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(54) **NOTIFICATION CONTROL DEVICE, NOTIFICATION CONTROL METHOD, AND STORAGE MEDIUM**

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B60W 40/105 (2006.01)

(52) **U.S. Cl.**

CPC ***B60W 50/14*** (2013.01); ***B60W 30/0956*** (2013.01); ***B60W 40/09*** (2013.01); ***B60W 40/105*** (2013.01); *B60W 2050/0083* (2013.01)

(57) **ABSTRACT**

A notification control device performs: detecting a sightline of a driver; causing an information output device to output a first warning when a first condition is satisfied; and causing the information output device to output a second warning when a second condition is satisfied. The first condition is a condition that the driver's sight line is out of a predetermined range in which the driver is considered to see a view in front of the mobile object and a state in which the sightline is out of the range is maintained for a first time. The second condition is a condition that the driver's sightline is out of the range, a risky object to be noticed is present in a reference area, and the state in which the sightline is out of the range is maintained for a second time shorter than the first time.

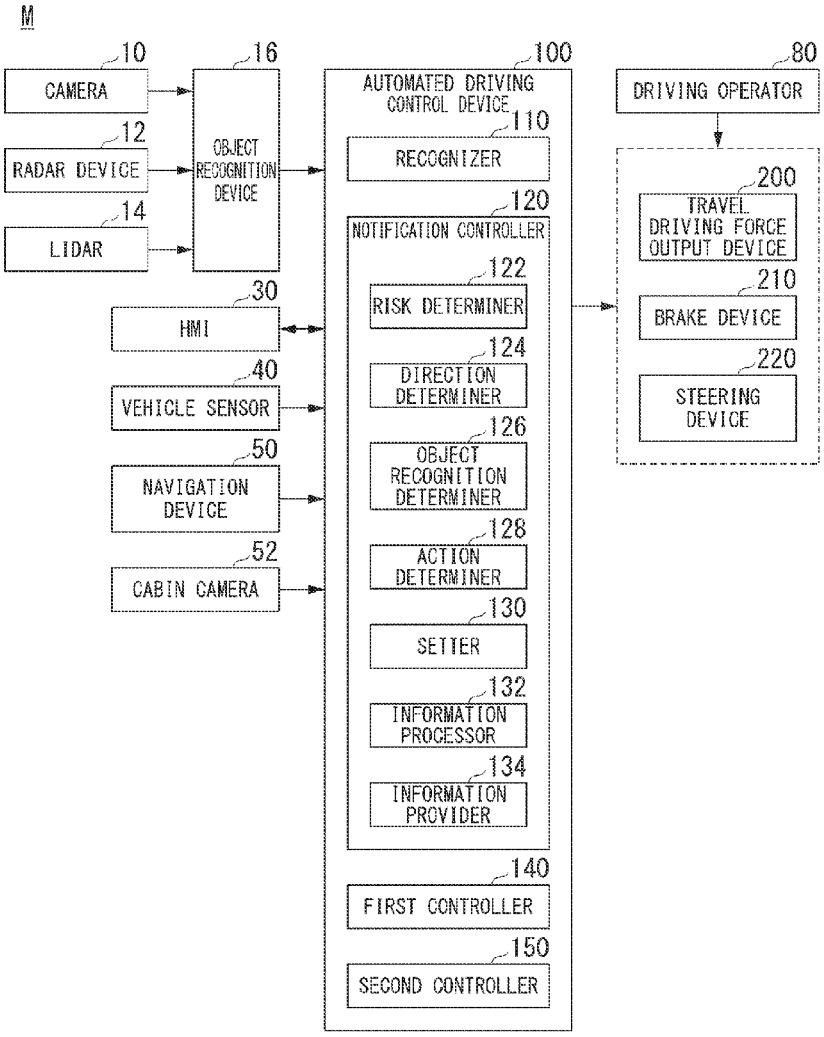


FIG. 1

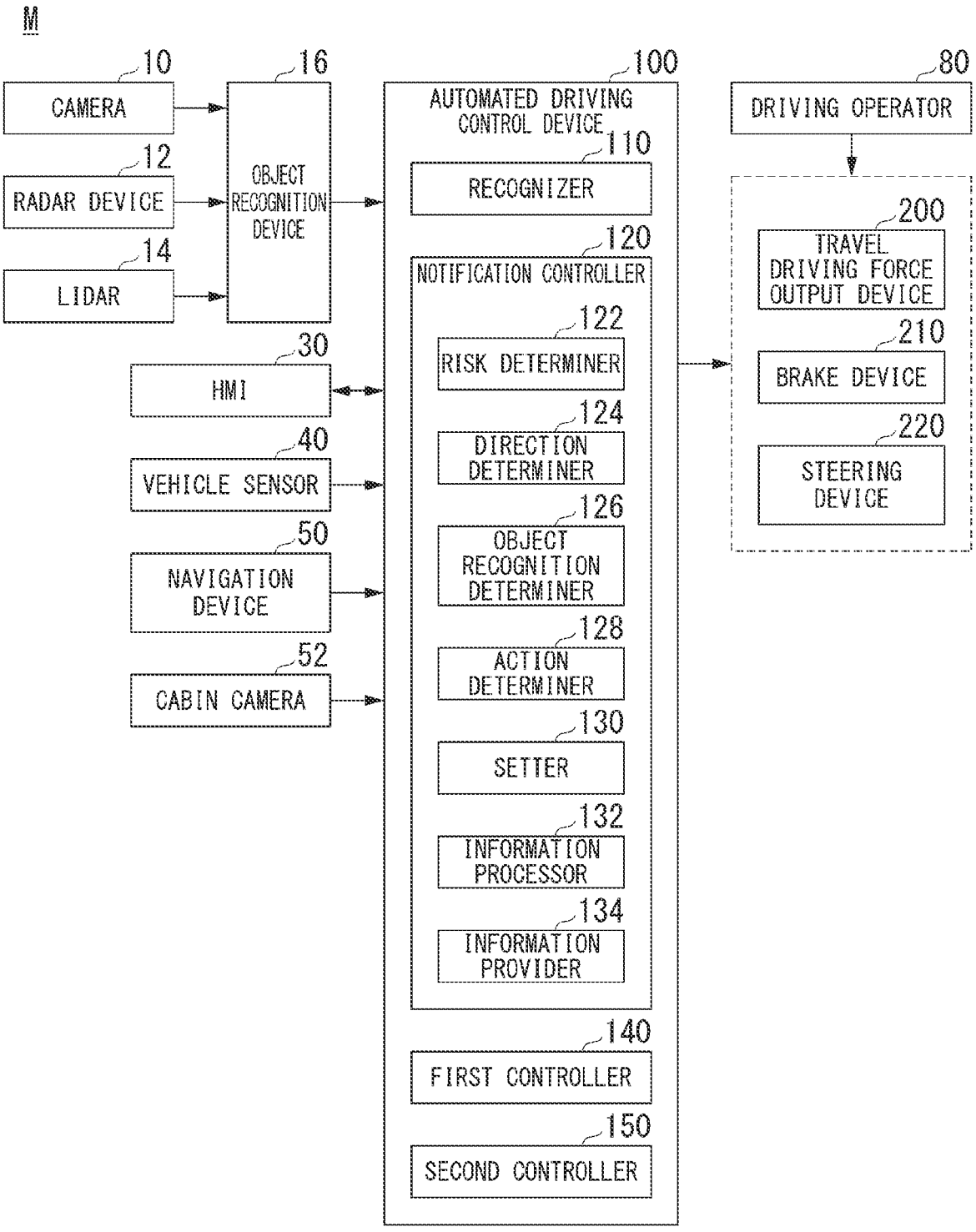

M
10
CAMERA
12
RADAR DEVICE
14
LIDAR
16
OBJECT RECOGNITION DEVICE
30
HMI
40
VEHICLE SENSOR
50
NAVIGATION DEVICE
52
CABIN CAMERA
100
AUTOMATED DRIVING CONTROL DEVICE
110
RECOGNIZER
120
NOTIFICATION CONTROLLER
122
RISK DETERMINER
124
DIRECTION DETERMINER
126
OBJECT RECOGNITION DETERMINER
128
ACTION DETERMINER
130
SETTER
132
INFORMATION PROCESSOR
134
INFORMATION PROVIDER
140
FIRST CONTROLLER
150
SECOND CONTROLLER
80
DRIVING OPERATOR
200
TRAVEL DRIVING FORCE OUTPUT DEVICE
210
BRAKE DEVICE
220
STEERING DEVICE

