the first angle θ**1** with respect to the radio wave radiation direction, a mark (third image) **38**A indicating the radio wave radiation direction (front face direction) D**12**, and a mark (fourth image) **38**B indicating the radio wave sensor installation position P**3**. Since the reflection power from the reference object **200** is large, the adjustment device **30** can detect a position where a reflection power larger than a threshold can be obtained, as the radio wave reflection position of the reference object **200**. Alternatively, the adjustment device **30** may detect a position where a reflection power can be obtained in a range in which the distance from the radio wave sensor **10** is L**1**, as the radio wave reflection position of the reference object **200**. Since the reference object **200** is stationary, the adjustment device **30** may detect, as the radio wave reflection position, a position where a stationary object is present and where a reflection power can be obtained in a range in which the distance from the radio wave sensor **10** is L**1**.

(71) On the display **33**, a display **39**A indicating the difference (angle difference) between the adjustment direction D**11** and the direction of the radio wave reflection position of the reference object **200** is also outputted. Further, on the display **33**, a display **39**B indicating the reflection power from the reference object **200** is also outputted. The user interface for outputting information regarding the difference is not limited to a graphical user interface such as the display **33** that displays a screen, and may be an audio interface that outputs sound. The sound may be sound of a text indicating the difference, or may be sound that occurs periodically. Variation in the interval of the sound that periodically occurs can indicate the difference. The user interface that outputs sound may output sound having a magnitude that corresponds to the reflection power intensity. The user interface may be configured to indicate the difference in terms of variation in the flashing cycle of a lamp. The lamp may be configured to indicate the reflection power intensity in terms of light intensity. In this manner, the user interface outputs information regarding the difference, thereby facilitating understanding of the difference by the user.

(72) The user interface may output at least one of sound and light only when the difference has become zero or in a predetermined range near zero. The sound or light may be outputted in combination with output performed by the display **33**. For example, when output of difference in terms of sound or light is not sufficient, output by the display **33** may be used in combination.

(73) In FIG. **7**, the mark **37** indicating the adjustment direction D**11** is depicted as a line extending

along the adjustment direction D**11**, but may be depicted as a dot that is present on the adjustment direction D**11**. The mark **37** indicating the adjustment direction D**11** may be depicted as a region that is spread around a dot or a line indicating the adjustment direction.

(74) In step S**171** in FIG. **6**, the adjustment worker of the radio wave sensor **10** directs the orientation of the radio wave sensor **10** roughly to the target area **100**. Accordingly, the detectable range **500** is rotated, and the reference object **200** enters the detectable range **500**. As a result, the mark **35** indicating the radio wave reflection position of the reference object **200** is displayed on the display **33** (see FIG. **7**). In FIG. **7**, the direction of the mark **35** indicating the radio wave reflection position and the mark **37** indicating the adjustment direction D**11** are deviated from each other, and it is seen that there is a difference therebetween (NO in step S**172**). This difference is shown in terms of a numerical value in the display **39**A indicating the angle difference.

(75) The adjustment worker rotates the radio wave sensor **10** in the left or right direction such that the mark **35** indicating the radio wave reflection position of the reference object **200** matches the position of the mark **37** indicating the adjustment direction D**11**, thereby adjusting the orientation in the horizontal direction (step S**173**). The adjustment direction D**11** displayed on the display **33** is tilted by almost the first angle θ**1**, being an angle identical to the second angle θ**2**, with respect to the radio wave radiation direction D**12**. Therefore, when the radio wave reflection position (the reference direction D**21**) of the reference object **200** is aligned with the adjustment direction D**11**, the radio wave radiation direction D**12** can be aligned with the target direction D**22**.

(76) As shown in FIG. **8**, when the mark **35** indicating the radio wave reflection position (the reference direction D**21**) of the reference object **200** has matched the position of the mark **37** indicating the adjustment direction D**11** (YES in step S**172**), adjustment of the orientation in the horizontal direction is completed.

(77) Subsequently, the elevation angle of the radio wave sensor **10** is adjusted (steps S**174**, S**175**). Elevation angle adjustment of the radio wave sensor **10** is performed by the adjustment worker adjusting, with reference to the display **39**B indicating the reflection power, the elevation angle to an elevation angle at which the reflection power from the reference object **200** becomes highest. The vertical plane directivity of the radio wave sensor **10** is different between the radio wave radiation direction D**12** and the adjustment direction D**11**. However, the elevation angle at which the reflection power becomes largest is common between the radio wave radiation direction D**12** and the adjustment direction D**11**. Therefore, when the elevation angle is adjusted to an elevation angle at which the reflection power from the reference object **200** present in the adjustment direction D**11** becomes largest, the reflection power from an object in the radio wave radiation direction D**12** (the base position P**2**) becomes largest.

(78) According to the method for installing the radio wave sensor **10** shown in FIG. **3** to FIG. **8**, the installation work of the radio wave sensor including installation of the reference object **200** can be performed only on the outer side **311**, which is one side, of the road **300**. Therefore, there is no need to enter the road **300** or close the road **300**.

