

NAVIGATIONAL SIGN IDENTIFYING DEVICE, AUTONOMOUS
CRUISING SYSTEM, NAVIGATIONAL SIGN IDENTIFYING METHOD,
AND PROGRAM

5 TECHNICAL FIELD

[0001] The present disclosure relates to a navigational sign identifying device, an autonomous cruising system, a navigational sign identifying method, and a program.

10 BACKGROUND ART

[0002] Patent Document 1 discloses an automatic visual recognition device which automatically identifies navigational signs.

[Reference Document of Conventional Art]

[Patent Document]

15 [0003]

[Patent Document 1] JP-H04-076562B

DESCRIPTION OF THE DISCLOSURE

[Problem(s) to be Solved by the Disclosure]

20 [0004] Meanwhile, since buoys which float on the sea surface are smaller than ships, it is difficult to identify description of the sign of a buoy which is apart from a ship.

[0005] The present disclosure is made in view of the above-described problem, and a main purpose thereof is to provide a navigational sign
25 identifying device, an autonomous cruising system, a navigational sign

identifying method, and a program, which are capable of improving the accuracy of identifying description of a sign.

[Summary of the Disclosure]

[0006] In order to solve the above-described problem, a navigational sign
5 identifying device according to one aspect of the present disclosure includes a first acquirer, a first identifier, a second acquirer, and a second identifier. The first acquirer acquires a first image including a buoy from a camera installed in a ship. The first identifier identifies a position of the buoy inside the first image. The second acquirer acquires a second image corresponding to a
10 partial area of the first image including the position of the buoy. The second image is higher in resolution than the first image. The second identifier identifies description of a sign of the buoy based on the second image.

[0007] In the above-described aspect, the camera may have an optical zoom function. The second acquirer may cause the camera to magnify and image a
15 range corresponding to the partial area of the first image to acquire the second image.

[0008] In the above-described aspect, the camera may have a pan/tilt function. The second acquirer may direct an imaging direction of the camera toward the range corresponding to the partial area of the first image based on the position
20 of the buoy.

[0009] In the above-described aspect, the second acquirer may acquire the second image by increasing the resolution of the partial area of the first image.

[0010] In the above-described aspect, the second acquirer may acquire the second image by causing an auxiliary camera to image the range
25 corresponding to the partial area of the first image. The auxiliary camera is

higher in resolution than the camera.

[0011] In the above-described aspect, the first identifier may identify the position of the buoy inside the first image by using a first learned model. The second identifier may identify the description of the sign of the buoy
5 based on the second image by using a second learned model.

[0012] In the above-described aspect, the first learned model and the second learned model may be formed by incorporating a first learned parameter and a second learned parameter into a common inference program, respectively. The first learned parameter and the second learned parameter are different
10 from each other.

[0013] In the above-described aspect, the first identifier may further identify a classification of the buoy.

[0014] In the above-described aspect, when the classification of the buoy is a lateral sign, the second identifier may identify whether the description of the
15 sign of the buoy is either one of a port sign and a starboard sign.

[0015] In the above-described aspect, when the classification of the buoy is a directional sign, the second identifier may identify whether the description of the sign of the buoy is either one of a North sign, an East sign, a South sign, and a West sign.

20 [0016] In the above-described aspect, when the classification of the buoy is a lateral sign, the second identifier may identify whether the description of the sign of the buoy is either one of the port sign and the starboard sign, by using a learned model for lateral signs, and when the classification of the buoy is a directional sign, the second identifier may identify whether the description of
25 the sign of the buoy is either one of a North sign, an East sign, a South sign,

and a West sign, by using a learned model for directional signs.

[0017] In the above-described aspect, the second acquirer may not acquire the second image, when the classification of the buoy is any one of an isolated obstruction sign, a safe water area sign, and a special sign.

- 5 [0018] In the above-described aspect, when a plurality of buoys are identified from the first image, the second acquirer and the second identifier may perform the acquisition of the second image and the identification of the description of the sign for each of the plurality of buoys, respectively.

[0019] In the above-described aspect, the navigational sign identifying device
10 may further include a display controller which displays a symbol indicative of the description of the sign of the buoy in any one of the first image, an electronic nautical chart, and a radar image based on the description of the sign of the buoy, the position of the buoy inside the first image, and an imaging direction of the camera.

- 15 [0020] In the above-described aspect, the navigational sign identifying device may further include a consistency determinator which determines consistency of the description of the sign of the buoy with description of the sign indicated by navigational sign data recorded on an electronic nautical chart, based on the description of the sign of the buoy, the position of the buoy inside the first
20 image, an imaging direction of the camera, and a position of the ship.

[0021] In the above-described aspect, the navigational sign identifying device may further include a display controller which displays a determination result of the consistency in any one of the first image, the electronic nautical chart, and a radar image.

- 25 [0022] Further, an autonomous cruising system according to another aspect of

the present disclosure may include the navigational sign identifying device described above and a route calculator. The route calculator calculates one of a route of the ship and a width of the route based on the position of the buoy inside the first image and an imaging direction of the camera, when the
5 description of signs of a plurality of buoys includes at least two of a port sign, a starboard sign, and a safe water area sign.

[0023] Further, an autonomous cruising system according to another aspect of the present disclosure may include the navigational sign identifying device described above, a virtual sign acquirer, and a route calculator. The virtual
10 sign acquirer acquires data indicative of a position of a virtual sign and description of the virtual sign. The route calculator calculates one of a route of the ship and a width of the route based on the description of the sign of the buoy, the position of the virtual sign, and the description of the virtual sign.

[0024] Further, an autonomous cruising system according to another aspect of
15 the present disclosure may include the navigational sign identifying device described above, a position detector, and a route calculator. The position detector detects a position of the ship. The route calculator sets a course-changing point through which the ship is to pass, based on the description of the sign of the buoy, the position of the buoy inside the first
20 image, an imaging direction of the camera, and the position of the ship.

[0025] Further, an autonomous cruising system according to another aspect of the present disclosure may include the navigational sign identifying device described above, a direction detector, and a route calculator. The direction
detector detects a heading of the ship. The route calculator sets a direction in
25 which the ship is to travel, based on the description of the sign of the buoy, an

imaging direction of the camera, and the heading of the ship.

[0026] In the above-described aspect, the autonomous cruising system may further include an autopilot which performs an autonomous navigation control based on the description of the sign of the buoy.