FIG. 2

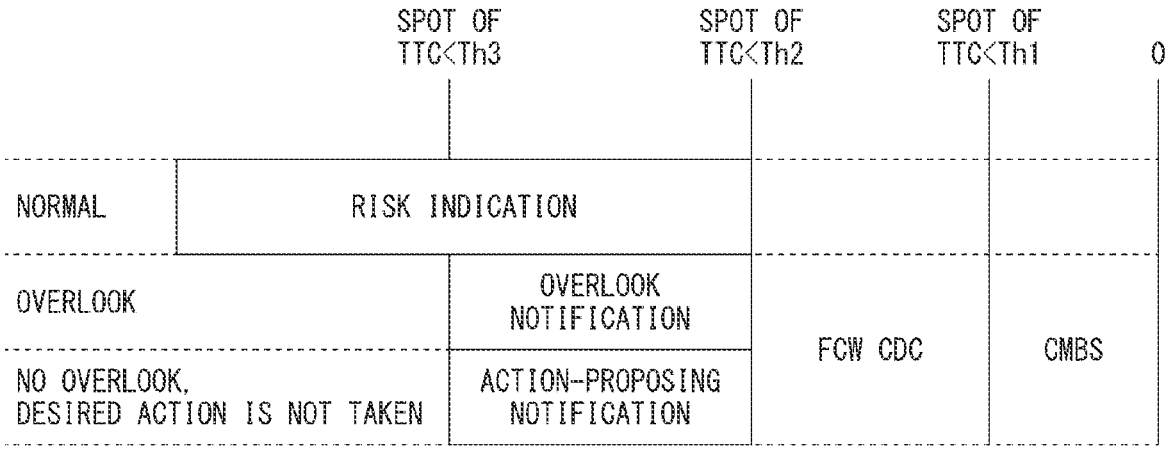


FIG. 3

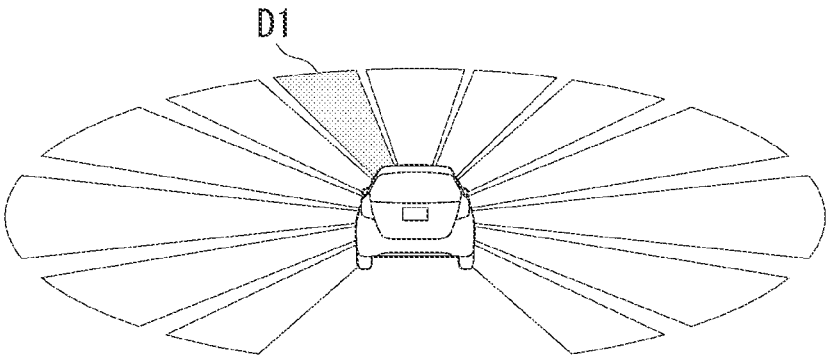


FIG. 4

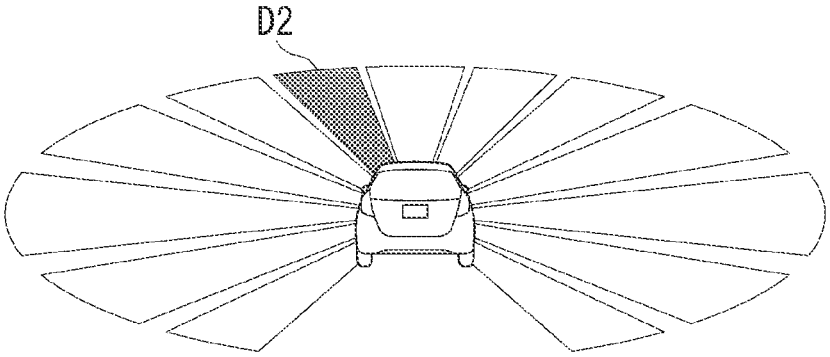


FIG. 5

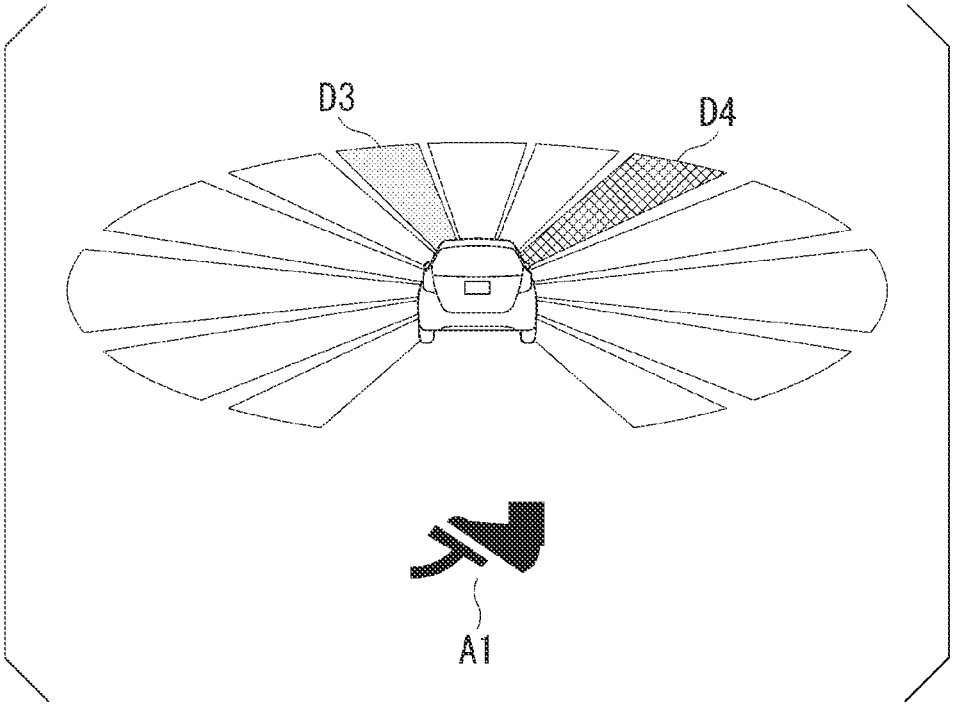


FIG. 6

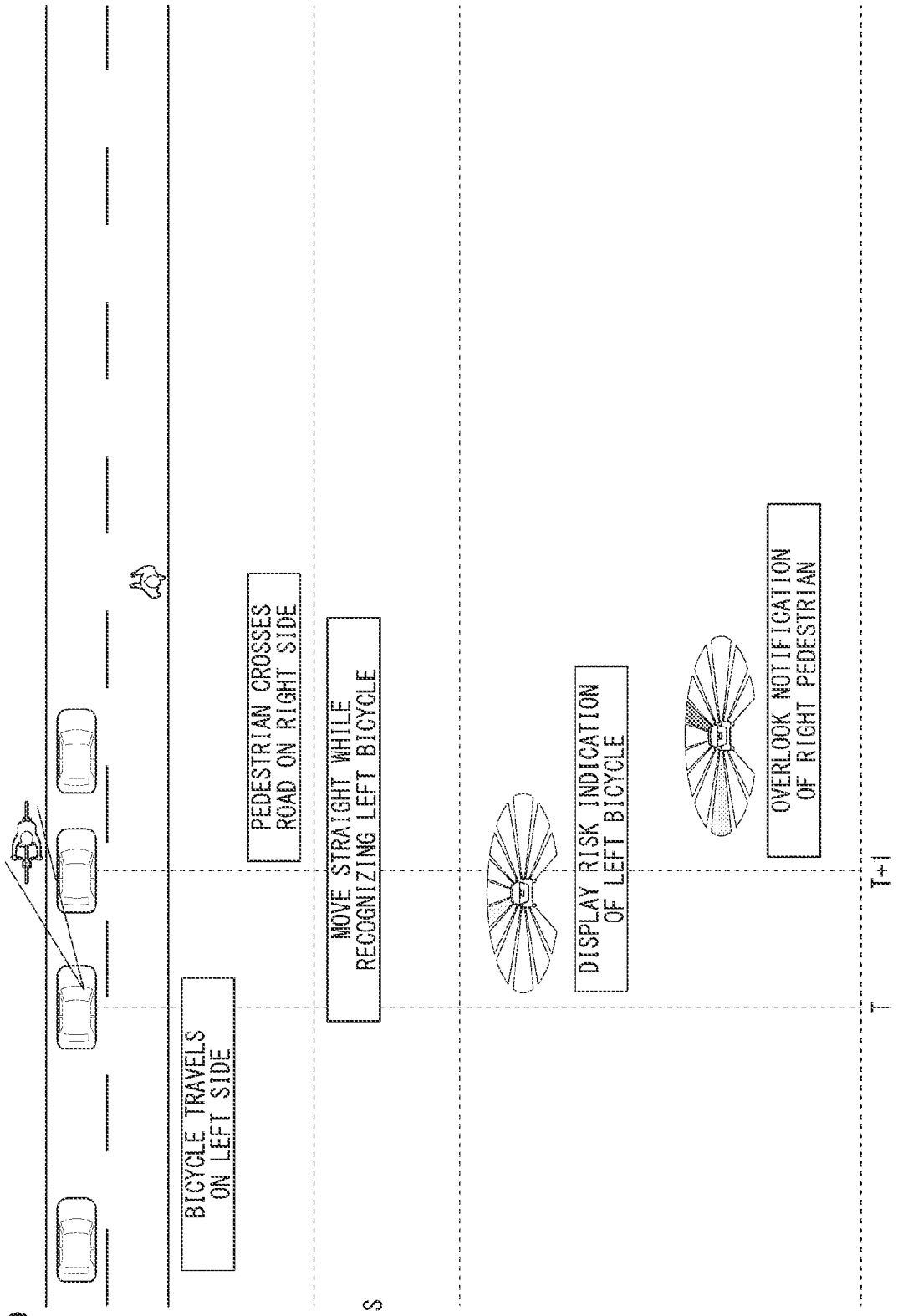

BICYCLE TRAVELS ON LEFT SIDE
PEDESTRIAN CROSSES ROAD ON RIGHT SIDE
MOVE STRAIGHT WHILE RECOGNIZING LEFT BICYCLE
DISPLAY RISK INDICATION OF LEFT BICYCLE
OVERLOOK NOTIFICATION OF RIGHT PEDESTRIAN
EVENT
DRIVER'S ACTION
HMI
T
T+1

FIG. 7

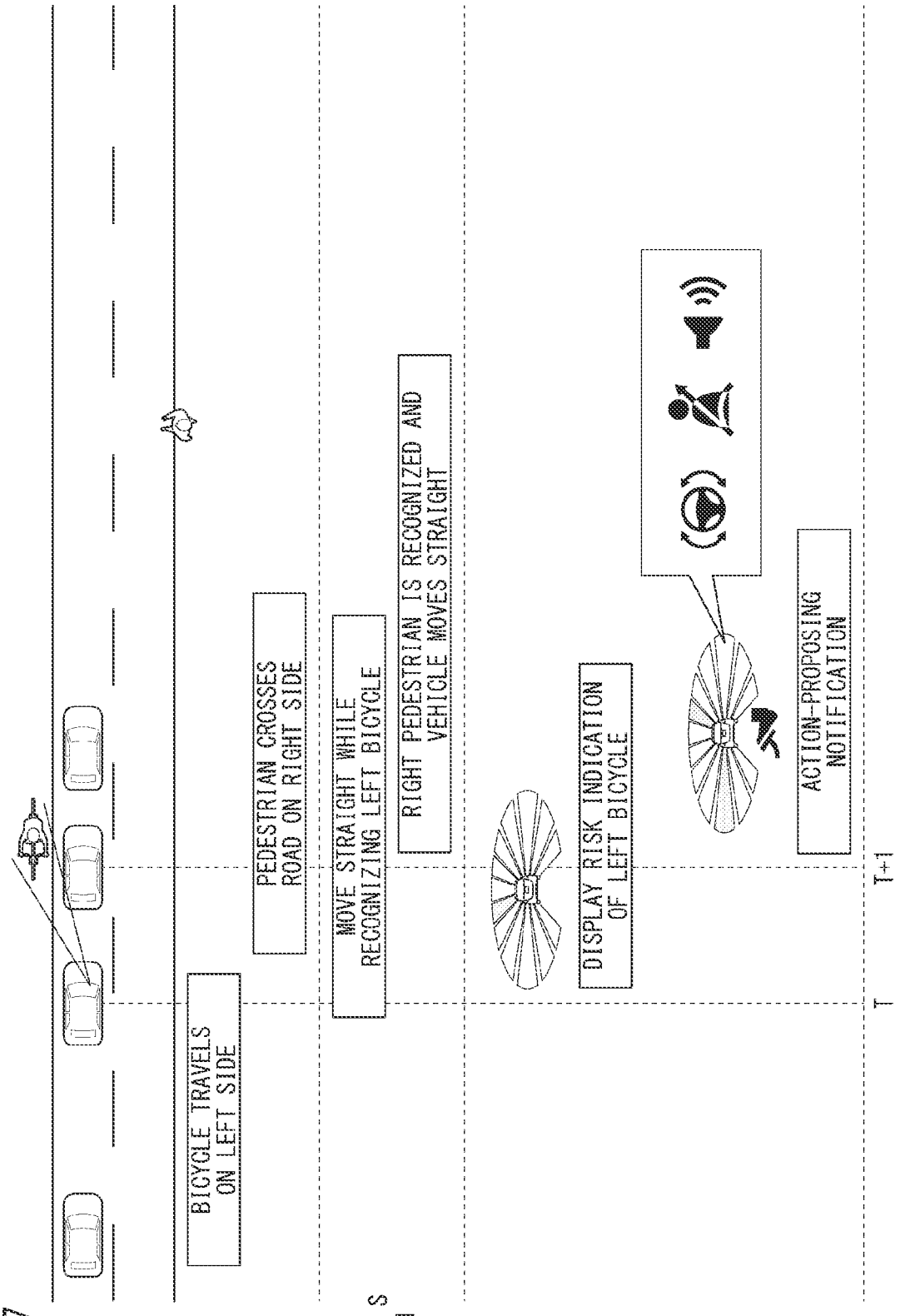

BICYCLE TRAVELS ON LEFT SIDE
PEDESTRIAN CROSSES ROAD ON RIGHT SIDE
MOVE STRAIGHT WHILE RECOGNIZING LEFT BICYCLE
RIGHT PEDESTRIAN IS RECOGNIZED AND VEHICLE MOVES STRAIGHT
DISPLAY RISK INDICATION OF LEFT BICYCLE
ACTION-PROPOSING NOTIFICATION
EVENT
DRIVER'S ACTION
HMI
T
T+1

FIG. 8

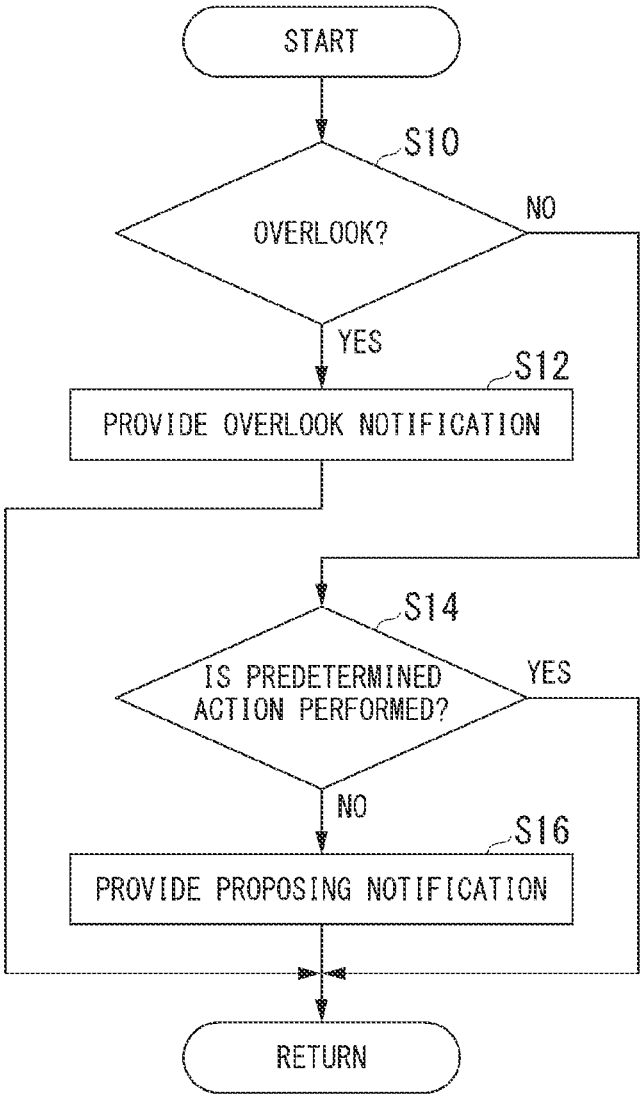

START
S10
OVERLOOK?
NO
YES
S12
PROVIDE OVERLOOK NOTIFICATION
S14
IS PREDETERMINED ACTION PERFORMED?
YES
NO
S16
PROVIDE PROPOSING NOTIFICATION
RETURN

FIG. 9

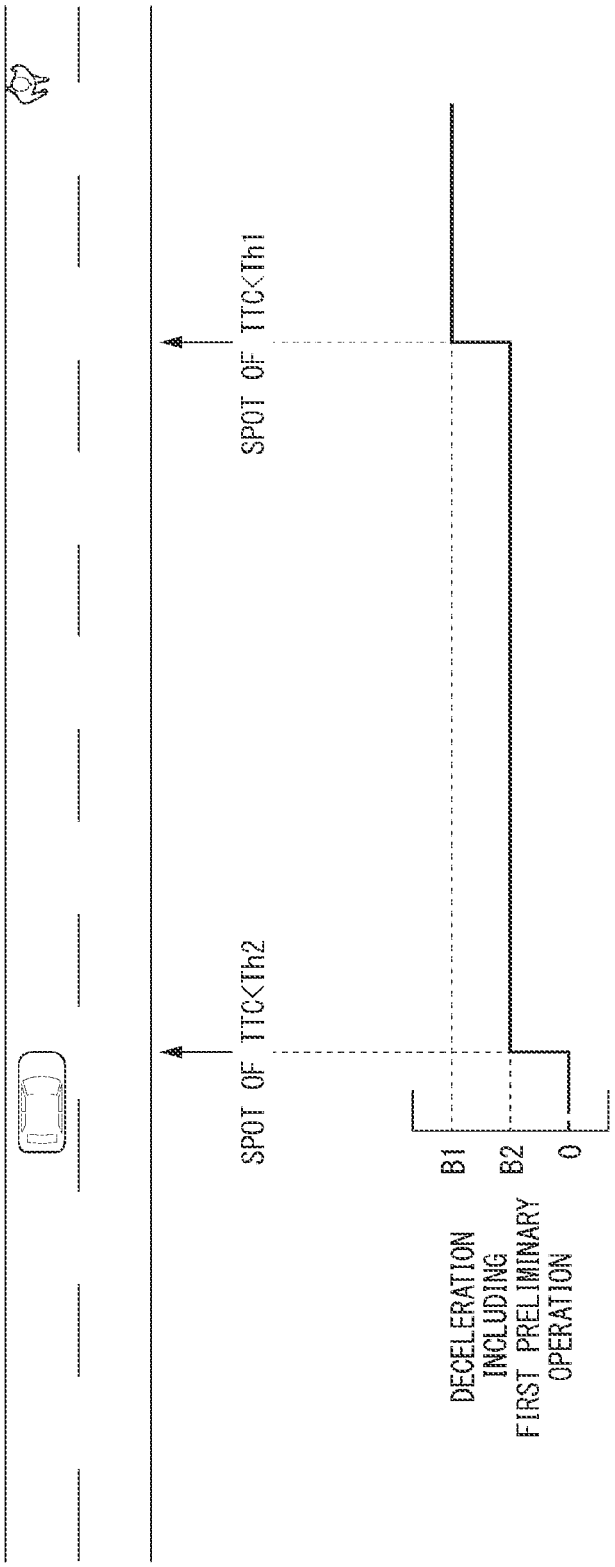

SPOT OF TTC<Th2
SPOT OF TTC<Th1
B1
B2
0
DECELERATION INCLUDING FIRST PRELIMINARY OPERATION

FIG. 10

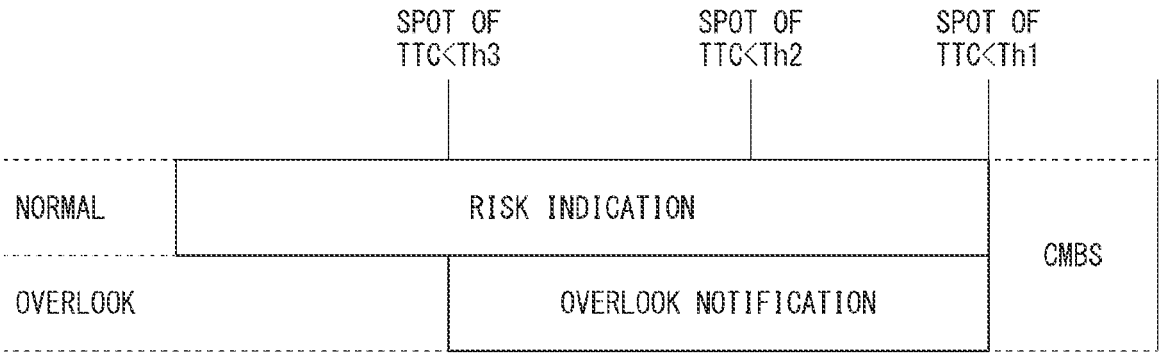
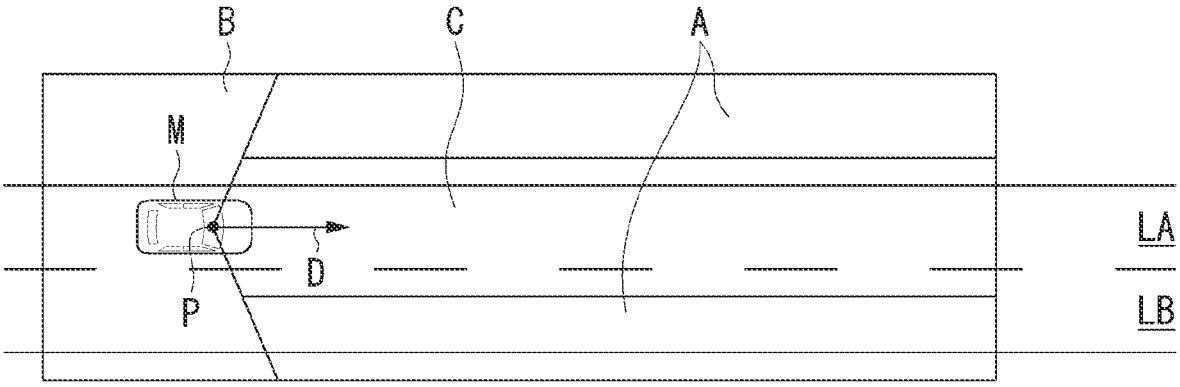