(79) FIG. **9** shows a procedure of adjustment work that uses the adjustment device **30** and the sighting device **45** provided to the radio wave sensor body **20**. In step S**181** in FIG. **9**, the orientation of the radio wave sensor **10** is visually adjusted by the worker by using the sighting device **45**. The sighting device **45** shown in FIG. **1** has three sighting directions D**31**, D**32**, D**33**. In orientation adjustment of the radio wave sensor **10**, a sighting direction D**31**, D**32**, D**33** that corresponds to the second angle θ**2** is selected. For example, when the second angle θ**2** is 10°, the first sighting direction D**31** having an angle (first angle θ**1**) of 10° with respect to the radio wave radiation direction D**12** is selected. In this case, the first sighting direction D**31** is the adjustment direction D**11**.

(80) Then, the worker adjusts the orientation of the radio wave sensor body **20** such that the first sighting direction D**31** being the adjustment direction D**11** is aligned with the direction (reference direction) D**21** of the reference object **200** installed at the installation position P**1**. Accordingly, the

radio wave radiation direction D**12** can be aligned with the target direction D**22**.
(81) Then, adjustment of the orientation of the radio wave sensor **10** may be completed. However, for fine adjustment of the orientation, step S**182** may be subsequently performed. In step S**182**, work from step S**171** to step S**175** shown in FIG. **6** is performed by using the adjustment device **30**. When the adjustment using the adjustment device **30** is performed after the adjustment using the sighting device **45** has been performed, accuracy of the orientation can be easily enhanced. That is, when the sighting device **45** is used, orientation adjustment that is generally accurate can be easily performed, and the error remaining in the orientation can be eliminated by using the adjustment device **30**.
(82) FIG. **10** to FIG. **13** show another example of the adjustment procedure of the orientation of the radio wave sensor **10**. In the adjustment procedure shown in FIG. **10** to FIG. **13**, the radio wave radiation direction (front face direction) D**12** is once directed to the reference object **200**, and then, the radio wave sensor **10** is rotated by a rotation angle of the second angle θ**2**. Accordingly, the radio wave radiation direction D**12** is aligned with the target direction D**22**. In the cases of the procedure shown in FIG. **10** to FIG. **13**, as shown in FIG. **10**, the sighting direction of the sighting device **45** is the same as the radio wave radiation direction (front face direction) D**12**.
(83) In the procedure shown in FIG. **10** to FIG. **13** as well, step S**11** to step S**16** in FIG. **3** are performed, whereby mounting of the radio wave sensor **10** (step S**15**) and installation of the reference object **200** (step S**16**) are performed. FIG. **11** shows a state where step S**15** and step S**16** have been completed.
(84) In the subsequent adjustment of the orientation of the radio wave sensor **10** (step S**17**), the worker aligns the radio wave radiation direction D**12** with the direction (the reference direction D**21**) of the reference object **200**. This work may be performed by using the sighting device **45** shown in FIG. **10**, or may be performed with reference to the display **33** of the adjustment device **30**.
(85) Here, the reference direction D**21** is a direction that has the second angle θ**2** (θ**2** is +10° clockwise about the position P**3**, for example) with respect to the target direction D**22**. That the reference direction D**21** is a direction that has the second angle θ**2** with respect to the target direction D**22** is known. Therefore, when the radio wave sensor **10** is rotated counterclockwise by a rotation angle of the second angle θ**2**, the radio wave radiation direction D**12** can be aligned with the target direction D**22** (see FIG. **13**). That is, the rotation angle (adjustment angle) when rotating the radio wave radiation direction of the radio wave sensor **10** in order to realize the state of FIG. **13** from the state of FIG. **12** is an angle that has a magnitude that corresponds to the second angle θ**2**.
(86) In the procedure shown in FIG. **10** to FIG. **13** as well, the orientation of the radio wave sensor **10** is adjusted, using the reference object **200** installed outside the target area **100** as a reference.
(87) The disclosed embodiment is illustrative in all aspects and should not be recognized as being restrictive. The scope of the present disclosure is defined by the scope of the claims rather than the above-described meaning, and is intended to include meaning equivalent to the scope of the claims and all modifications within the scope.
REFERENCE SIGNS LIST
(88) **10** radio wave sensor **20** radio wave sensor body **21** transmission antenna **21**A antenna element **21**B antenna element **22** reception antenna **22**A antenna element **22**B antenna element **22**C antenna element **22**D antenna element **23** transmission/reception circuit **24** signal processing circuit **25** interface **26** housing **27** front face **30** adjustment device **31** processor **32** memory **33** display **35** mark of radio wave reflection position of reference object **37** mark of adjustment direction **38**A mark of radio wave radiation direction **38**B mark of radio wave sensor installation position **39**A display of difference between adjustment direction and direction of radio wave reflection position **39**B display of reflection power **40** cable **45** sighting device **46** rear sight **47** first front sight **48** second front sight **49** third front sight **50** support **100** target area **200** reference object **300** road **301**

lane **302** lane **311** road outer side **312** road outer side **350** arc **500** detectable range **600** radio wave D**11** adjustment direction D**12** radio wave radiation direction D**21** reference direction D**22** target direction D**31** first sighting direction D**32** second sighting direction D**33** third sighting direction L**1** first distance L**2** second distance P**1** reference object installation position P**2** base position in target area P**3** radio wave sensor installation position θ**1** first angle θ**2** second angle