- 5 [0027] Further, a method of identifying a navigational sign according to another aspect of the present disclosure includes acquiring a first image including a buoy from a camera installed in a ship, identifying a position of the buoy inside the first image, acquiring a second image corresponding to a partial area of the first image including the position of the buoy, the second
10 image being higher in resolution than the first image, and identifying description of a sign of the buoy based on the second image.

- [0028] Further, a program according to another aspect of the present disclosure causes a computer to perform processing which includes acquiring a first image including a buoy from a camera installed in a ship, identifying a
15 position of the buoy inside the first image, acquiring a second image corresponding to a partial area of the first image including the position of the buoy, the second image being higher in resolution than the first image, and identifying description of a sign of the buoy based on the second image.

[Effect of the Disclosure]

- 20 [0029] According to the present disclosure, it becomes possible to improve the accuracy of identifying the description of the sign.

BRIEF DESCRIPTION OF DRAWINGS

[0030]

- 25 Fig. 1 is a block diagram illustrating one example of a configuration of

an autonomous cruising system.

Fig. 2 is a view illustrating description of signs of a buoy.

Fig. 3 is a block diagram illustrating one example of a functional configuration of a navigational sign identifying device.

5 Fig. 4 is a view illustrating one example of a first image.

Fig. 5 is a view illustrating one example of identification by a first identifier.

Fig. 6 is a view illustrating one example of a second image.

Fig. 7 is a flowchart illustrating an example procedure of a
10 navigational sign identifying method.

Fig. 8 is a flowchart illustrating an example procedure of a sign description identification processing.

Fig. 9 is a view illustrating one example of a buoy management database.

15 Fig. 10 is a view illustrating one example of indication by a display unit.

Fig. 11 is a view illustrating another example of indication by the display unit.

Fig. 12 is a block diagram illustrating another example of the
20 configuration of the navigational sign identifying device.

Fig. 13 is a block diagram illustrating still another example of the configuration of the navigational sign identifying device.

Fig. 14 is a block diagram illustrating one example of a configuration of a second identifier according to a first modification.

25 Fig. 15 is a flowchart illustrating an example procedure of a

port-starboard sign identification processing.

Fig. 16 is a view illustrating one example of a by-country port-starboard mode table.

Fig. 17 is a block diagram illustrating one example of a configuration
5 of a second identifier according to a second modification.

Fig. 18 is a flowchart illustrating an example procedure of the sign description identification processing.

Fig. 19 is a view illustrating lighting patterns etc. of the buoy.

10 MODES FOR CARRYING OUT THE DISCLOSURE

[0031] Hereinafter, one embodiment of the present disclosure is described with reference to the drawings.

[0032] Fig. 1 is a block diagram illustrating one example of a configuration of an autonomous cruising system 100. The autonomous cruising system 100
15 may be an ICT system mounted on a ship. Below, a ship on which the autonomous cruising system 100 is mounted is referred to as "the ship."

[0033] The autonomous cruising system 100 may include a navigational sign identifying device 1, a camera 2, a radar 3, an AIS 4, a radio communicator 5, a display unit 6, a GNSS receiver 7, a gyrocompass 8, an ECDIS 9, and an
20 autopilot 10. These apparatuses may be connected to a network N, such as a LAN, so that mutual network communications are possible.

[0034] The navigational sign identifying device 1 may be a computer including a CPU, a RAM, a ROM, a nonvolatile memory, and an input/output interface. The CPU of the navigational sign identifying device 1 may
25 perform information processing according to a program loaded to the RAM

from the ROM or the nonvolatile memory.

[0035] The program may be supplied, for example, via an information storage medium, such as an optical disc or a memory card, or may be supplied, for example, via a communication network, such as the Internet or LAN.

- 5 [0036] The camera 2 may be a digital camera which images outside of the ship to generate image data. The camera 2 may be installed, for example, in a bridge of the ship so as to be oriented to the bow direction of the ship (heading). The camera 2 may be a visible light camera which can image at least a visible range. It may be capable of imaging not only the visible range
10 but also an infrared range.

[0037] In this embodiment, the camera 2 may be a camera having a pan/tilt function and an optical zoom function (so-called "PTZ camera"). The camera 2 may perform pan, tilt, or zoom operation according to a command from the navigational sign identifying device 1.

- 15 [0038] The radar 3 may transmit a radio wave around the ship, receive a reflection wave thereof, and generate echo data based on the reception signal. Further, the radar 3 may discriminate or identify a target object from the echo data, and generate Target-object Tracking data (TT data) indicative of a position and a speed of the target object.

- 20 [0039] The AIS (Automatic Identification System) 4 may receive AIS data from other ships or land controls which exist around the ship. Without being limited to the AIS, a VDES (VHF Data Exchange System) may also be used. The AIS data may include a position and a speed of another ship.

- [0040] The AIS 4 may acquire AIS data indicative of a position and
25 description of a sign of a virtual sign. The AIS 4 is one example of a virtual

sign acquirer. The virtual sign using the AIS is a so-called "virtual AIS navigational sign."

[0041] The radio communicator 5 may include various radio apparatuses for realizing communications with other ships or land controls, such as radio
5 apparatuses of an ultrashort wave band, an intermediate wave band, and a shortwave band.

[0042] The display unit 6 may be a display device, for example, with a touch sensor (so-called "touch panel"). The display unit may be a liquid crystal display or an organic electroluminescence display. Without being limited to
10 the touch sensor, other pointing devices, such as a trackball or a mouse may also be used.

[0043] On the display unit 6, an image captured by the camera 2, a radar image generated by the radar 3, an electronic nautical chart, or a synthetic image in which the radar image is synthesized with the electronic nautical
15 chart may be displayed.

[0044] The GNSS receiver 7 may detect the position of the ship (ship position based on the radio wave received from a GNSS (Global Navigation Satellite System)). The GNSS receiver 7 is one example of a position detector which detects the ship position.

20 [0045] The gyrocompass 8 may detect the heading (bow direction) of the ship. The gyrocompass 8 is one example of a direction detector which detects the heading of the ship. Without being limited to the gyrocompass, other types of direction meters, such as a GPS compass, may also be used.

[0046] The ECDIS (Electronic Chart The display and Information System) 9
25 may acquire the ship position from the GNSS receiver 7, and display the ship

position on the electronic nautical chart. Further, the ECDIS 9 may also display a scheduled route of the ship on the electronic nautical chart. Without being limited to the ECDIS, a GNSS plotter may also be used.