SPOT OF TTC<Th3
SPOT OF TTC<Th2
SPOT OF TTC<Th1
NORMAL
RISK INDICATION
CMBS
OVERLOOK
OVERLOOK NOTIFICATION

FIG. 11


B
C
A
M
D
P
LA
LB

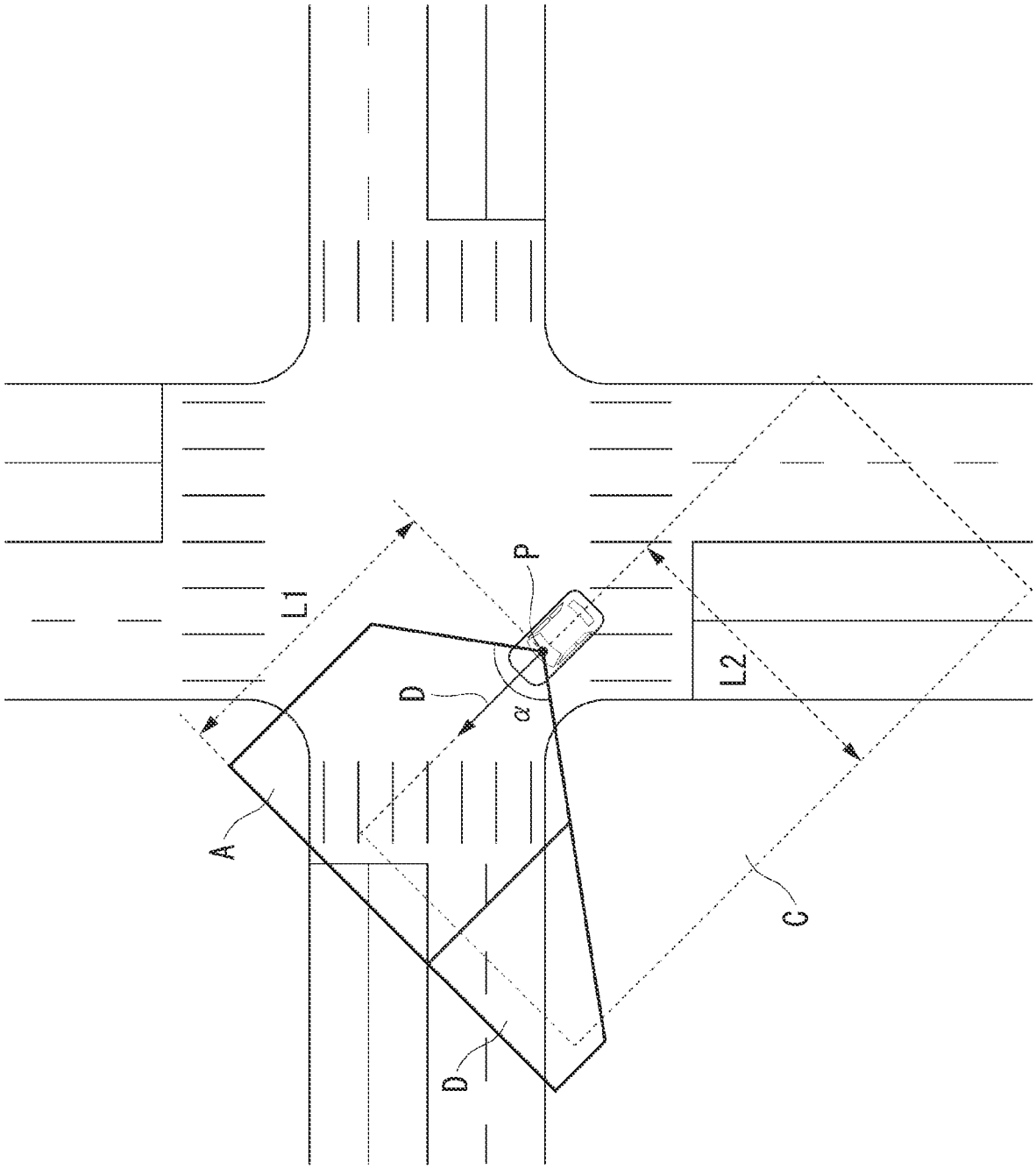


FIG. 12

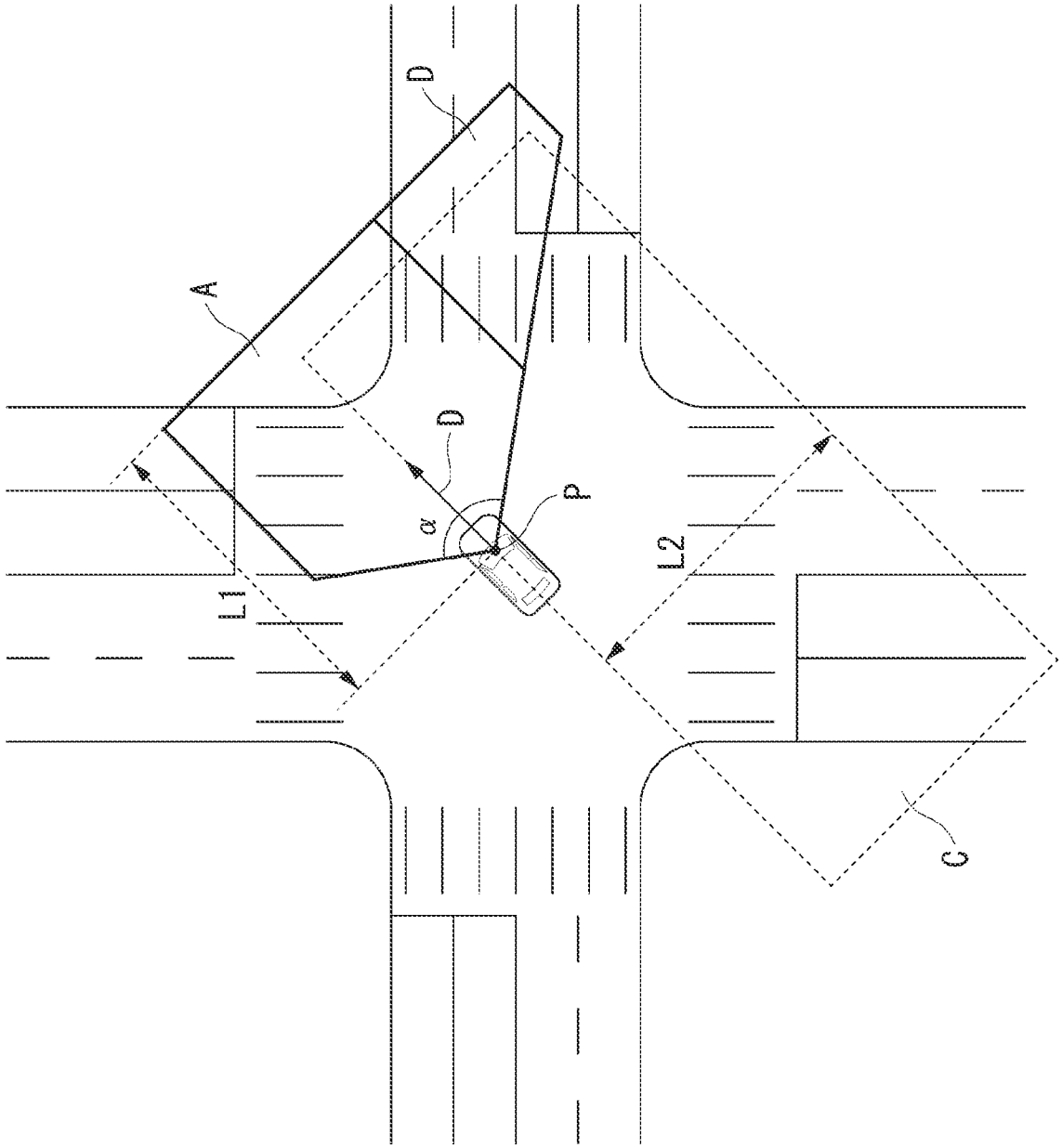


FIG. 13

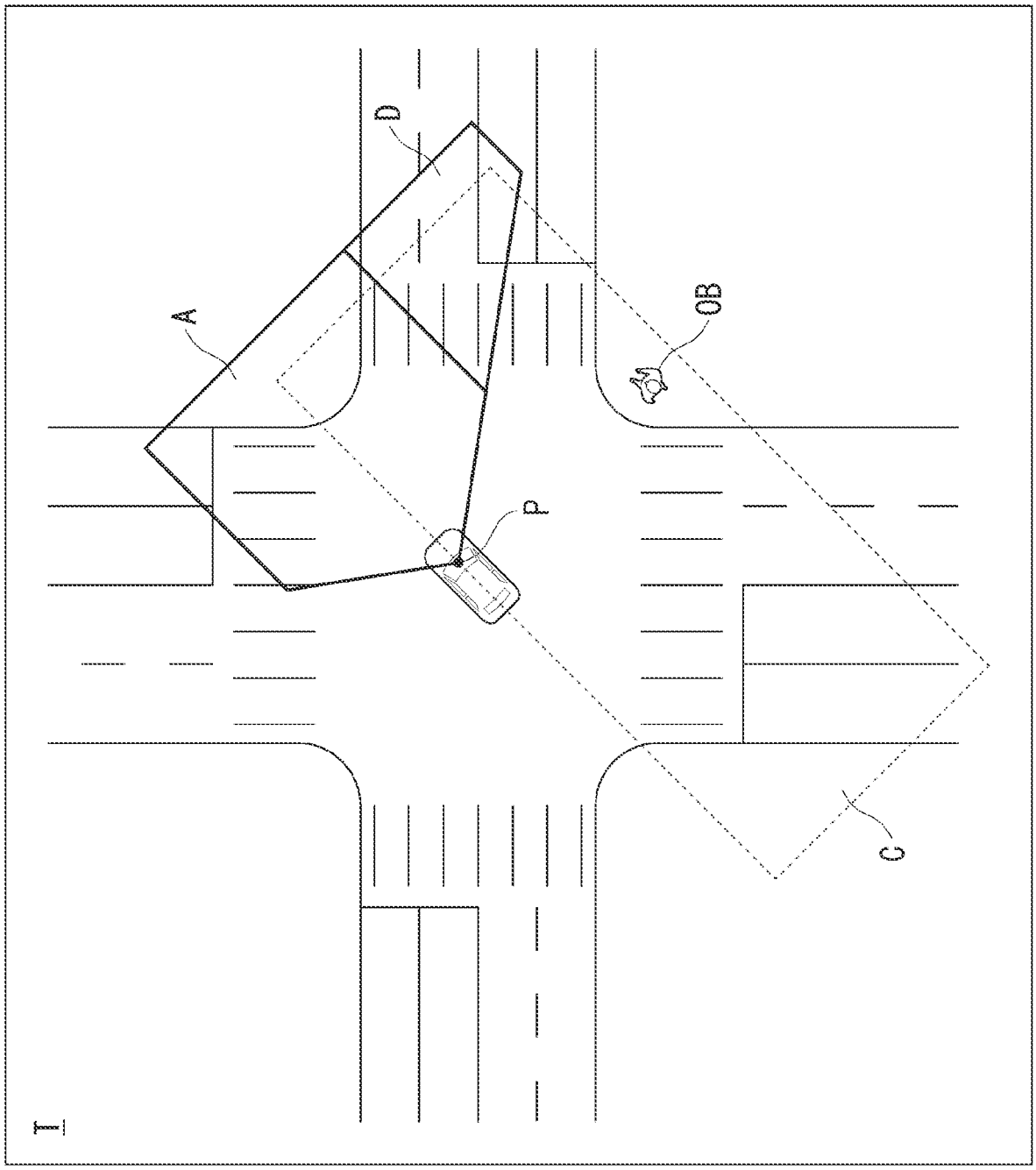


FIG. 14

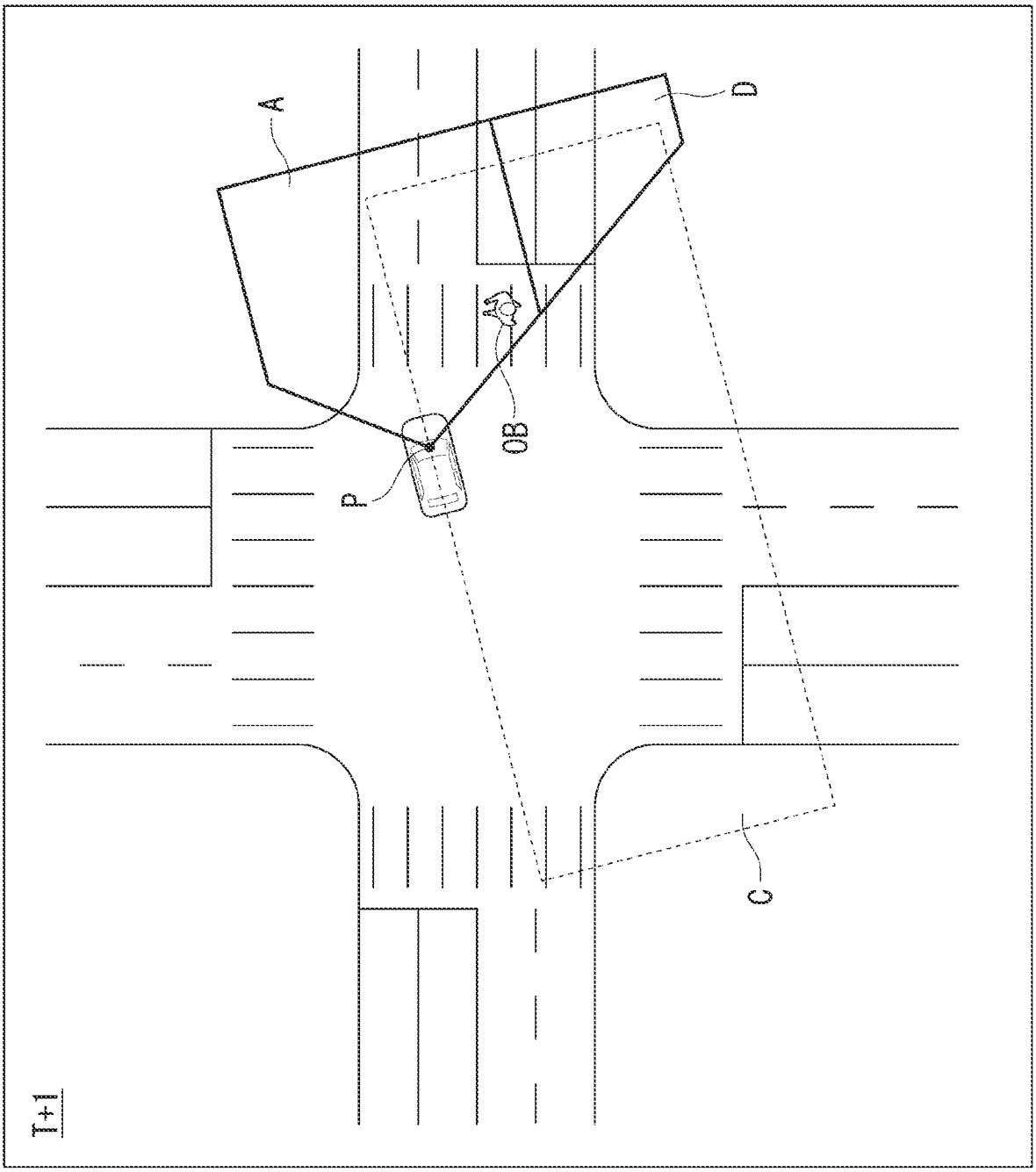


FIG. 15

FIG. 16

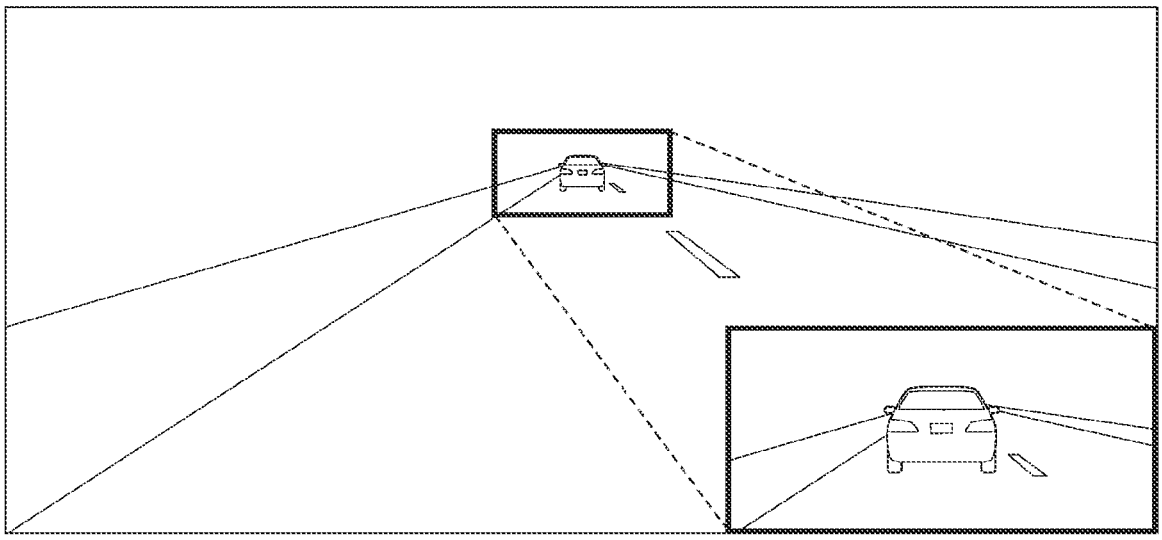


FIG. 17

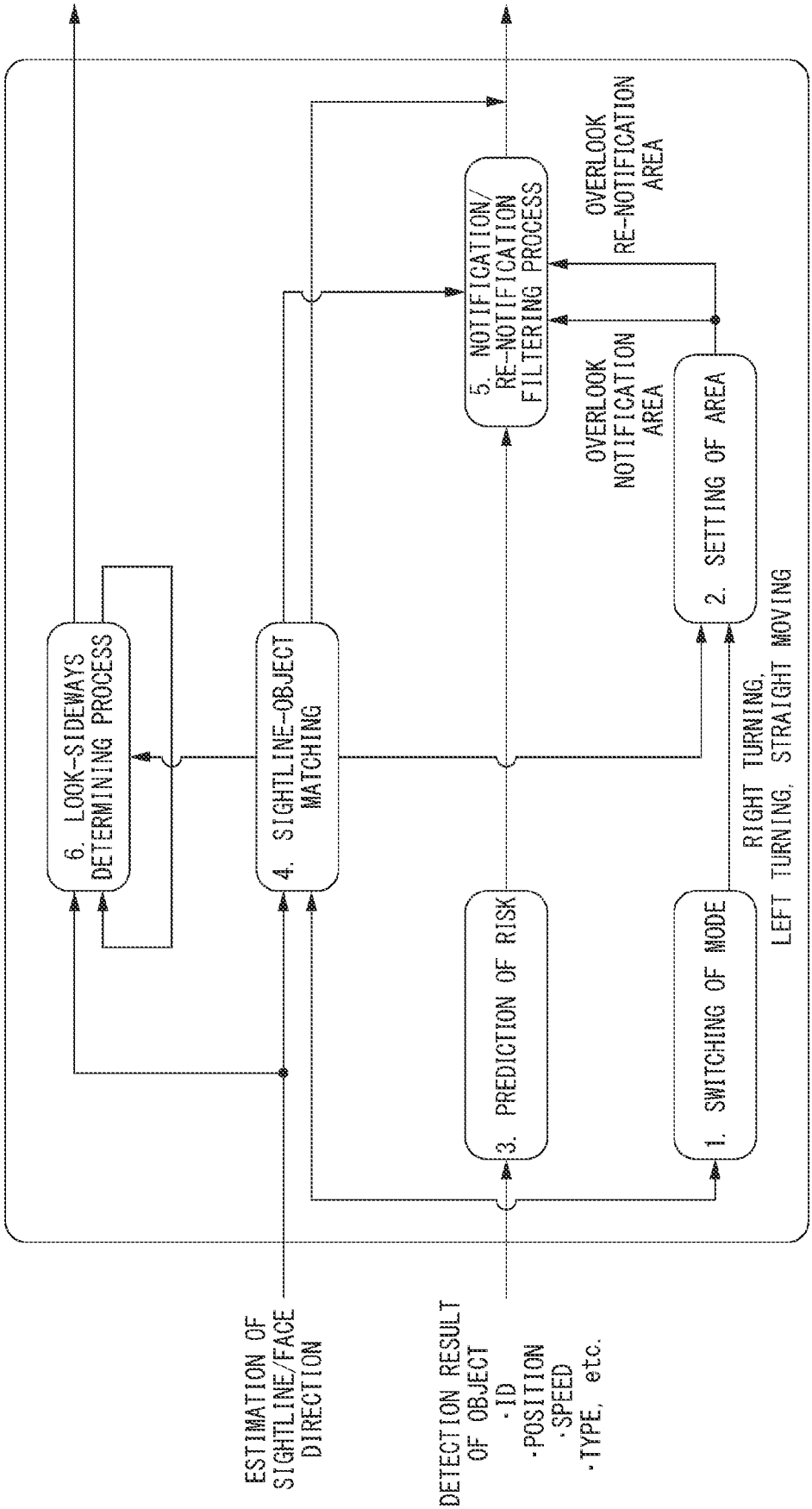

ESTIMATION OF SIGHTLINE/FACE DIRECTION
DETECTION RESULT OF OBJECT
·ID
·POSITION
·SPEED
·TYPE, etc.
6. LOOK-SIDEWAYS DETERMINING PROCESS
4. SIGHTLINE-OBJECT MATCHING
3. PREDICTION OF RISK
1. SWITCHING OF MODE
5. NOTIFICATION/ RE-NOTIFICATION FILTERING PROCESS
2. SETTING OF AREA
OVERLOOK NOTIFICATION AREA
OVERLOOK RE-NOTIFICATION AREA
RIGHT TURNING, LEFT TURNING, STRAIGHT MOVING

FIG. 18

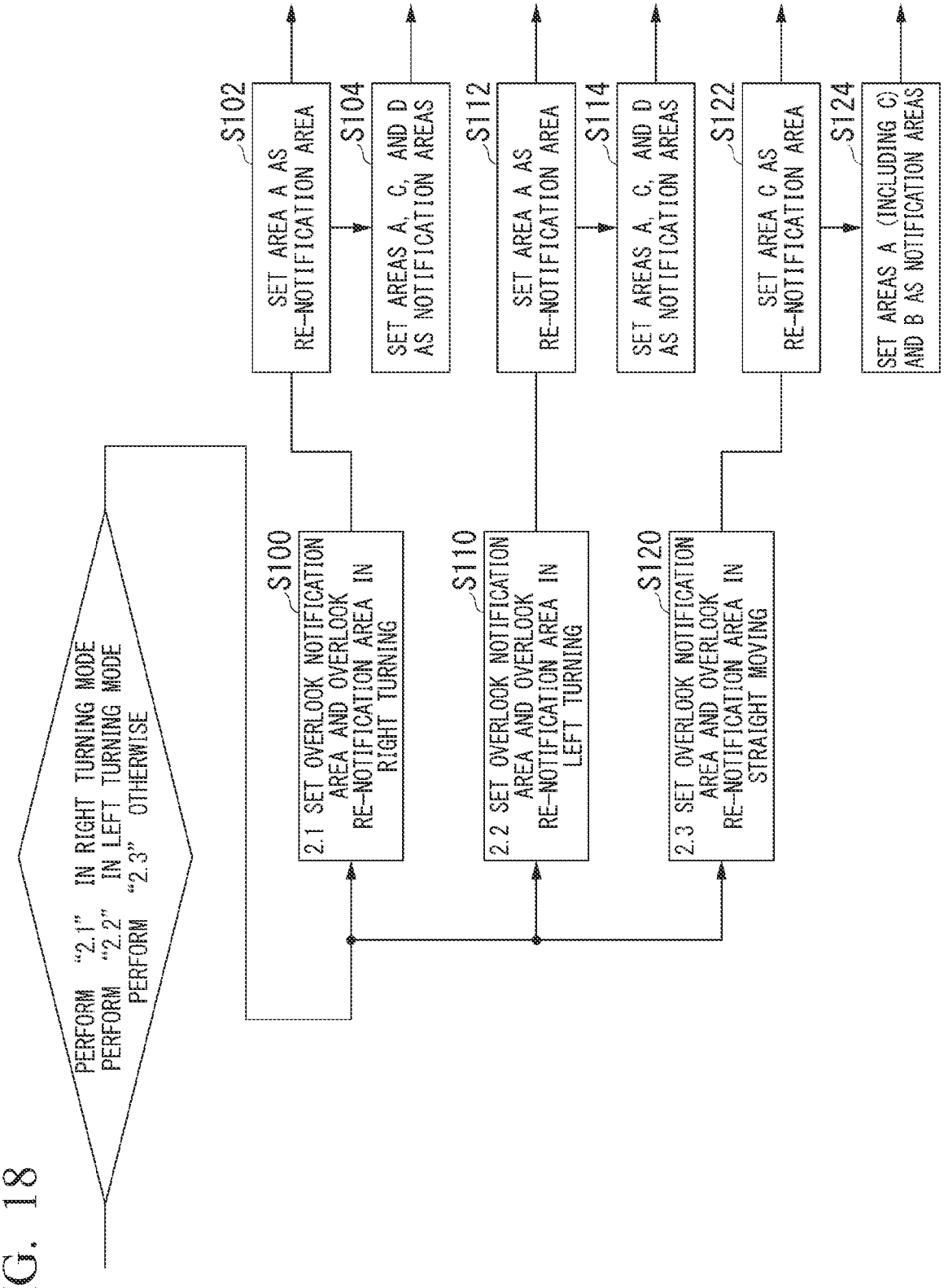

PERFORM "2.1" IN RIGHT TURNING MODE