Claims

1. A method for installing a radio wave sensor configured to radiate a radio wave to a range including a target area that is set for detection of an object, the method comprising: a step of installing a reference object; and a step of adjusting a radio wave radiation direction of the radio wave sensor by rotating the radio wave sensor, using the reference object as a reference, wherein: the reference object is installed at a first position outside the target area, the step of adjusting the radio wave radiation direction includes aligning an adjustment direction having a first angle with respect to the radio wave radiation direction, with a reference direction extending from the radio wave sensor toward the reference object, and the first angle is identical to a second angle between the reference direction and a target direction extending from the radio wave sensor toward a second position in the target area, such that: the step of adjusting the radio wave radiation direction includes: aligning the radio wave radiation direction with the reference direction, and rotating the radio wave radiation direction after having aligned the radio wave radiation direction with the reference direction, thereby aligning the radio wave radiation direction with the target direction extending from the radio wave sensor toward the second position, wherein a rotation angle when rotating the radio wave radiation direction has a magnitude that corresponds to an angle between the reference direction and the target direction.
2. The method for installing the radio wave sensor according to claim 1, wherein a first distance from the radio wave sensor to the first position is a distance identical to a second distance from the radio wave sensor to a second position in the target area.
3. The method for installing the radio wave sensor according to claim 2, wherein the step of adjusting the radio wave radiation direction includes adjusting an elevation angle of the radio wave sensor on the basis of a radio wave reflection power from the reference object.
4. The method for installing the radio wave sensor according to claim 1, wherein the step of adjusting the radio wave radiation direction further includes displaying, on a screen, a radio wave reflection position of the reference object and the adjustment direction.
5. The method for installing the radio wave sensor according to claim 1, wherein the step of adjusting the radio wave radiation direction further includes outputting, performed by a device configured to calculate a difference between the adjustment direction and a direction of a radio wave reflection position of the reference object, information regarding the difference via a user interface.
6. The method for installing the radio wave sensor according to claim 1, wherein the aligning of the adjustment direction with the reference direction includes aligning a sight of a sighting device provided to the radio wave sensor, with the reference object, and the adjustment direction is identical to a sighting direction of the sighting device.
7. The method for installing the radio wave sensor according to claim 1, wherein the target area is set in a range including a lane for vehicle traveling, and the reference object is installed outside the lane in which the target area is set.
8. The method for installing the radio wave sensor according to claim 1, wherein the target area is set in a range including a road for vehicle traveling, and the reference object is installed outside the road.
9. The method for installing the radio wave sensor according to claim 8, wherein the radio wave sensor is installed on one outer side out of both outer sides at left and right of the road, and the

reference object is installed on the one outer side.

10. The radio wave sensor that is installed according to the method of claim 1, the radio wave sensor comprising: a housing of the radio wave sensor; a sighting device having a sighting direction that has an angle with respect to a radio wave radiation direction of the radio wave sensor, wherein the sighting direction is a direction extending from the radio wave sensor toward a position outside the target area, when the radio wave radiation direction is directed to the target area.

11. An adjustment device for adjusting a radio wave radiation direction of the radio wave sensor installed according to the method of claim 1, by rotating the radio wave sensor that is configured to radiate a radio wave to an inside and an outside of a target area that is set for detection of an object, the adjustment device comprising: a display configured to display a screen including a first image that indicates a radio wave reflection position of a reference object installed outside the target area and that is to be used for adjustment of the radio wave radiation direction, and a second image indicating an adjustment direction; and a controller configured to execute an operation of setting the adjustment direction, wherein: the adjustment direction is a direction that has a first angle with respect to the radio wave radiation direction, the first angle is an angle identical to a second angle between a reference direction extending from the radio wave sensor toward the reference object and a target direction extending from the radio wave sensor toward a second position in the target area, the second position is a position determined by an operator based on the target area, the reference direction is a direction determined by the operator based on an installation position for installing the radio wave sensor, the second position, and the second angle, and the adjusting of the radio wave radiation direction includes: aligning the radio wave radiation direction with the reference direction, and rotating the radio wave radiation direction after having aligned the radio wave radiation direction with the reference direction, thereby aligning the radio wave radiation direction with the target direction extending from the radio wave sensor toward the second position, wherein a rotation angle when rotating the radio wave radiation direction has a magnitude that corresponds to an angle between the reference direction and the target direction.

12. The adjustment device according to claim 11, wherein the controller is configured to calculate a difference between the adjustment direction and a direction of the radio wave reflection position, and to output information regarding the difference via a user interface.