[0047] The autopilot 10 may calculate a target rudder angle for turning the
5 bow toward a target course based on the target course acquired from the navigational sign identifying device 1 etc. and the heading acquired from the gyrocompass 8, and drive a steering mechanism so as to bring a rudder angle of the steering mechanism closer to the target rudder angle. Further, the autopilot 10 may also control an engine.

10 [0048] Although in this embodiment the navigational sign identifying device 1 is an independent device, it may be integrated with another device, such as the ECDIS 9. That is, the function of the navigational sign identifying device 1 may be realized by another device, such as the ECDIS 10.

[0049] Further, although in this embodiment the display unit 2 is also an
15 independent device, without being limited to this configuration, a display unit provided to another device, such as the ECDIS 9, may also be used as the display unit 2 which displays the image generated by the navigational sign identifying device 1.

[0050] Fig. 2 is a view illustrating the description of the signs of a buoy.
20 The buoy may be a navigational sign which floats on the sea surface. The classification and the description of the sign of the buoy may be classified according to the color of the buoy, the shape of a top mark, etc.

[0051] The classification of the buoy may include a lateral sign, a directional sign, an isolated obstruction sign, a safe water area sign, and a special sign.
25 The description of the sign of the lateral sign may include a port sign and a

starboard sign. The port and starboard may indicate left and right when going to a water source. The description of the sign of the directional sign may include a North sign, an East sign, a South sign, and a West sign.

[0052] As for the isolated obstruction sign, the safe water area sign, and the
5 special sign, the description of these signs may not be subdivided any more, that is, it can be said that the classification of the buoy itself indicates the description of the sign.

[0053] Meanwhile, since the buoy which floats on the sea surface is smaller
10 than a ship, it is difficult to identify the description of the sign of the buoy which is apart from the ship. Thus, in this embodiment, the accuracy of identifying the description of the sign is improved by acquiring an image stepwise as will be described below.

[0054] Fig. 3 is a block diagram illustrating one example of a functional
15 configuration of the navigational sign identifying device 1 according to one embodiment. The navigational sign identifying device 1 may include a first acquirer 11, a first identifier 12, a second acquirer 13, a second identifier 14, a display controller 15, a route calculator 16, and a consistency determinator 18.

[0055] These function parts may be realized by the CPU of the navigational
20 sign identifying device 1 performing information processing according to a program. Note that some function parts of the display controller 15 or the route calculator 16 may be realized by a computer which is different from the navigational sign identifying device 1 and included in the ECDIS 9 or the autopilot 10.

[0056] Further, the navigational sign identifying device 1 may be provided
25 with a model memory 17 which stores a learned model. This memory may

be provided to the nonvolatile memory of the navigational sign identifying device 1. Without being limited to this configuration, the model memory 17 may be provided outside the navigational sign identifying device 1.

[0057] The first acquirer 11 may acquire a first image generated by the camera 2. In detail, the first acquirer 11 may sequentially acquire a plurality of time-series first images generated by the camera 2, and may sequentially provide them to the first identifier 12.

[0058] The first image may be an image captured when the camera 2 is in a normal state. The normal state may be a state in which, for example, the magnification of optical zoom is the minimum, and the imaging direction is in the heading direction. The camera 2 may repeat the generation of the first image in the normal state, except for a period when it is controlled by the second acquirer 13.

[0059] For example, the plurality of time-series first images may be a plurality of still images (frames) included in a video, or may be a plurality of still images individually generated by imaging at a given interval.

[0060] Fig. 4 is a view illustrating one example of a first image P1 acquired by the first acquirer 11. This drawing illustrates one example in which the first image P1 includes a port sign LL and a starboard sign LR which float on the sea surface ahead of the ship, in addition to a ship body (hull) SP of the ship.

[0061] The first identifier 12 may identify a position of the buoy inside the first image P1. In detail, the first identifier 12 may identify the position of the buoy inside the first image P1 by using a first learned model stored in the model memory 17. The first identifier 12 may further identify the

classification of this buoy, along with the position of the buoy inside the first image P1.

[0062] The first learned model may be generated by machine learning which uses an image for learning (learning image) as input data, and uses a label of the buoy inside the learning image (or a label of the classification of the buoy) and a position of the buoy as teacher data. The first learned model generated in this way may estimate the label of the buoy inside the first image P1 (or the label of the classification of the buoy), the position of the buoy, and probability of the buoy. The position of the buoy may be expressed, for example, by coordinates of a boundary box which surrounds the buoy.

[0063] As the first learned model, an object detection model, such as an SSD (Single Shot MultiBox Detector), a YOLO (You Only Look Once), or a Mask R-CNN may be used. Without being limited to this configuration, an area division model, such as a Semantic Segmentation or an Instance Segmentation, or a characteristic point detection model, such as a Keypoint Detection may be used as the first learned model.

[0064] Fig. 5 is a view illustrating one example of identification of the first image P1 by the first identifier 12. This drawing illustrates one example in which each of the port sign LL and the starboard sign LR is identified as a buoy (or a lateral buoy), and is surrounded by a boundary box BB.

[0065] The second acquirer 13 may acquire a second image which corresponds to a partial area of the first image P1 including the position of the buoy and which is higher in resolution than the first image P1. The partial area may be the boundary box BB (see Fig. 5) identified by the first identifier 12, for example.

[0066] The camera 2 may include a lens part 21 which realizes the optical zoom function, and a pan/tilt mechanism 22 which realizes the pan/tilt function, and the second acquirer 13 may acquire the second image by controlling the lens part 21 and the pan/tilt mechanism 22 of the camera 2.

5 [0067] In detail, the second acquirer 13 may acquire the second image by controlling the lens part 21 so that the camera 2 magnifies a range of the real space corresponding to the partial area of the first image P1 and images the range. Thus, by utilizing the optical zoom function, the second image which is higher in resolution than the first image P1 may be acquired.

10 [0068] Further, the second acquirer 13 may control the pan/tilt mechanism 22 so that the imaging direction of the camera 2 is turned to an area of the real space corresponding to the partial area of the first image P1. The second acquirer 13 may set a target value of the imaging direction of the camera 2 according to the position of the buoy inside the first image P1 identified by the
15 first identifier 12.

[0069] Fig. 6 is a view illustrating one example of the second image P2 acquired by the second acquirer 13. This drawing illustrates one example in which the port sign LL is included in the second image P2. In the second image P2, it may be easier to identify the color of the port sign LL and the
20 shape of a top mark TM than in the first image P1 (see Fig. 4).