PERFORM "2.2" IN LEFT TURNING MODE
PERFORM "2.3" OTHERWISE
S100
2.1 SET OVERLOOK NOTIFICATION AREA AND OVERLOOK RE-NOTIFICATION AREA IN RIGHT TURNING
S102
SET AREA A AS RE-NOTIFICATION AREA
S104
SET AREAS A, C, AND D AS NOTIFICATION AREAS
S110
2.2 SET OVERLOOK NOTIFICATION AREA AND OVERLOOK RE-NOTIFICATION AREA IN LEFT TURNING
S112
SET AREA A AS RE-NOTIFICATION AREA
S114
SET AREAS A, C, AND D AS NOTIFICATION AREAS
S120
2.3 SET OVERLOOK NOTIFICATION AREA AND OVERLOOK RE-NOTIFICATION AREA IN STRAIGHT MOVING
S122
SET AREA C AS RE-NOTIFICATION AREA
S124
SET AREAS A (INCLUDING C) AND B AS NOTIFICATION AREAS

FIG. 19

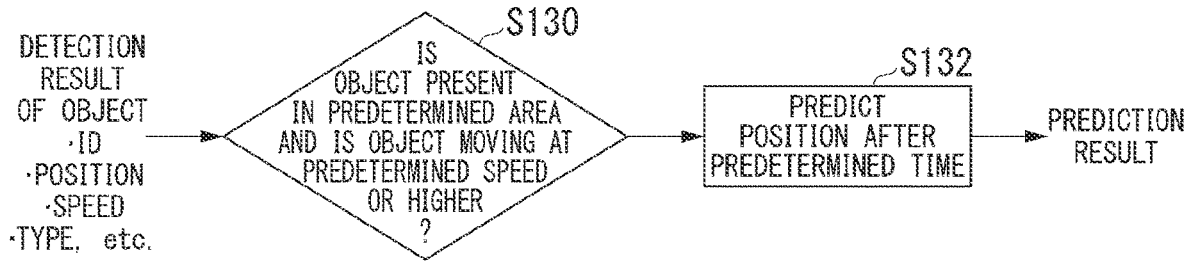

DETECTION RESULT OF OBJECT
·ID
·POSITION
·SPEED
·TYPE, etc.
S130
IS OBJECT PRESENT IN PREDETERMINED AREA AND IS OBJECT MOVING AT PREDETERMINED SPEED OR HIGHER ?
S132
PREDICT POSITION AFTER PREDETERMINED TIME
PREDICTION RESULT