[0070] Note that, as illustrated in Fig. 5, when a plurality of buoys (in the illustrated example, the port sign LL and the starboard sign LR) are identified inside the first image P1, the second acquirer 13 may cause the camera 2 to sequentially image each of the plurality of buoys to acquire the second image
25 P2 for each of the plurality of buoys.

[0071] The second identifier 14 may identify the description of the sign of the buoy based on the second image P2. In detail, the second identifier 14 may identify the description of the sign of the buoy based on the second image P2 by using a second learned model stored in the model memory 17.

5 [0072] The second learned model may be generated by machine learning in which the learning image is used as input data, and the label of the description of the sign of the buoy inside the learning image is used as teacher data. The second learned model thus generated may estimate the label of the description of the sign of the buoy inside the second image P2, and the probability thereof.

10 [0073] As the second learned model, for example, a model similar to the above-described first learned model may be used. In this case, the first learned model and the second learned model may be models in which a first learned parameter and a second learned parameter, which are different from each other, are incorporated into a common inference program.

15 [0074] Without being limited to this configuration, the second learned model may be an object identification model which identifies an object but does not detect the position of the object.

[0075] Further, the second learned model may include a learned model for lateral signs which is specialized in identification of the description of the sign
20 of the lateral sign, and a learned model for directional signs which is specialized in identification of the description of the sign of the directional sign.

[0076] Figs. 7 and 8 are flowcharts illustrating an example procedure of a navigational sign identifying method realized by the navigational sign
25 identifying device 1. These drawings mainly illustrate processing related to

the acquisition of the image and the identification of the description of the sign among the processings performed by the navigational sign identifying device 1.

[0077] The CPU of the navigational sign identifying device 1 may function as
5 the first acquirer 11, the first identifier 12, the second acquirer 13, and the second identifier 14 by performing information processing illustrated in these drawings according to the program.

[0078] As illustrated in Fig. 7, first, the navigational sign identifying device 1 may acquire the first image P1 (see Fig. 4) from the camera 2 (S11: processing
10 as the first acquirer 11).

[0079] Next, the navigational sign identifying device 1 may identify the position and the classification of the buoy inside the first image P1 by using the first learned model (S12: processing as the first identifier 12).

[0080] Next, the navigational sign identifying device 1 may determine
15 whether the classification of the buoy identified in the first image P1 is a lateral buoy or a direction buoy (S13).

[0081] If the classification of the buoy is a lateral buoy or a direction buoy (S13→YES), the navigational sign identifying device 1 may control the camera 2 to acquire the second image P2 (see Fig. 6) which is obtained by
20 magnifying and imaging the buoy (S14: processing as the second acquirer 13).

[0082] Next, the navigational sign identifying device 1 may perform a sign description identification processing for identifying the description of the sign of the buoy based on the second image P2 (S15: processing as the second identifier 14).

25 [0083] As illustrated in Fig. 8, at the sign description identification processing

S15, if the classification of the buoy is a lateral buoy (S21→lateral buoy), the navigational sign identifying device 1 may identify whether the description of the sign is either one of the port sign and the starboard sign, by using the learned model for lateral signs as the second learned model (S22).

- 5 [0084] On the other hand, if the classification of the buoy is a direction buoy (S21→direction buoy), the navigational sign identifying device 1 may identify whether the description of the sign is either one of the North sign, the East sign, the South sign, and the West sign, by using the learned model for directional signs as the second learned model (S23).
- 10 [0085] Note that, if the classification of the buoy is not a lateral buoy or a direction buoy (S13→NO) (i.e., if the classification of the buoy is the isolated obstruction sign, the safe water area sign, or the special sign), the navigational sign identifying device 1 may not acquire the second image P2. It is because the classification itself indicates the description of the sign for these buoys.
- 15 [0086] If a plurality of buoys are identified inside the first image P1 at S12, the navigational sign identifying device 1 may perform S13-S15 for all the identified buoys (S16). That is, it may perform the acquisition of the second image P2 and the identification of the description of the sign for all the buoys which are the lateral buoys or the direction buoys.
- 20 [0087] According to the above embodiment, since the description of the sign is identified from the second image P2 which is magnified and imaged based on the position of the buoy identified in the first image P1 and which is higher in resolution than the first image P1, it becomes possible to improve the accuracy of identifying the description of the sign.
- 25 [0088] Further, according to this embodiment, since the description of the

sign is identified from the second image P2 after the classification of the buoy is identified in the first image P1, it can narrow down the description of the sign according to the classification of the buoy, and it becomes possible to further improve the accuracy of identifying the description of the sign.

- 5 [0089] Without being limited to this configuration, the buoy and its position may be identified from the first image P1, and the classification of the buoy and the description of the sign may be identified from the second image P2.

[0090] Fig. 9 is a view illustrating one example of a buoy management DB (database). The buoy management DB may be a database for managing the
10 information on the buoy which is identified or acquired, and may be provided to the nonvolatile memory of the navigational sign identifying device 1. The buoy management DB may include not only the information on the buoy identified from the image of the camera 2 but also the information on the virtual sign acquired by the AIS 4.

- 15 [0091] The buoy management DB may include fields, such as "identifier," "classification," "description of sign," "position in image," "actual position," and "virtual buoy." The "identifier" may be an identifier for identifying the buoy. The "virtual buoy" may indicate whether it is a virtual buoy.

[0092] The "classification" may indicate the classification of the buoy. The
20 "description of sign" may indicate the description of the sign of the buoy. If the "classification" is a lateral sign or a directional sign, the port sign etc. or the North sign etc. may be inputted into the "description of sign." On the other hand, if the "classification" is the isolated obstruction sign, the safe water area sign, or the special sign, data may not be inputted into the
25 "description of sign."

[0093] The "position in image" may indicate the position of the buoy inside the first image P1 (see Fig. 4). Note that, in the case of the virtual buoy, data may not be inputted into the "position in image." The "actual position" may indicate the actual position of the buoy. The actual position of the buoy
5 identified from the image of the camera 2 may be calculated based on the position of the buoy inside the image and the imaging direction of the camera 2.

[0094] Returning to description of Fig. 3, the display controller 15 may generate display data related to the buoy, and output it to the display unit 6.
10 In detail, the display controller 15 may display a symbol indicative of the description of the sign of the buoy in the first image P1, the electronic nautical chart, or the radar image based on the description of the sign of the identified buoy, the position of the buoy inside the first image P1, and the imaging direction of the camera 2.

15 [0095] For example, as illustrated in Fig. 10, the display controller 15 may display on the display unit 6 an image with symbols ML and MR indicative of the description of the port sign LL and the starboard sign LR inside the first image P1, which are associated with the positions of the port sign LL and the starboard sign LR. Each of the symbols ML and MR may include a character
20 string indicative of the description of the sign, for example.

[0096] Further, as illustrated in Fig. 11, the display controller 15 may display on the display unit 6 an image with symbols TL and TR indicative of the description of the port sign LL and the starboard sign LR inside a synthesized image CP in which the electronic nautical chart is synthesized with the radar
25 image, which are associated with the positions corresponding to the actual

positions of the port sign LL and the starboard sign LR. Each of the symbols TL and TR may have a shape indicative of the description of the sign, for example.

[0097] In the synthesized image CP, a symbol SF of the ship, a scheduled
5 route RT of the ship, a course-changing point DF on the scheduled route RT, a symbol EL of another ship, etc. may be displayed.

[0098] Further, symbols VL and VR indicative of the description of the virtual signs may be displayed in the synthesized image CP. The symbols VL and VR may have similar shapes to the symbols TL and TR. Preferably, the
10 symbols VL and VR may be displayed so that they are discriminable from the symbols TL and TR, for example, by changing their transparencies.

[0099] The route calculator 16 may calculate a target course (i.e., the bearing, the course-changing point, and the route) for performing the autonomous navigation control based on the description of the sign of the identified buoy.
15 The calculated target course may be provided to the autopilot 10 which performs the autonomous navigation control. Here, an incorrect recognition of the identified description of the navigational sign may become a cause of a serious accident when performing the autonomous navigation control. Therefore, the autonomous cruising system which fits for the real environment
20 navigation can be realized by performing the autonomous navigation control with the identification of the description of the navigational sign which is improved in the accuracy by the present disclosure.

[0100] As illustrated in Fig. 5, when the buoy identified inside the first image P1 includes the port sign LL and the starboard sign LR, the route calculator 16
25 may calculate a scheduled route or route width of the ship based on the

positions of the port sign LL and the starboard sign LR inside the first image P1, and the imaging direction of the camera 2. In detail, the route calculator 16 may set the scheduled route RT of the ship based on the actual positions of the port sign LL and the starboard sign LR which are calculated from the positions of the port sign LL and the starboard sign LR inside the first image P1, and the imaging direction of the camera 2 so that the scheduled route RT passes through between the port sign LL and the starboard sign LR from the ship position (see Fig. 11). Without being limited to this configuration, when the buoy identified inside the first image P1 includes the port sign LL or the starboard sign LR, and the safe water area sign, the route calculator 16 may set the scheduled route RT of the ship between the port sign LL or the starboard sign LR, and the safe water area sign.

[0101] Further, the route calculator 16 may calculate a distance between the port sign LL and the starboard sign LR as a route width W based on the actual positions of the port sign LL and the starboard sign LR which are calculated from the positions of the port sign LL and the starboard sign LR inside the first image P1, and the imaging direction of the camera 2. The calculated route width W may be displayed in the first image P1 displayed on the display unit 6, or may be displayed in the synthesized image CP in which the electronic nautical chart is synthesized with the radar image (see Fig. 11).

[0102] The route calculator 16 may set the course-changing point through which the ship goes, based on the description of the sign of the identified buoy, the position of the buoy inside the first image P1, the imaging direction of the camera 2, and the ship position. In detail, the route calculator 16 may set one or more course-changing point DF for setting the scheduled route RT of the

ship which arrives at a port or leaves the port based on the description of the lateral sign and the sign of the direction buoy which are identified, the actual positions of these buoys which are calculated from the positions of these buoys in the first image P1 and the imaging direction of the camera 2, and the ship position (see Fig. 11). Without being limited to this configuration, the route calculator 16 may set one or more course-changing points for setting an evading route which avoids an obstacle or a special area based on the description of the identified isolated obstruction sign or special sign, the actual positions of these buoys calculated from the positions of these buoys in the first image P1, the imaging direction of the camera 2, and the ship position.

[0103] The route calculator 16 may set the direction in which the ship is to travel based on the description of the sign of the identified buoy, the imaging direction of the camera 2, and the heading of the ship. For example, the route calculator 16 may maintain or adjust the direction in which the ship is to travel so that the buoy, such as the lateral buoy, continues being included in the plurality of time-series first images P1. Further, the route calculator 16 may set the direction in which the ship is to travel by further using the position of the buoy inside the first image P1 so that the ship goes between the port sign and the starboard sign, or goes in the direction along the plurality of port signs or starboard signs.

[0104] The route calculator 16 may calculate the target course for performing the autonomous navigation control (i.e., the direction, the course-changing point, and the route) based on, in addition to the description of the sign of the identified buoy, the position and the description of the virtual sign. In detail, when the data of the virtual port sign VL and the virtual starboard sign VR are

acquired, the route calculator 16 may set the scheduled route RT of the ship so that the ship passes through not only between the port sign LL and the starboard sign LR which are identified inside the first image P1 but also between the virtual port sign VL and the virtual starboard sign VR.

5 [0105] The consistency determinator 18 may determine the consistency (matching) of the description of the sign of the buoy with the description of the sign which is indicated by the navigational sign data recorded on the electronic nautical chart based on the description of the sign of the identified buoy, the position of the buoy inside the first image P1, the imaging direction
10 of the camera 2, and the ship position. In detail, the consistency determinator 18 may calculate the actual position of the buoy based on the position of the buoy inside the first image P1, the imaging direction of the camera 2, and the ship position, and extract the navigational sign data corresponding to the actual position of the buoy from the navigational sign data recorded on the
15 electronic nautical chart, and determine whether the description of the sign of the identified buoy matches with the description of the sign of the extracted navigational sign data.

[0106] The display controller 15 may display the determination result by the consistency determinator 18 in the first image P1, the electronic nautical chart,
20 or the radar image. For example, the display controller 15 may display it so that a symbol indicative of "match" or "not match" is associated with the buoy in the first image P1 (see Fig. 10) or the synthesized image CP (see Fig. 11) which are displayed on the display unit 6. Alternatively, the display controller 15 may display the symbol indicative of the description of the sign
25 (the symbols ML and MR of Fig. 10, or the symbols TL and TR of Fig. 11),

for the buoy which is matched.