FIG. 20

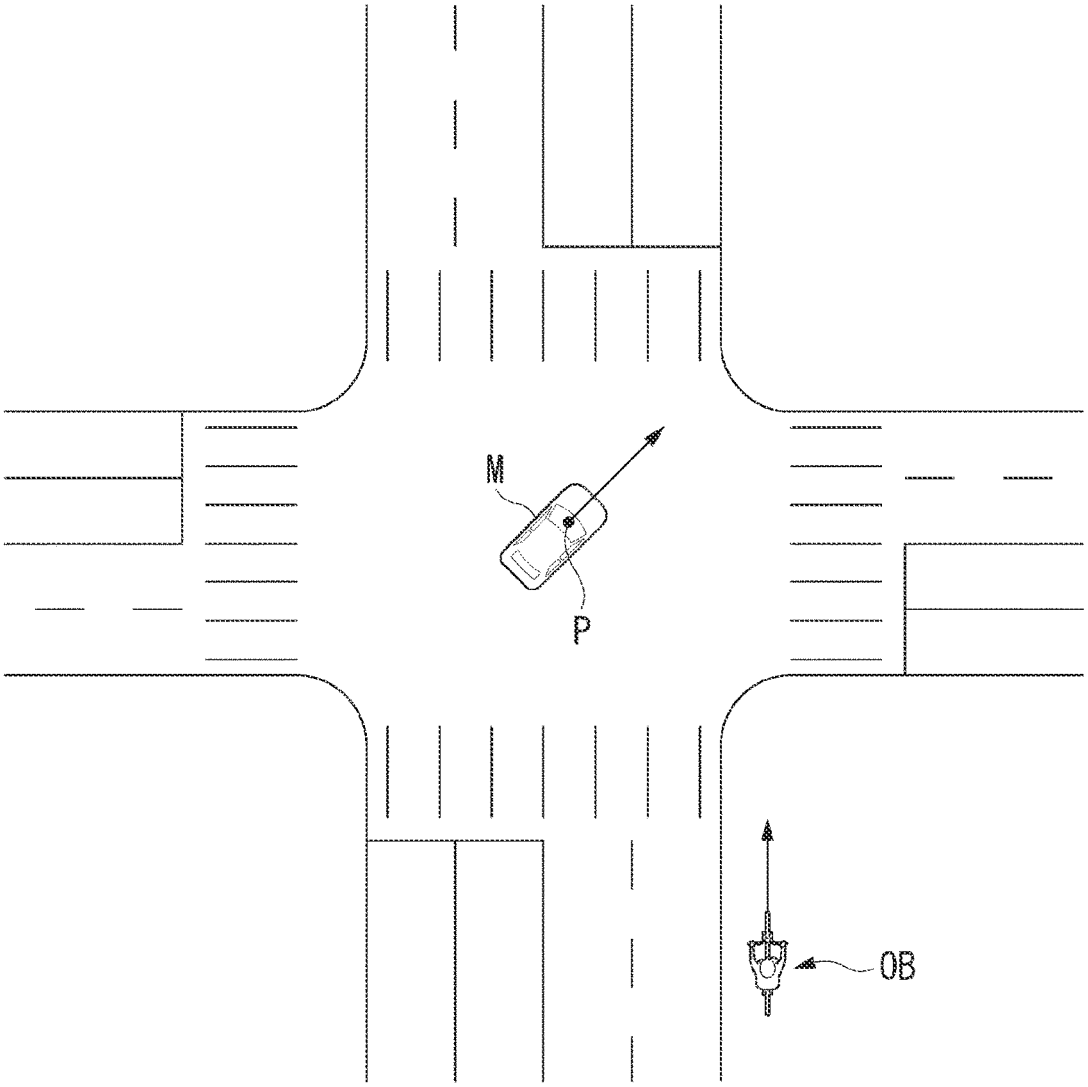

M
P
OB

FIG. 21

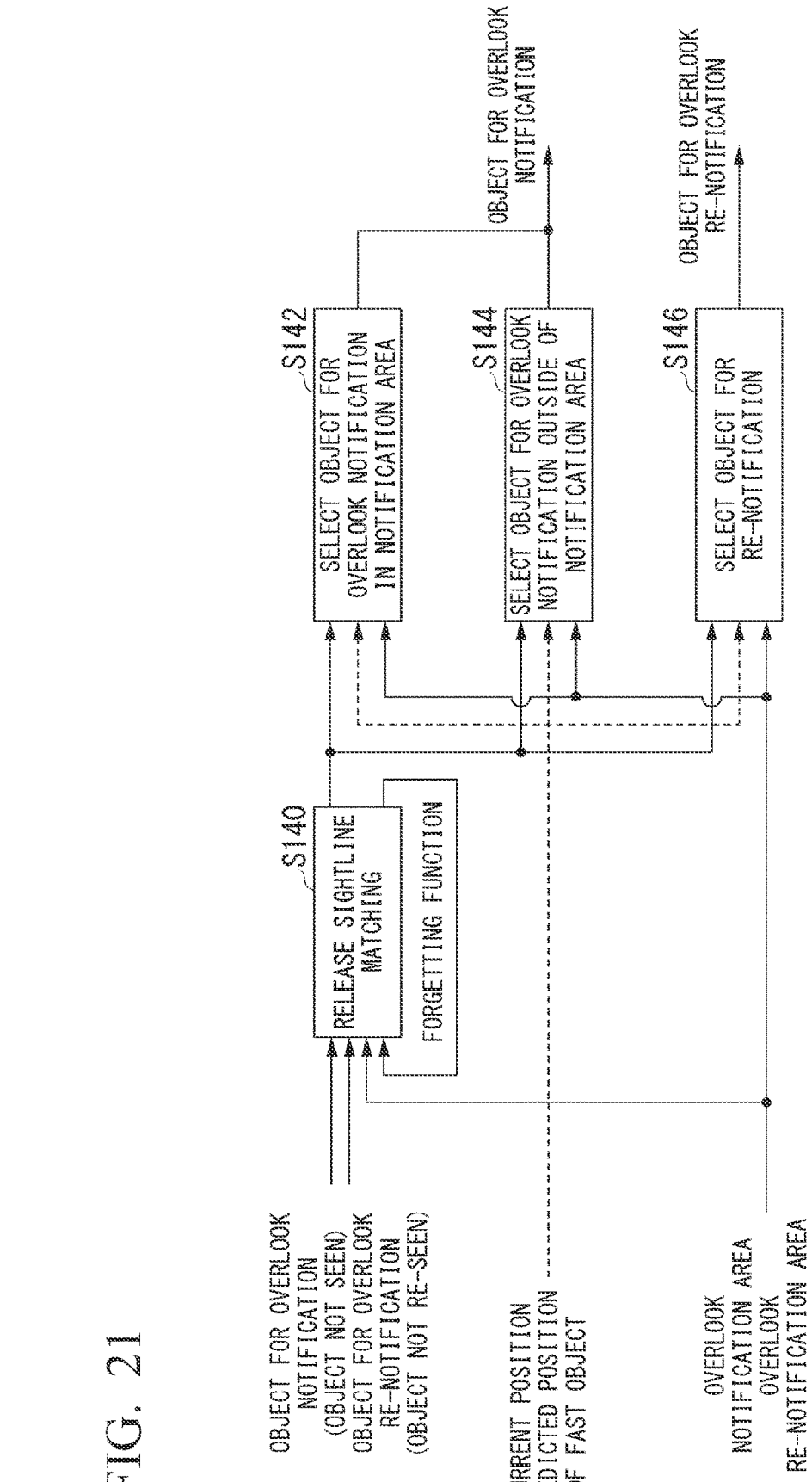

OBJECT FOR OVERLOOK NOTIFICATION (OBJECT NOT SEEN)
OBJECT FOR OVERLOOK RE-NOTIFICATION (OBJECT NOT RE-SEEN)
CURRENT POSITION
PREDICTED POSITION OF FAST OBJECT
OVERLOOK NOTIFICATION AREA
OVERLOOK RE-NOTIFICATION AREA
S140
RELEASE SIGHTLINE MATCHING
FORGETTING FUNCTION
S142
SELECT OBJECT FOR OVERLOOK NOTIFICATION IN NOTIFICATION AREA
S144
SELECT OBJECT FOR OVERLOOK NOTIFICATION OUTSIDE OF NOTIFICATION AREA
S146
SELECT OBJECT FOR RE-NOTIFICATION
OBJECT FOR OVERLOOK NOTIFICATION
OBJECT FOR OVERLOOK RE-NOTIFICATION

FIG. 22

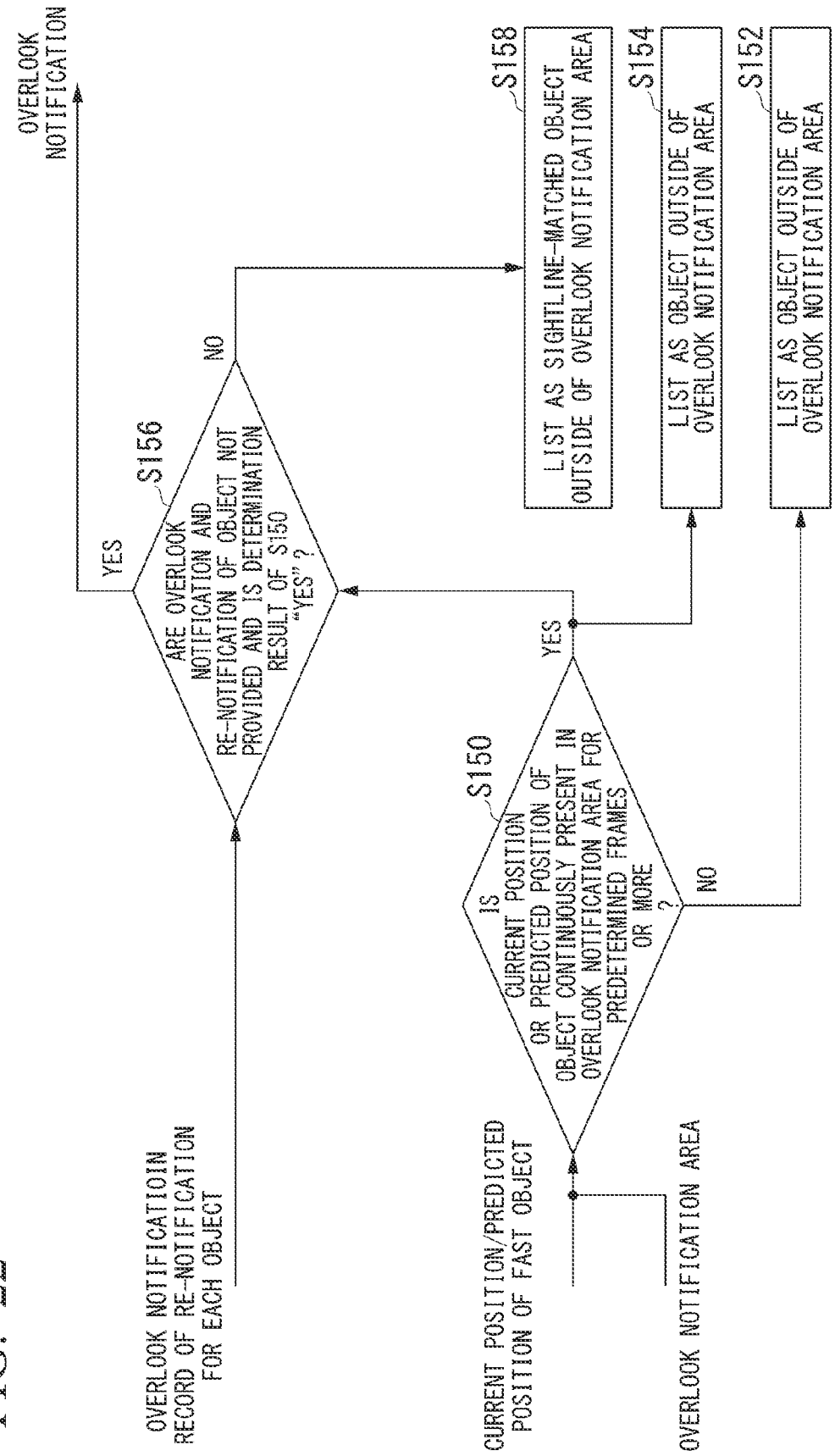

OVERLOOK NOTIFICATION
S158
LIST AS SIGHTLINE-MATCHED OBJECT OUTSIDE OF OVERLOOK NOTIFICATION AREA
S154
LIST AS OBJECT OUTSIDE OF OVERLOOK NOTIFICATION AREA
S152
LIST AS OBJECT OUTSIDE OF OVERLOOK NOTIFICATION AREA
S156
ARE OVERLOOK NOTIFICATION AND RE-NOTIFICATION OF OBJECT NOT PROVIDED AND IS DETERMINATION RESULT OF S150 "YES"?
YES
NO
S150
IS CURRENT POSITION OR PREDICTED POSITION OF OBJECT CONTINUOUSLY PRESENT IN OVERLOOK NOTIFICATION AREA FOR PREDETERMINED FRAMES OR MORE?
YES
NO
OVERLOOK NOTIFICATIOIN RECORD OF RE-NOTIFICATION FOR EACH OBJECT
CURRENT POSITION/PREDICTED POSITION OF FAST OBJECT
OVERLOOK NOTIFICATION AREA