[0107] The configuration of the navigational sign identifying device 1 is not limited to the example illustrated in Fig. 3. For example, as illustrated in Fig. 12, the second acquirer 13A may be an image processor which acquires the
 5 second image by increasing the resolution of the partial area of the first image. Thus, by increasing the resolution, the second image which is higher in the resolution than the first image may be acquired.

[0108] Without being limited to this configuration, the first acquirer 11 may acquire the first image by thinning or averaging the original images generated
 10 by the camera 2, and the second acquirer 13 may acquire the second image by cutting out an area corresponding to the partial area of the first image from the original image. The second image which is higher in resolution than the first image may be acquired also by this configuration.

[0109] Further, as illustrated in Fig. 13, the second acquirer 13B may be a
 15 camera controller which acquires the second image by causing an auxiliary camera 3 which is higher in resolution than the camera 2 to image an area of the real space corresponding to the partial area of the first image. Thus, by utilizing the auxiliary camera 3, the second image which is higher in resolution than the first image may be acquired.

20 [0110] The auxiliary camera 3 may include, similarly to the camera 2 illustrated in Fig. 3, a lens part 31 which realizes the optical zoom function, and a pan/tilt mechanism 32 which realizes the pan/tilt function. The lens part 31 of the auxiliary camera 3 may be higher in magnification than the lens part 21 of the camera 2.

[First Modification]

[0111] Below, a first modification is described. For the configuration and the processing which overlap with the above embodiment, detailed description may be omitted by assigning the same reference character.

- 5 [0112] The interpretation of the lateral buoy may be opposite between the port sign and the starboard sign depending on the country. Thus, in this modification, the port sign and the starboard sign may be identified or discriminated without depending on the ship positioning, as described below.

[0113] Fig. 14 is a block diagram illustrating one example of a configuration
10 of a second identifier 14A according to the first modification. This drawing mainly illustrates a function part for identifying the description of the sign of the lateral buoy, among function parts realized by the second identifier 14A.

[0114] The second identifier 14A may include a color identifier 31, a shape identifier 32, a country determinator 33, and a port-starboard determinator 34.

- 15 The color identifier 31 and the shape identifier 32 are examples of a mode identifier.

[0115] When the classification of the buoy identified by the first identifier 12 (classification identifier) illustrated in Fig. 3 is a lateral buoy, the function part of the second identifier 14A may identify the description of the sign of the
20 lateral buoy included in the second image P2 (see Fig. 6).

[0116] Fig. 15 is a flowchart illustrating an example procedure of a port-starboard sign identification processing S22 according to the first modification, which is realized by the second identifier 14A. The navigational sign identifying device 1 may perform the information processing
25 illustrated in this drawing according to the program.

[0117] The navigational sign identification processing S22 may correspond to S22 illustrated in Fig. 8. That is, the navigational sign identifying device 1 may perform the port-starboard sign identification processing S22, when the classification of the buoy identified at S12 illustrated in Fig. 7 is a lateral buoy.

5 [0118] First, the navigational sign identifying device 1 may identify whether the color of the lateral buoy included in the second image P2 is either green or red (S31: processing as the color identifier 31). Green and red are examples of a first mode and a second mode.

[0119] Next, the navigational sign identifying device 1 may identify whether
10 the top mark of the lateral buoy included in the second image P2 is either a cylinder shape or a cone shape (S32: processing as the shape identifier 32). The cylinder shape and the cone shape are examples of the first mode and the second mode.

[0120] The identification of the color and the identification of the shape of the
15 top mark may be performed using the learned model, similarly to the above embodiment. For example, the learned model which identifies both the color and the shape of the top mark may be used, or the learned model which identifies the color and the learned model which identifies the shape of the top mark may be used separately.

20 [0121] Next, the navigational sign identifying device 1 may determine the country to which the detected position of the ship detected by the GNSS receiver 7 (see Fig. 1) belongs (S33: processing as the country determinator 33). For example, the navigational sign identifying device 1 may determine which country's territorial water the coordinates of the detected position of the
25 ship are included based on the nautical chart data.

[0122] Next, the navigational sign identifying device 1 may refer to a by-country port-starboard mode table and determine whether the description of the sign of the lateral buoy is either the port sign or the starboard sign based on the color identified at S31, the shape of the top mark identified at S32, and
5 the country determined at S33 (S34: processing as the port-starboard determinator 34).

[0123] Fig. 16 is a view illustrating one example of the by-country port-starboard mode table. The by-country port-starboard mode table may be a table indicative of a correspondence relationship between the mode of the
10 buoy and the description of the sign, and may be provided to the nonvolatile memory of the navigational sign identifying device 1.

[0124] In detail, the by-country port-starboard mode table may indicate whether green or red in the color of the lateral buoy corresponds to either one of the port sign and the starboard sign in each country. Further, the
15 by-country port-starboard mode table may indicate whether the cylinder shape or the cone shape of the top mark corresponds to either one of the port sign and the starboard sign in each country.

[0125] According to the first modification described above, it becomes possible to discriminate or identify the port sign and the starboard sign based
20 on the description of the sign of the lateral buoy, without depending on the ship position.

[Second Modification]

[0126] Hereinafter, a second modification is described. For the
25 configuration and the processing which overlap with the above embodiment,

detailed description may be omitted by assigning the same reference character.

[0127] The classification of the buoy and the description of the sign may be identifiable or discriminable based on the elements, such as the color of the buoy, the shape of the top mark, and the lighting pattern. However, when
5 directly identifying or discriminating the description of the sign based on the image, the contribution of each element may not be known, and therefore, the identification or discrimination accuracy may not be sufficient. Thus, in this modification, the accuracy of identifying the description of the sign is improved, as described below.

10 [0128] Fig. 17 is a block diagram illustrating one example of a configuration of a second identifier 14B according to the second modification. The second identifier 14B may include a color identifier 41, a first candidate determinator 42, a shape identifier 43, a second candidate determinator 44, a lighting pattern identifier 45, a third candidate determinator 46, and a sign description
15 determinator 47.

[0129] Fig. 18 is a flowchart illustrating an example procedure of a sign description identification processing S15 according to the second modification, which is realized by the second identifier 14B. The navigational sign identifying device 1 may perform the information processing illustrated in this
20 drawing according to the program. The sign description identification processing S15 may correspond to S15 illustrated in Fig. 7.