FIG. 23

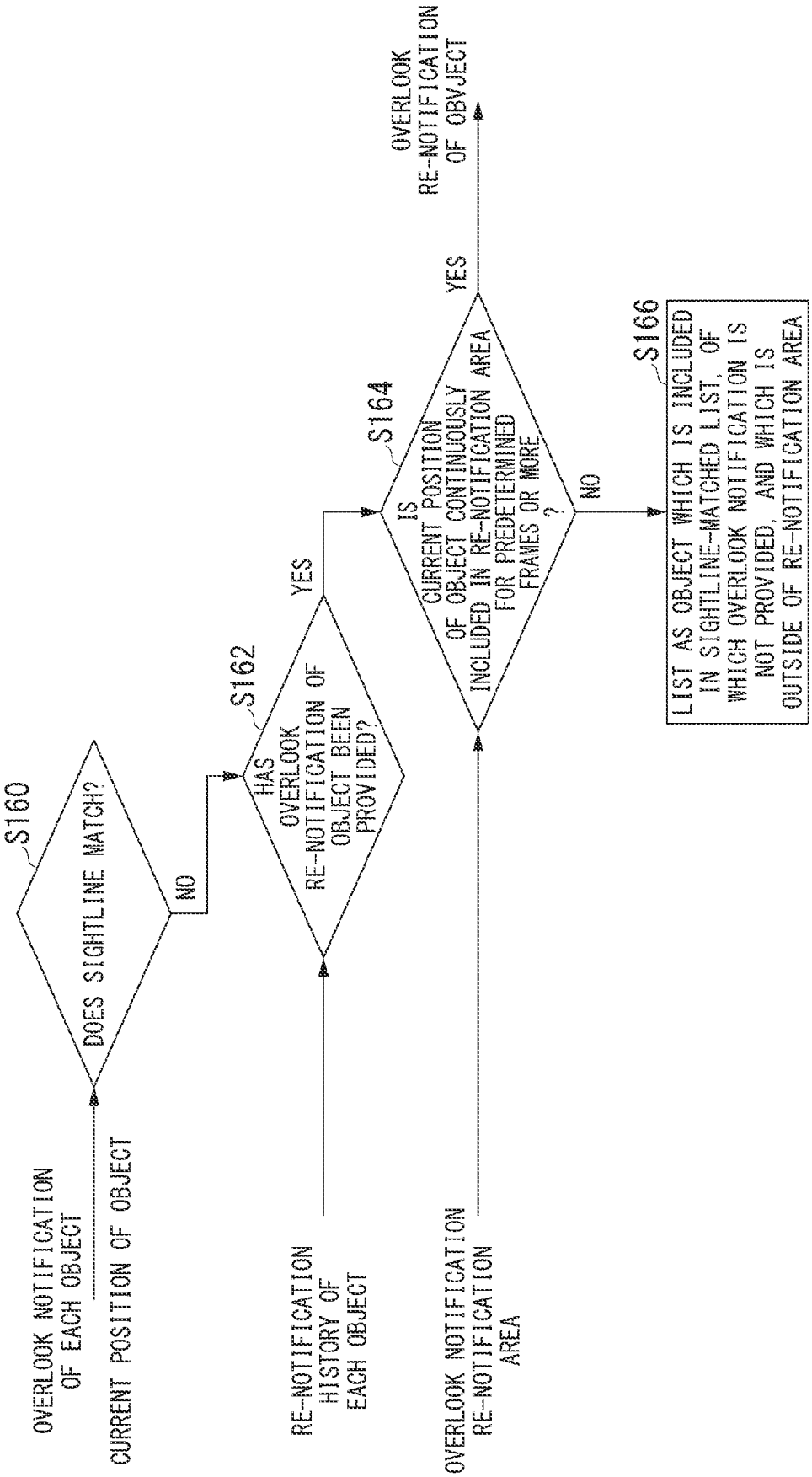
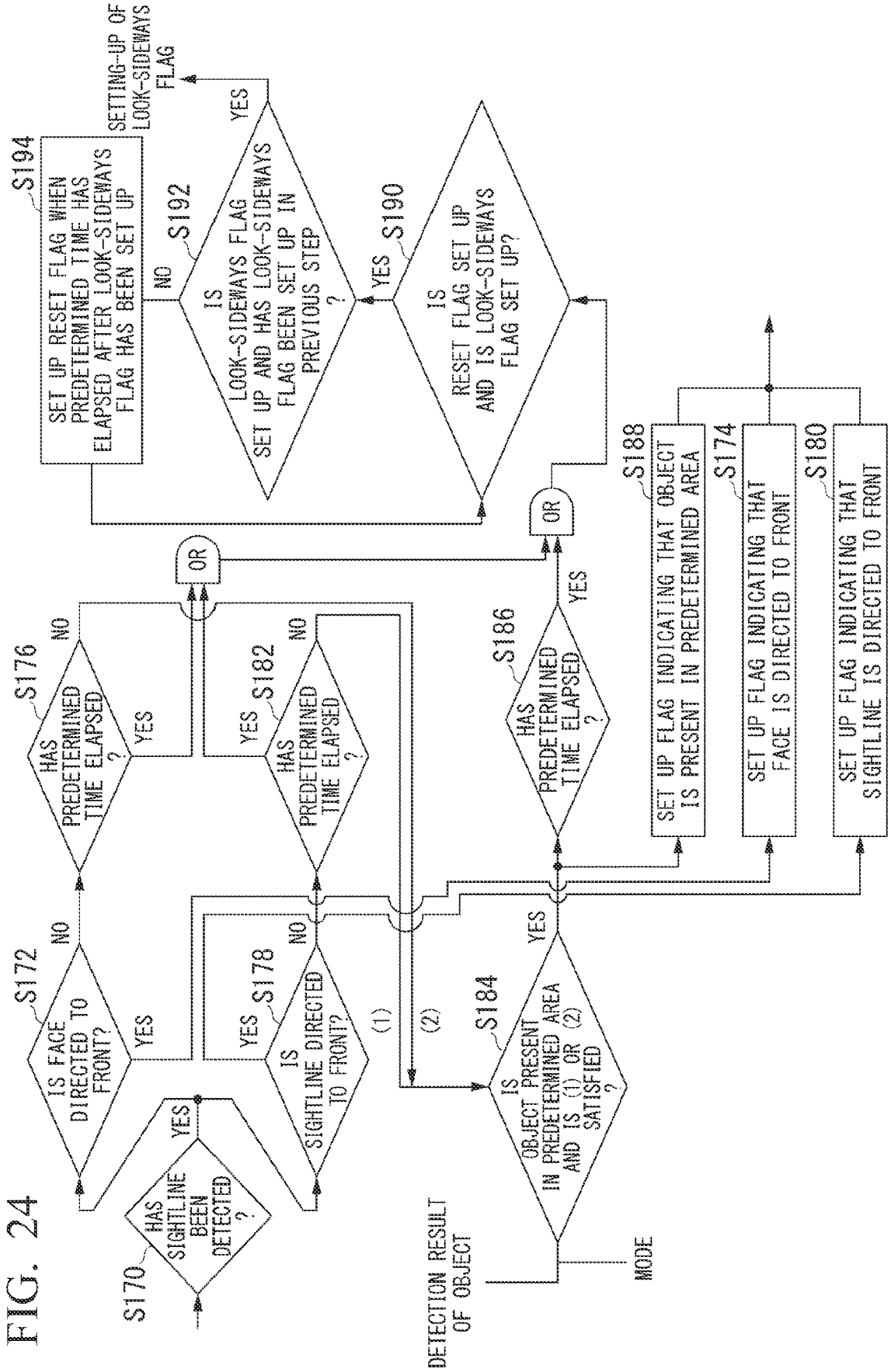

OVERLOOK NOTIFICATION OF EACH OBJECT
CURRENT POSITION OF OBJECT
S160
DOES SIGHTLINE MATCH?
NO
S162
HAS OVERLOOK RE-NOTIFICATION OF OBJECT BEEN PROVIDED?
YES
RE-NOTIFICATION HISTORY OF EACH OBJECT
S164
IS CURRENT POSITION OF OBJECT CONTINUOUSLY INCLUDED IN RE-NOTIFICATION AREA FOR PREDETERMINED FRAMES OR MORE ?
YES
OVERLOOK RE-NOTIFICATION OF OBVJECT
NO
S166
LIST AS OBJECT WHICH IS INCLUDED IN SIGHTLINE-MATCHED LIST, OF WHICH OVERLOOK NOTIFICATION IS NOT PROVIDED, AND WHICH IS OUTSIDE OF RE-NOTIFICATION AREA
OVERLOOK NOTIFICATION RE-NOTIFICATION AREA

FIG. 24


S170
HAS SIGHTLINE BEEN DETECTED ?
YES
S172
IS FACE DIRECTED TO FRONT?
NO
YES
S174
SET UP FLAG INDICATING THAT FACE IS DIRECTED TO FRONT
S176
HAS PREDETERMINED TIME ELAPSED ?
NO
YES
S178
IS SIGHTLINE DIRECTED TO FRONT?
NO
YES
S180
SET UP FLAG INDICATING THAT SIGHTLINE IS DIRECTED TO FRONT
S182
HAS PREDETERMINED TIME ELAPSED ?
NO
YES
S184
IS OBJECT PRESENT IN PREDETERMINED AREA AND IS (1) OR (2) SATISFIED ?
NO
YES
S186
HAS PREDETERMINED TIME ELAPSED ?
NO
YES
S188
SET UP FLAG INDICATING THAT OBJECT IS PRESENT IN PREDETERMINED AREA
S190
IS RESET FLAG SET UP AND IS LOOK-SIDEWAYS FLAG SET UP?
YES
S192
IS LOOK-SIDEWAYS FLAG SET UP AND HAS LOOK-SIDEWAYS FLAG BEEN SET UP IN PREVIOUS STEP ?
NO
YES
S194
SET UP RESET FLAG WHEN PREDETERMINED TIME HAS ELAPSED AFTER LOOK-SIDEWAYS FLAG HAS BEEN SET UP
SETTING-UP OF LOOK-SIDEWAYS FLAG
OR
OR
(1)
(2)
DETECTION RESULT OF OBJECT
MODE

NOTIFICATION CONTROL DEVICE, NOTIFICATION CONTROL METHOD, AND STORAGE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] Priority is claimed on Japanese Patent Application No. 2022-157040, filed Sep. 29, 2022, the content of which is incorporated herein by reference.

BACKGROUND

Field

[0002] The present invention relates to a notification control device, a notification control method, and a storage medium.

Description of Related Art

[0003] In the related art, a warning device that issues a warning later when an occupant's operating state of an onboard device is detected and the occupant's sightline direction is in a predetermined area than when the occupant's sightline direction is outside of the predetermined area has been disclosed (Japanese Unexamined Patent Application, First Publication No. 2010-49383).

SUMMARY

[0004] However, in the related art, a warning suitable for a driver may not be issued. The present invention was made in consideration of the aforementioned circumstances and an objective thereof is to provide a notification control device, a notification control method, and a storage medium that can more appropriately issue a warning.

[0005] A notification control device, a notification control method, and a storage medium according to the present invention employ the following configurations.

[0006] (1) According to an aspect of the present invention, there is provided a notification control device including a storage medium storing computer-readable instructions and one or more processors connected to the storage medium, wherein the one or more processors execute the computer-readable instructions to perform: detecting a sightline of a driver of a mobile object; causing an information output device, which is configured to output a warning to a driver, to output a first warning when a first condition is satisfied; and causing the information output device to output a second warning when a second condition is satisfied, the first condition is a condition that the driver's sight line is out of a predetermined range in which the driver is considered to see a view in front of the mobile object and a state in which the sightline is out of the range is maintained for a first time, and the second condition is a condition that the driver's sightline is out of the range, a risky object to be noticed is present in a reference area set with respect to the mobile object, and the state in which the sightline is out of the range is maintained for a second time shorter than the first time.

[0007] (2) In the aspect of (1), the one or more processors may execute the computer-readable instructions to perform detecting a face direction of the driver, the first condition may be a condition that the face direction of the driver is out of a predetermined range in which the driver is considered to see a view in front of the mobile object and a state in which the face direction is out of the range is maintained for a first time, and the second condition may be a condition that the face direction of the driver is out of the range, a risky object to be noticed is present in a reference area set with respect to the mobile object, and the state in which the face direction is out of the range is maintained for a second time shorter than the first time.

[0008] (3) In the aspect of (1) or (2), the one or more processors may execute the computer-readable instructions to perform: causing the information output device to output the first warning when the first condition is satisfied after the information output device has output the first warning and a third time longer than the second time elapses after the first warning has been output; and causing the information output device not to output the first warning when the first condition is satisfied after the information output device has output the first warning and the third time does not elapse after the first warning has been output.

[0009] (4) In the aspect of (1) or (2), the one or more processors may execute the computer-readable instructions to perform: causing the information output device to output the second warning when the second condition is satisfied after the information output device has output the first warning and a third time longer than the second time elapses after the first warning has been output; and causing the information output device not to output the second warning when the second condition is satisfied after the information output device has output the first warning and the third time does not elapse after the first warning has been output.

[0010] (5) In the aspect of (1) or (2), the one or more processors may execute the computer-readable instructions to perform: causing the information output device to output the first warning when the first condition is satisfied after the information output device has output the second warning and a third time longer than the second time elapses after the second warning has been output; and causing the information output device not to output the first warning when the first condition is satisfied after the information output device has output the second warning and the third time does not elapse after the second warning has been output.

[0011] (6) In the aspect of (1) or (2), the one or more processors may execute the computer-readable instructions to perform: causing the information output device to output the second warning when the second condition is satisfied after the information output device has output the second warning and a third time longer than the second time elapses after the second warning has been output; and causing the information output device not to output the second warning when the second condition is satisfied after the information output device has output the second warning and the third time does not elapse after the second warning has been output.

[0012] (7) In the aspect of (1) or (2), the reference area set with respect to the mobile object may be a reference area including a trajectory along which the mobile object is scheduled to move.

[0013] (8) In the aspect of (7), the one or more processors may execute the computer-readable instructions to perform setting a length of the reference area on the basis of a speed of the mobile object.

[0014] (9) In the aspect of (8), the one or more processors may execute the computer-readable instructions to perform: setting the reference area according to behavior of the mobile object when the mobile object moves straight, turns right, or turns left; and setting a width of the reference area

in a traveling direction of the mobile object when the mobile object turns right or left to be longer than a width of the reference area in the traveling direction of the mobile object when the mobile object moves straight.

[0015] (10) According to another aspect of the present invention, there is provided a notification control method that is performed by a computer, the notification control method including: a step of detecting a sightline of a driver of a mobile object; a step of causing an information output device, which is configured to output a warning to a driver, to output a first warning when a first condition is satisfied; and a step of causing the information output device to output a second warning when a second condition is satisfied, wherein the first condition is a condition that the driver's sight line is out of a predetermined range in which the driver is considered to see a view in front of the mobile object and a state in which the sightline is out of the range is maintained for a first time, and the second condition is a condition that the driver's sightline is out of the range, a risky object to be noticed is present in a reference area set with respect to the mobile object, and the state in which the sightline is out of the range is maintained for a second time shorter than the first time.

[0016] (11) According to another aspect of the present invention, a non-transitory computer storage medium is provided storing a program, the program causing a computer to perform: a process of detecting a sightline of a driver of a mobile object; a process of causing an information output device, which is configured to output a warning to a driver, to output a first warning when a first condition is satisfied; and a process of causing the information output device to output a second warning when a second condition is satisfied, the first condition is a condition that the driver's sight line is out of a predetermined range in which the driver is considered to see a view in front of the mobile object and a state in which the sightline is out of the range is maintained for a first time, and the second condition is a condition that the driver's sightline is out of the range, a risky object to be noticed is present in a reference area set with respect to the mobile object, and the state in which the sightline is out of the range is maintained for a second time shorter than the first time.

[0017] According to the aspects of (1) to (11), since the notification control device issues a warning according to satisfied conditions, it is possible to more appropriately issue a warning. For example, when a risky object is present in a reference area, a warning is issued at an earlier timing than when a risky object is not present in the reference area, and thus it is possible to issue a warning at a more appropriate timing. According to the aspects of (3) to (6), issuing of a warning is curbed before the third time elapses even when the first condition or the second condition is satisfied after a warning has been issued, and thus it is possible to reduce trouble of a driver. For example, after a warning has been issued, a driver may direct the sightline to a space for avoiding a risky object. In this case, it is possible to curb re-issuing of a warning.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. **1** is a diagram showing a configuration of a vehicle M in which a driving support device according to an embodiment is mounted.