[0130] Fig. 19 is a view illustrating the color, the shape of the top mark, and the lighting pattern corresponding to the description of the sign of the buoy. The description of the sign of the buoy may be classified according to the
25 color of the buoy, the shape of the top mark, and the lighting pattern. The

lighting pattern may be a temporal pattern of turning on and off of light.

[0131] As illustrated in Fig. 18, the navigational sign identifying device 1 may first identify a color candidate of the buoy included in the second image P2 (S41: processing as the color identifier 41). In detail, the navigational sign identifying device 1 may identify the color candidate of the buoy in the second image P2 by using the learned model. Further, the navigational sign identifying device 1 may calculate a first probability indicative of the probability of the color candidate, along with the color candidate.

[0132] Next, the navigational sign identifying device 1 may determine a first candidate of the description of the sign of the buoy corresponding to the identified color candidate (S42: processing as the first candidate determinator 42). In detail, the navigational sign identifying device 1 may determine the description of the sign corresponding to the color candidate as the first candidate, while referring to the table indicative of the correspondence relationship between the color and the description of the sign.

[0133] Next, the navigational sign identifying device 1 may identify a shape candidate of the top mark of the buoy included in the second image P2 (S43: processing as the shape identifier 43). In detail, the navigational sign identifying device 1 may identify the shape candidate of the top mark of the buoy in the second image P2 by using the learned model. Further, the navigational sign identifying device 1 may calculate a second probability which indicates the probability of the shape candidate, along with the shape candidate.

[0134] Next, the navigational sign identifying device 1 may determine a second candidate of the description of the sign of the buoy corresponding to

the identified shape candidate (S44: processing as the second candidate determinator 44). In detail, the navigational sign identifying device 1 may determine the description of the sign corresponding to the shape candidate as the second candidate, while referring to the table indicative of the correspondence relationship between the shape and the description of the sign.

[0135] Next, the navigational sign identifying device 1 may identify a lighting pattern candidate of the buoy from the plurality of time-series second images P2 (S45: processing as lighting pattern identifier 45). The navigational sign identifying device 1 may identify the lighting pattern candidate of the buoy according to a given rule.

[0136] In detail, the navigational sign identifying device 1 may extract the temporal pattern of turning on and off of the light of the buoy from the plurality of time-series second images P2, and select a standard temporal pattern which is most similar to the extracted temporal pattern from a plurality of standard temporal patterns stored beforehand, as the lighting pattern candidate. The standard temporal pattern may be created based on the lighting pattern of the description of the sign (see Fig. 19).

[0137] Further, the navigational sign identifying device 1 may calculate a third probability indicative of the probability of the lighting pattern candidate, along with the lighting pattern candidate. In detail, the navigational sign identifying device 1 may calculate the similarity of the extracted temporal pattern to the standard temporal pattern which is the lighting pattern candidate, as the third probability.

[0138] Next, the navigational sign identifying device 1 may determine a third candidate of the description of the sign of the buoy corresponding to the

identified lighting pattern candidate (S46: processing as the third candidate determinator 46). In detail, the navigational sign identifying device 1 may determine the description of the sign corresponding to the standard temporal pattern which is the lighting pattern candidate, as the third candidate.

5 [0139] Next, the navigational sign identifying device 1 may determine whether the present time is either daytime or night (S47), and if it is daytime, it may apply a criteria for daytime (S48), and if it is night, it may apply a criteria for night (S49). The present time may be a time at which the image is generated by the camera 2. The criteria may be for determining the
10 description of the sign of the buoy.

[0140] Next, the navigational sign identifying device 1 may determine the description of the sign of the buoy based on the first candidate of the description of the sign determined at S42, the second candidate of the description of the sign determined at S44, and the third candidate of the
15 description of the sign determined at S46 (S50: processing as the sign description determinator 47).

[0141] In detail, if at least two of the first candidate, the second candidate, and the third candidate are the same description of the sign, the navigational sign identifying device 1 may determine the same description of the sign as
20 the description of the sign of the buoy. For example, if two of the first candidate, the second candidate, and the third candidate are the port signs, and the remaining one is the starboard sign, the port sign may be determined as the description of the sign.

[0142] Further, the navigational sign identifying device 1 may determine the
25 description of the sign of the buoy based on the first probability, the second

probability, and the third probability. For example, a candidate corresponding to the highest probability among the first probability, the second probability, and the third probability may be determined as the description of the sign. Further, when the plurality of candidates indicate the same description of the sign, the probability corresponding to them may be added up.

[0143] The navigational sign identifying device 1 may use different weights, which are given to the first probability, the second probability, and the third probability daytime, respectively, between the criteria for daytime and the criteria for night. For example, it may give priority to a candidate according to the color of the buoy and the shape of the top mark which are easily visible in a bright environment during daytime, and give priority to a candidate according to the lighting pattern of the buoy which is easily visible also in a dark environment during night.

[0144] That is, in the criteria for daytime, the weights of the first and second probabilities according to the color of the buoy and the shape of the top mark may be made higher than the weight of the third probability according to the lighting pattern of the buoy. On the contrary, in the criteria for night, the weight of the third probability according to the lighting pattern of the buoy may be made higher than the weights of the first and second probabilities according to the color of the buoy and the shape of the top mark.

[0145] Note that the technique for determining the description of the sign according to this modification may be applied not only to the lateral sign and the directional sign but also to the isolated obstruction sign, the safe water area sign, and the special sign.

[0146] Although the embodiment of the present disclosure is described above, the present disclosure is not limited to the above embodiment, and it is needless to say that various changes are possible for the person skilled in the art.

5

DESCRIPTION OF REFERENCE CHARACTERS

[0147] 1 Navigational Sign Identifying Device, 2 Camera, 3 Radar, 4 AIS, 5 Radio Communicator, 6 Display Unit, 7 GNSS Receiver, 8 Gyrocompass, 9 ECDIS, 10 Autopilot, 11 First Acquirer, 12 First Identifier, 13 Second Acquirer, 14 Second Identifier, 15 Display Controller, 16 Route Calculator, 17 Model Memory, 21 Lens Part, 22 Pan/Tilt Mechanism, 31 Color Identifier, 32 Shape Identifier, 33 Country Determinator, 34 Port-starboard Determinator, 41 Color Identifiers, 42 First Candidate Determinator, 43 Shape Identifier, 44 Second Candidate Determinator, 45 Lighting Pattern Identifier, 46 Third Candidate Determinator, 47 Sign Description Determinator, 100 Autonomous Cruising System

CLAIMS

1. A navigational sign identifying device, comprising:
 - a first acquirer configured to acquire a first image including a buoy
 - 5 from a camera installed in a ship;
 - a first identifier configured to identify a position of the buoy inside the first image;
 - a second acquirer configured to acquire a second image corresponding to a partial area of the first image including the position of the buoy, the
 - 10 second image being higher in resolution than the first image; and
 - a second identifier configured to identify description of a sign of the buoy based on the second image.
2. The navigational sign identifying device of claim 1, wherein
- 15 the camera has an optical zoom function, and
 - wherein the second acquirer causes the camera to magnify and image a range corresponding to the partial area of the first image to acquire the second image.
- 20 3. The navigational sign identifying device of claim 2, wherein the camera has a pan/tilt function, and
 - wherein the second acquirer directs an imaging direction of the camera toward the range corresponding to the partial area of the first image based on the position of the buoy.

4. The navigational sign identifying device of claim 1, wherein the second acquirer acquires the second image by increasing the resolution of the partial area of the first image.

5 5. The navigational sign identifying device of claim 1, wherein the second acquirer acquires the second image by causing an auxiliary camera to image the range corresponding to the partial area of the first image, the auxiliary camera being higher in resolution than the camera.

10 6. The navigational sign identifying device of any one of claims 1 to 5, wherein the first identifier identifies the position of the buoy inside the first image by using a first learned model, and

wherein the second identifier identifies the description of the sign of the buoy based on the second image by using a second learned model.

15

7. The navigational sign identifying device of claim 6, wherein the first learned model and the second learned model are formed by incorporating a first learned parameter and a second learned parameter into a common inference program, respectively, the first learned parameter and the
20 second learned parameter being different from each other.

8. The navigational sign identifying device of any one of claims 1 to 7, wherein the first identifier further identifies a classification of the buoy.

25 9. The navigational sign identifying device of claim 8, wherein,

when the classification of the buoy is a lateral sign, the second identifier identifies whether the description of the sign of the buoy is either one of a port sign and a starboard sign.

5 10. The navigational sign identifying device of claim 8 or 9, wherein, when the classification of the buoy is a directional sign, the second identifier identifies whether the description of the sign of the buoy is either one of a North sign, an East sign, a South sign, and a West sign.

10 11. The navigational sign identifying device of any one of claims 8 to 10, wherein, when the classification of the buoy is a lateral sign, the second identifier identifies whether the description of the sign of the buoy is either one of the port sign and the starboard sign, by using a learned model for lateral signs, and when the classification of the buoy is a directional sign, the
15 second identifier identifies whether the description of the sign of the buoy is either one of a North sign, an East sign, a South sign, and a West sign, by using a learned model for directional signs.

 12. The navigational sign identifying device of any one of claims
20 8 to 11, wherein the second acquirer does not acquire the second image, when the classification of the buoy is any one of an isolated obstruction sign, a safe water area sign, and a special sign.

 13. The navigational sign identifying device of any one of claims
25 1 to 12, wherein, when a plurality of buoys are identified from the first image,

the second acquirer and the second identifier perform the acquisition of the second image and the identification of the description of the sign for each of the plurality of buoys, respectively.

5 14. The navigational sign identifying device of any one of claims 1 to 13, further comprising a display controller configured to display a symbol indicative of the description of the sign of the buoy in any one of the first image, an electronic nautical chart, and a radar image based on the description of the sign of the buoy, the position of the buoy inside the first image, and an
10 imaging direction of the camera.

 15. The navigational sign identifying device of any one of claims 1 to 14, further comprising a consistency determinator configured to determine consistency of the description of the sign of the buoy with description of the
15 sign indicated by navigational sign data recorded on an electronic nautical chart, based on the description of the sign of the buoy, the position of the buoy inside the first image, an imaging direction of the camera, and a position of the ship.

20 16. The navigational sign identifying device of claim 15, further comprising a display controller configured to display a determination result of the consistency in any one of the first image, the electronic nautical chart, and a radar image.

25 17. An autonomous cruising system, comprising:

the navigational sign identifying device of any one of claims 1 to 16;
and

a route calculator configured to calculate one of a route of the ship and
a width of the route based on the position of the buoy inside the first image
5 and an imaging direction of the camera, when the description of signs of a
plurality of buoys includes at least two of a port sign, a starboard sign, and a
safe water area sign.

18. An autonomous cruising system, comprising:
10 the navigational sign identifying device of any one of claims 1 to 16;
a virtual sign acquirer configured to acquire data indicative of a
position of a virtual sign and description of the virtual sign; and
a route calculator configured to calculate one of a route of the ship and
a width of the route based on the description of the sign of the buoy, the
15 position of the virtual sign, and the description of the virtual sign.

19. An autonomous cruising system, comprising:
the navigational sign identifying device of any one of claims 1 to 16;
a position detector configured to detect a position of the ship; and
20 a route calculator configured to set a course-changing point through
which the ship is to pass, based on the description of the sign of the buoy, the
position of the buoy inside the first image, an imaging direction of the camera,
and the position of the ship.

25 20. An autonomous cruising system, comprising:

the navigational sign identifying device of any one of claims 1 to 16;
a direction detector configured to detect a heading of the ship; and
a route calculator configured to set a direction in which the ship is to
travel, based on the description of the sign of the buoy, an imaging direction of
5 the camera, and the heading of the ship.

21. The autonomous cruising system of any one of claims 17 to 20,
further comprising an autopilot configured to perform an autonomous
navigation control based on the description of the sign of the buoy.
10

22. A method of identifying a navigational sign, comprising the
steps of:
acquiring a first image including a buoy from a camera installed in a
ship;
15 identifying a position of the buoy inside the first image;
acquiring a second image corresponding to a partial area of the first
image including the position of the buoy, the second image being higher in
resolution than the first image; and
identifying description of a sign of the buoy based on the second
20 image.

23. A program configured to cause a computer to perform
processing, the processing comprising:
acquiring a first image including a buoy from a camera installed in a
25 ship;

- identifying a position of the buoy inside the first image;
 - acquiring a second image corresponding to a partial area of the first image including the position of the buoy, the second image being higher in resolution than the first image; and
- 5 identifying description of a sign of the buoy based on the second image.