[0019] FIG. **2** is a diagram showing a notification timing when a risky object is present.

[0020] FIG. **3** is a diagram showing an example of a risk indication.

[0021] FIG. **4** is a diagram showing an example of overlook notification.

[0022] FIG. **5** is a diagram showing an example of action-proposing notification.

[0023] FIG. **6** is a diagram showing an example of a relationship between an event, a driver's action, and information provided by an HMI.

[0024] FIG. **7** is a diagram showing another example of a relationship between an event, a driver's action, and information provided by an HMI.

[0025] FIG. **8** is a flowchart showing an example of a routine that is performed by a notification controller.

[0026] FIG. **9** is a diagram showing braking control.

[0027] FIG. **10** is a diagram showing another example of a notification mode.

[0028] FIG. **11** is a diagram showing a notification area and a re-notification area of a straight road.

[0029] FIG. **12** is a diagram showing a notification area and a re-notification area of a crossing.

[0030] FIG. **13** is a diagram showing a notification area and a re-notification area of a crossing.

[0031] FIG. **14** is a diagram showing an example of a situation in which notification is performed.

[0032] FIG. **15** is a diagram showing an example of a situation in which re-notification is performed.

[0033] FIG. **16** is a diagram showing an example of a situation in which warning is issued.

[0034] FIG. **17** is a diagram schematically showing a process associated with notification.

[0035] FIG. **18** is a diagram showing an area setting process.

[0036] FIG. **19** is a diagram showing a risk predicting process.

[0037] FIG. **20** is a diagram showing a fast object.

[0038] FIG. **21** is a diagram showing a notification and re-notification filtering process.

[0039] FIG. **22** is a diagram showing a process of selecting an object of overlook notification outside of a notification area.

[0040] FIG. **23** is a diagram showing a process of selecting an object of re-notification.

[0041] FIG. **24** is a diagram showing a look-sideways determining process.

DETAILED DESCRIPTION

[0042] Hereinafter, a notification control device, a notification control method, and a storage medium according to an embodiment of the present invention will be described with reference to the accompanying drawings. In the following description, a mobile object is assumed to be a vehicle, but a mobile object may be an object other than a vehicle.

First Embodiment

[0043] Entire configuration FIG. **1** is a diagram showing a configuration of a vehicle M in which a driving support device **100** according to an embodiment is mounted. A vehicle M is, for example, a vehicle with two wheels, three wheels, or four wheels, and a drive source thereof is an internal combustion engine such as a diesel engine or a gasoline engine, an electric motor, or a combination thereof.

The electric motor operates using electric power generated by a power generator connected to the internal combustion engine or electric power discharged from a secondary battery or a fuel cell.

[0044] For example, a camera **10**, a radar device **12**, a Light Detection and Ranging (LIDAR) **14**, an object recognition device **16**, a human-machine interface (HMI) **30**, a vehicle sensor **40**, a cabin camera **52**, a driving operator **80**, a driving support device **100**, a travel driving force output device **200**, a brake device **210**, and a steering device **220** are mounted in the vehicle M. These devices or instruments are connected to each other via a multiplex communication line such as a controller area network (CAN) communication line, a serial communication line, a radio communication network, or the like. The configuration shown in FIG. **1** is only an example, and part of the configuration may be omitted or another configuration may be added thereto.

[0045] The camera **10** is, for example, a digital camera using a solid-state imaging device such as a charge coupled device (CCD) or a complementary metal oxide semiconductor (CMOS). The camera **10** is attached to an arbitrary position on a vehicle (hereinafter referred to as a vehicle M) in which a vehicle system **1** is mounted. The camera **10** includes, for example, a camera imaging a front view, a camera imaging a left-front view, a camera imaging a right-front view, a camera imaging a left-rear view, and a camera imaging a right-rear view. For example, the camera **10** imaging a front view is attached to an upper part of a front windshield, a rear surface of a rearview mirror, or the like. For example, the camera imaging a left-front view is attached to a left A pillar, the vicinity of the A pillar, the vicinity of a left sideview mirror, or the like, the camera imaging a right-front view is attached to a right A pillar, the vicinity of the A pillar, the vicinity of a right sideview mirror, or the like, the camera imaging a left-rear view is attached to a left C pillar, the vicinity of the C pillar, or the like, and the camera imaging a right-rear view is attached to a right C pillar, the vicinity of the C pillar, or the like. The positions to which these cameras are attached are not particularly limited as long as the cameras can image corresponding imaging areas. The camera **10** images the surroundings of the vehicle M, for example, periodically and repeatedly. The camera **10** may be a stereoscopic camera.

[0046] The radar device **12** detects at least a position (a distance and a direction) of an object by radiating radio waves such as millimeter waves to the surroundings of the vehicle M and detecting radio waves (reflected waves) reflected by the object. The radar device **12** is attached to an arbitrary position on the vehicle M. The radar device **12** may detect a position and a speed of an object using a frequency modulated continuous wave (FM-CW) method. The radar device **12** may be attached to, for example, the vicinities of the positions to which the cameras are attached. For example, the camera **10** and the radar device **12** may be attached as a pair.

[0047] The LIDAR device **14** radiates light (or electromagnetic waves of wavelengths close to light) to the surroundings of the vehicle M and measures scattered light. The LIDAR device **14** detects a distance to an object on the basis of a time period from radiation of light to reception of light. The radiated light is, for example, a pulse-like laser beam. The LIDAR device **14** is attached to an arbitrary position on the vehicle M.

[0048] The object recognition device **16** performs a sensor fusion process on results of detection from some or all of the camera **10**, the radar device **12**, and the LIDAR device **14** and recognizes a position, a type, a speed, and the like of an object. The object recognition device **16** outputs the result of recognition to the driving support device **100**. The object recognition device **16** may output the results of detection from the camera **10**, the radar device **12**, and the LIDAR device **14** to the driving support device **100** without any change. The object recognition device **16** may be omitted from the vehicle system **1**. Some or all of the camera **10**, the radar device **12**, the LIDAR device **14**, and object recognition device **16** are examples of a "detection device."

[0049] The HMI **30** presents various types of information to an occupant of the vehicle M and receives an input operation from the occupant. The HMI **30** includes various types of display devices, a speaker, a buzzer, a vibration generator (a vibrator), a touch panel, a switch, and keys. The vibration generator causes a seat belt of a driver's seat to vibrate or causes a steering wheel to vibrate, for example, under the control of the driving support device **100**. The HMI is an example of an "information provision device" or an "information output device." The vehicle sensor **40** includes a vehicle speed sensor detecting a speed of the vehicle M, an acceleration sensor detecting an acceleration, a yaw rate sensor detecting an angular velocity around a vertical axis, and a direction sensor detecting a direction of the vehicle M.

[0050] A navigation device **50** includes, for example, a global navigation satellite system (GNSS) receiver, a guidance controller, and a storage storing map information.

[0051] The GNSS receiver identifies a position of the vehicle M on the basis of signals received from GNSS satellites. The position of the vehicle M may be identified or complemented by an inertial navigation system (INS) using the output of the vehicle sensor **40**. For example, the guidance controller determines a route from the position of the vehicle M identified by the GNSS receiver (or an input arbitrary position) to a destination input by an occupant with reference to the map information and causes the HMI **30** to output guidance information such that the vehicle M travels along the route. The map information is, for example, information in which a road shape is expressed by links indicating a road and nodes connected by the inks. The map information may include a curvature of a road and point of interest (POI) information. The navigation device **50** may transmit a current position and a destination of the vehicle M to a navigation server via a communication device and acquire a route from the navigation server.

[0052] The cabin camera **52** is, for example, a digital camera using a solid-state imaging device such as a CCD or a CMOS. The cabin camera **52** is attached to a position on the vehicle M at which an occupant (for example, a driver sitting on a driver's seat) of the vehicle M can be imaged. For example, the cabin camera **52** images an imaging area with a predetermined period.

[0053] The driving operator **80** includes, for example, an accelerator pedal, a brake pedal, a steering wheel, a shift lever, and other operators. A sensor detecting an amount of operation or whether an operation has been performed is attached to the driving operator **80**. Results of detection from the sensor are output to some or all of the travel driving force output device **200**, the brake device **210**, and the steering device **220**.

[0054] The travel driving force output device **200** outputs a travel driving force (a torque) for allowing the vehicle to travel to driving wheels. The travel driving force output device **200** includes, for example, a combination of an internal combustion engine, an electric motor, and a transmission and an electronic control unit (ECU) that controls them. The ECU controls the elements on the basis of information input from the driving support device **100** or information input from the driving operator **80**.

[0055] The brake device **210** includes, for example, a brake caliper, a cylinder that transmits a hydraulic pressure to the brake caliper, an electric motor that generates a hydraulic pressure in the cylinder, and an ECU. The ECU controls the electric motor on the basis of the information input from the driving support device **100** or the information input from the driving operator **80** such that a brake torque based on a braking operation is output to vehicle wheels. The brake device **210** may include a mechanism for transmitting a hydraulic pressure generated by an operation on the brake pedal included in the driving operator **80** to the cylinder via a master cylinder as a backup. The brake device **210** is not limited to the above-mentioned configuration, and may be an electronically controlled hydraulic brake device that controls an actuator on the basis of the information input from the driving support device **100** such that the hydraulic pressure of the master cylinder is transmitted to the cylinder.

[0056] The steering device **220** includes, for example, a steering ECU and an electric motor. The electric motor changes a direction of turning wheels, for example, by applying a force to a rack-and-pinion mechanism. The steering ECU drives the electric motor on the basis of the information input from the driving support device **100** or the information input from the driving operator **80** to change the direction of the turning wheels. For example, the steering device **220** or the steering wheel may serve as an "information provision device" or an "information output device" that notifies or informs the driver of information. For example, when avoidance of a risky object which will be described later is proposed to a user by rotating the steering wheel or temporarily fixing the steering wheel to a position to which the steering wheel rotates by a predetermined angle, the steering device or the steering wheel serves as an "information provision device" or an "information output device."

[0057] Driving Support Device

[0058] The driving support device **100** includes, for example, a recognizer **110**, a notification controller **120**, a first controller **140**, and a second controller **150**. The notification controller **120** includes, for example, a risk determiner **122**, a direction determiner **124**, an object recognition determiner **126**, an action determiner **128**, a setter **130**, an information processor **132**, and an information provider **134**. These functional units are realized, for example, by causing a hardware processor such as a central processing unit (CPU) to execute a program (software). Some or all of such elements may be realized by hardware (a circuit part including circuitry) such as a large scale integration (LSI) device, an application-specific integrated circuit (ASIC), or a field-programmable gate array (FPGA), or a graphics processing unit (GPU) or may be cooperatively realized by software and hardware. The program may be stored in a storage device (a storage device including a non-transitory storage medium) such as an HDD or a flash memory of the driving support device **100** in advance or may be stored in a removable storage medium such as a DVD or a CD-ROM and installed in the HDD or the flash memory of the driving support device **100** by attaching the removable storage medium (a non-transitory storage medium) to a drive device.

[0059] Settings in the travel driving force output device **200**, the brake device **210**, and the steering device **220** are performed such that instructions for the travel driving force output device **200**, the brake device **210**, and the steering device **220** from the driving support device **100** are executed with higher priority than the results of detection from the driving operator **80**. When a braking force based on an amount of operation on the brake pedal is greater than an instruction from the driving support device **100**, braking may be set such that the former is preferentially executed. As a structure for preferentially executing the instruction from the driving support device **100**, a communication priority in an onboard LAN may be used.

[0060] Process when risky object is present

[0061] When a risky object is present in front of the vehicle M, the driving support device **100** performs various types of processes on the basis of an index value indicating a degree of closeness of the vehicle M to the risky object and threshold values.

[0062] The "degree of closeness" is expressed by various index values indicating a degree of closeness between objects. For example, the "degree of closeness" is a time-to-collision (TTC) which is an index value calculated by dividing a distance by a relative speed (a direction in which the objects approach each other is defined as positive). When the relative speed is negative (a direction in which the objects are separated from each other), the TTC is set to the infinite. The TTC is an index value indicating that the "degree of closeness" is higher as the value thereof becomes lower. When a "first condition" is satisfied, it means, for example, that the TTC is less than a first threshold value Th**1**. The first threshold value Th**1** is, for example, about 1 comma number [sec]. Instead of the TTC, an index value having the same characteristics such as vehicle time headway (THW) or another index value may be used as the "degree of closeness." A TTC adjusted in consideration of acceleration or jerk may be used as the "degree of closeness." In the following description, the "degree of closeness" is assumed to be the TTC.

[0063] A risky object is, for example, an object which is to be avoided by the vehicle M. Examples of the risky object include an object interfering with the vehicle M when the vehicle moves in a current state and an object with a likelihood of interference. The object with a likelihood of interference is, for example, an object of which a degree of closeness after a predetermined time period is equal to or greater than a predetermined degree in consideration of a position, a moving direction, and a moving speed of the object and a position, a moving method, and a moving speed of the vehicle M. The object may be a traffic participant such as a pedestrian, a bicycle, or a vehicle or an object other than a traffic participant, such as an object placed on a road or a fallen object.

[0064] The recognizer **110** recognizes a risky object near the vehicle M on the basis of the information input from the object recognition device **16**. Recognition means, for example, that a risky object classified as described above is present and thus a relative position of the risky object with respect to the vehicle M is recognized. For example, the recognizer **110** tracks the recognized object.

[0065] The risk determiner **122** determines a direction in which there is a risk, for example, on the basis of the position of the risky object. For example, the risk determiner **122** determines that a risk is present in front of the vehicle M when a risky object is present in front of the vehicle M.

[0066] For example, the direction determiner **124** analyses an image captured by the cabin camera **52** and determines a direction of a driver's face or a direction of a driver's sightline on the basis of the result of analysis.

[0067] The object recognition determiner **126** determines (estimates) whether the driver has seen the risky object. For example, information indicating a correlation between a driver's sightline direction (an effective field of view in the sightline direction) in an image and a position of an object with respect to the vehicle M is stored in the storage device of the driving support device **100** in advance. The object recognition determiner **126** determines whether the determined sightline direction in the image matches a direction of a position of a risky object with reference to the information indicating the correlation, determines that the driver sees the risky object when both match, and determines that the driver does not see the risky object when both do not match. For example, when the driver sees a sideview mirror or a lateral side (when the sightline or the face faces the sideview mirror or the lateral side), it is determined that the driver has seen an object supposed to appear in the sideview mirror or an object present on the lateral side. The object recognition determiner **126** may derive a score based on the number of matching times or the time of matching and determine that the driver has seen the risky object when the score is equal to or greater than a threshold value. For example, when the driver sees the rearview mirror (when the sightline faces the rearview mirror), it may be determined that the driver has seen an object supposed to appear in the rearview mirror. Instead of the aforementioned process, whether the driver has seen the risky object may be determined using a predetermined algorithm.

[0068] The action determiner **128** determines an action of the driver. The action is, for example, an operation state of the accelerator pedal, an operation state of the steering wheel, or an operation state of the brake pedal. The action determiner **128** determines the action of the driver, for example, on the basis of results of detection from a sensor detecting amounts of operation of the accelerator pedal, the brake pedal, and the steering wheel or whether an operation is performed.

[0069] The setter **130** sets an area for a mobile object M according to behavior of the mobile object M. Details for setting of the area will be described later.

[0070] The information processor **132** adds identification information to the object recognized by the recognizer **110**. The information processor **132** adds information indicating whether the driver has seen the object, information indicating whether notification has been performed, or information indicating whether re-notification has been performed to the identification information of the object. The information processor **132** generates and manages information (which is an example of "correlation information") in which the identification information of the object is correlated with information indicating a processing result from the driving support device **100** as described above. This information is stored in the storage device of the driving support device **100**. The information processor **132** predicts a future position of the object on the basis of a position or a position change of the object recognized by the recognizer **110**.

[0071] The information provider **134** provides information on the basis of the determination result from the object recognition determiner **126**, the determination result from the action determiner **128**, the processing result from the setter **130**, the processing result from the information processor **132**, and the like. For example, notification or warning is output. Details thereof will be described later.

[0072] Notification timing FIG. **2** is a diagram showing a notification timing at which a risky object is present. When a risky object is present, the information provider **134** displays a risk indication indicating a direction in which the risky object is present on a display. FIG. **3** is a diagram showing an example of a risk indication. For example, as shown in FIG. **3**, contents with which a direction (D**1** in the drawing) in which a risky object is present with respect to the vehicle M can be recognized are displayed. The information provider **134** provides the risk indication to the driver, for example, until the TTC reaches a second threshold value Th**2**. The second threshold value Th**2** is, for example, about 3 [sec] or less or greater than about 3 [sec]. The risk indication, an overlook notification which will be described later, and an action-proposing notification which will be described later are an example of a "third process."

[0073] The information provider **134** provides an overlook notification when the driver does not see a risky object until the TTC reaches a third threshold value Th**3**. The overlook notification is a notification for notifying that the driver is not seeing the risky object. FIG. **4** is a diagram showing an example of an overlook notification. For example, as shown in FIG. **4**, contents with which a direction (D**2** in the drawing) in which a risky object is present with respect to the vehicle M can be recognized are displayed. For example, a direction in which the risky object is present is notified in a more emphasized mode than the mode shown in FIG. **3**. The emphasized mode may be, for example, a mode in which the driver becomes more likely to face a direction in which a more risky object is present such as emphasis by a color or emphasis by flicking or turning on an icon or the like. For example, the information provider **134** provides an overlook notification to the driver from a time point at which the TTC has reached the third threshold value Th**3** to a time point at which the TTC has reached the second threshold value Th**2**. For example, the overlook notification is continuously provided even if a risky object is seen when the TTC is between the third threshold value Th**3** and the second threshold value Th**2**. The third threshold value Th**3** is, for example, about 4 [sec] or less or greater than about 4 [sec].

[0074] The information provider **134** provides an action-proposing notification (a fourth process) when the driver sees a risky object (when it is estimated that the driver has seen a risky object) and the driver does not perform a predetermined action until the TTC reaches the third threshold value Th**3**. The action-proposing notification is a notification for proposing that the driver perform an action to avoiding the risky object. The information provider **134** provides the action-proposing notification to the driver, for example, from a time point at which the TTC reaches the third threshold value Th**3** to a time point at which the TTC reaches the second threshold value Th**2**. For example, the action-proposing notification is continuously provided even if the driver performs an action based on the action-propos-

ing notification when the TTC is between the third threshold value Th**3** and the second threshold value Th**2**.

[0075] The predetermined action is, for example, an action corresponding to deceleration or turning. The predetermined action means, for example, that the brake pedal is operated or that the steering wheel (an operator for performing steering) is operated in the direction in which a risky object is avoided. The predetermined action means that an amount of operation on the accelerator pedal is less by a predetermined value than the amount of operation before a predetermined time or that an operation on the accelerator pedal is released. Release means that the driver stops the operation on the accelerator pedal such that the amount of operation is zero or close to zero.

[0076] FIG. **5** is a diagram showing an example of the action-proposing notification. For example, as shown in FIG. **5**, contents with which a direction (D**3** in the drawing) in which a risky object is present with respect to the vehicle M can be recognized as shown in FIG. **3** (or FIG. **4**) are displayed. As shown in FIG. **5**, contents with which a direction (D**4** in the drawing) in which the vehicle M travels to avoid the risky object can be recognized by the driver are displayed. The contents include information indicating an action to be performed by the driver as the action-proposing notification. In FIG. **5**, an icon (A**1** in the drawing) for prompting the driver to operate the brake pedal to decelerate the vehicle is displayed.

[0077] The action-proposing notification may not be an indication, but may be a notification based on speech, voice, sound, a notification (a notification based on fixing the steering wheel to a position at which the steering wheel rotates by a predetermined angle in a direction parallel to the traveling direction or a notification based on rotating the steering wheel by a predetermined angle or returning the steering wheel to the original position) based on the driver's recognizing a traveling direction by automatically steering the steering wheel in a progress direction, a notification by strengthening a binding force of a seat belt by controlling a pre-tensioner mechanism of the driver's seat belt, or a notification by causing the seat belt to vibrate. The information provider **134** provides an action-proposing notification to the driver, for example, from a time point at which the TTC reaches the third threshold value Th**3** to a time point at which the TTC reaches the second threshold value Th**2**.

[0078] Here, the predetermined action means that an amount of operation on the accelerator pedal is less by a predetermined value than the amount of operation before a predetermined time or that an operation on the accelerator pedal is released. The driver tends to perform an action for avoidance after decreasing the amount of operation on the accelerator pedal or stopping the operation on the accelerator pedal when the driver does not perform an action for controlling deceleration or steering, recognizes a risky object, and avoids the risky object. This tendency has been found by analyzing various results of experiment, simulation, or the like. In this way, the information provider **134** can provide information in which the driver's intention is more reflected by determining whether the action-proposing notification is to be provided on the basis of whether the predetermined action has been performed.

[0079] In the aforementioned example, when the driver sees the risky object while the overlook notification is being performed, the overlook notification may be stopped even before the TTC has not reached the second threshold value Th**2**. In the example, when the driver has performed an action based on proposal or a predetermined action while the action-proposing notification is being performed, the action-proposing notification may be stopped even before the TTC reaches the second threshold value Th**2**.

[0080] In the example, when an event in which a risky object is present occurs while the TTC is between the third threshold value Th**3** and the second threshold value Th**2** (for example, when a pedestrian has popped out), the information provider **134** provides a notification along with a risky indication on the basis of the driver's action at that time. For example, the information provider **134** provides the overlook notification when the driver does not see the risky object and provides the action-proposing notification when the driver sees the risky object and performs the predetermined action.

Specific Example 1

[0081] FIG. **6** is a diagram showing an example of a relationship between an event, a driver's action, and information provided in the HMI. It is assumed that the vehicle M travels straight on a road. At this time, it is assumed that a bicycle travels on the left side of the vehicle M. At time T, the driver of the vehicle M sees the bicycle and the driver causes the vehicle M to travel straight while recognizing the bicycle. In this case, the information provider **134** displays a risk indication indicating the direction of the bicycle with respect to the vehicle M on the display. Thereafter, at time T+1, it is assumed that a pedestrian being going to cross a road on the right side of the vehicle M appears. At this time, when the driver does not see the pedestrian, the information provider **134** displays an overlook notification for the pedestrian on the display.

[0082] As described above, the information provider **134** notifies the driver of appropriate information on the basis of the driver's degree of recognition of the surroundings. Accordingly, the driver can control the vehicle M such that the vehicle M avoids the risky object with time to spare.

Specific Example 2

[0083] FIG. **7** is a diagram showing another example of a relationship between an event, a driver's action, and information provided in the HMI. Differences from those shown in FIG. **6** will be mainly described below. At time T+1, it is assumed that a pedestrian being going to cross a road on the right side of the vehicle M appears. At this time, when the driver does not see the pedestrian and does not perform a predetermined action, the information provider **134** provides an action-proposing notification.

[0084] As described above, the information provider **134** notifies the driver of appropriate information on the basis of the driver's degree of recognition of the surroundings and the driver's action. Accordingly, the driver can control the vehicle M such that the vehicle M avoids the risky object with time to spare.

[0085] Flowchart FIG. **8** is a flowchart showing an example of a routine which is performed by the notification controller **120**. In this routine, it is assumed that a risky object is present at a predetermined distance in front of the vehicle M. First, the notification controller **120** determines whether the driver overlooks the risky object (Step S**10**). When the driver overlooks the risky object (when the driver

does not see the risky object), the notification controller **120** performs an overlook notification (Step S**12**).

[0086] When the driver does not overlook the risky object (when the driver sees the risky object), the notification controller **120** determines whether the driver is performing a predetermined action (Step S**14**). When the driver is performing a predetermined action, this routine ends. In this case, for example, a risky indication indicating a direction of a position of the risky object with respect to the vehicle M is displayed on the display.

[0087] When the driver does not perform the predetermined action, the notification controller **120** provides an action-proposing notification (Step S**16**). Thereafter, this routine ends.

[0088] As described above, the notification controller **120** can notify the driver of appropriate information on the basis of the driver's degree of recognition of the surroundings and the driver's action. For example, when the driver is performing the predetermined action, the notification controller **120** does not provide an action-proposing notification and thus it is possible to reduce inconvenience to the driver. Particularly, when the driver's amount of operation on the accelerator pedal decreases or the driver stops the operation on the accelerator pedal, the driver is estimated to perform an action for avoiding a risky object and thus the notification controller **120** curbs notifying the driver. As a result, the notification controller **120** can provide information in which the driver's intention is reflected.

[0089] In the example, the overlook notification or the action-proposing notification is displayed, but the overlook notification and the action-proposing notification may be simultaneously displayed. For example, information indicating that deceleration is to be performed may be notified using the overlook notification or the steering wheel may rotate or vibrate automatically such that the driver recognizes a direction in which the risky object is avoided.

[0090] One or both of the overlook notification and the action-proposing notification may be omitted. For example, the overlook notification may not be performed when the driver overlooks the risky object. The action-proposing notification may also be performed when the driver overlooks the risky object.

[0091] Braking Control

[0092] Routines when the TTC is less than the second threshold value Th**2** and when the TTC is less than the first threshold value Th**1** will be described below with reference to FIG. **9**. FIG. **9** is a diagram showing braking control.

[0093] When a degree of closeness between a risky object and the vehicle M satisfies a predetermined condition (for example, when the TTC is less than the second threshold value Th**2**), the first controller **140** performs a first action for notifying a driver of the vehicle M that the risky object is present. The first action is, for example, an action for instructing the brake device **210** and/or the travel driving force output device **200** to output a braking force for decelerating the vehicle M at a second deceleration B**2** from a time point at which the TTC becomes less than the second threshold value Th**2** to a time point at which the TTC becomes less than the first threshold value Th**1**. The second deceleration B**2** is a deceleration less than a first deceleration B**1** (close to zero). The second threshold value Th**2** is greater than the first threshold value Th**1**. The first action is so-called CDC control. At this time, a warning (FCW) indicating that the vehicle becomes close to the risky object in front may be output. Deceleration using the braking force may be performed when the warning (FCW) has been output for a predetermined time.

[0094] The second controller **150** performs a second action when the TTC is less than the first threshold value Th**1**. The second action is an action for controlling the vehicle M such that the vehicle M does not collide with the risky object (a collision mitigation braking system (CMBS)). For example, the second controller **150** instructs the brake device **210** and/or the travel driving force output device **200** to output a braking force for decelerating the vehicle M at the first deceleration B**1**. The first deceleration B**1** is, for example, a deceleration of about 0 comma number [G] (close to 1). Accordingly, the second controller **150** rapidly decelerates and stops the vehicle M to avoid collision with the risky object. Functions of calculating a brake output, a regenerative control quantity, an engine brake quantity, and the like from the instructed deceleration are provided in the ECU of the brake device **210** or the travel driving force output device **200**, and the ECU determines the control quantities on the basis of the instructed deceleration and the speed of the vehicle M. This technique is known and thus detailed description thereof will be omitted.

[0095] For example, the second controller **150** may determine whether an object is present in a lateral area extending from slightly before the risky object to the rear side of the vehicle and cause the vehicle M to travel in a traveling lane beside the risky object and to avoid the risky object when no object is present in the lateral area. For example, when it is difficult to avoid the risky object using the braking force, the second controller **150** may cause the vehicle to travel in a lateral traveling lane.

[0096] In the example, when the TTC is less than the second threshold value Th**2** or less than the first threshold value Th**1**, the CDC or the CMBS is performed, but a traffic sign detecting function (TSR), a traffic signal detecting function (TLI), a function of detecting or notifying of a vehicle approaching the vehicle M from the right or left side thereof, an automatic steering avoiding function, an emergency braking system, or the like may be started to perform various types of control instead (or in addition) thereof. For example, the traffic sign detecting function (TSR), the traffic signal detecting function (TLI), or the function of detecting or notifying of a vehicle approaching the vehicle M from the right or left side thereof may be started when the vehicle M passes through a crossing, or the automatic steering avoiding function may be started when the vehicle M approaches a pedestrian.

[0097] Notification According to Road Structure.

[0098] The notification controller **120** may skip causing the vehicle M to provide an action-proposing notification according to a road structure. FIG. **10** is a diagram showing another example of the notification mode. For example, when the vehicle M enters a crossing and is going to turn right or turn left and a risky object is a specific type such as a pedestrian, proposing notification may be omitted. In this case, the warning (FCW) and the CDC control may be omitted and the overlook notification may be performed until the TTC reaches the first threshold value Th**1**. This is because it is difficult to predict movement of a pedestrian in the crossing and an action cannot be easily proposed.

[0099] As described above, the notification controller **120** can notify of appropriate information on the basis of the driver's degree of recognition of the surroundings and the

driver's action. As a result, the notification controller **120** can provide information in which the driver's intention is reflected.

[0100] The threshold values Th**1** to Th**3** may be changed according to the speed of the vehicle M and performance or specifications of various devices for recognizing a risky object (specifications or functions of the camera **10**, the radar device **12**, the LIDAR device **14**, the object recognition device **16**, the recognizer **110**, or the like). For example, various devices may be set on the basis of a distance at which an object is recognizable.

[0101] Another example of process associated with overlook notification

[0102] An overlook notification or an overlook re-notification may be provided as follows. The notification controller **120** performs notification when a risky object enters a surrounding area (for example, areas A and B at the time of traveling straight or areas C and D at the time of turning right or turning left which will be described later) and the driver does not see the risky object, and then performs re-notification when the risky object enters a moving area (for example, the area C at the time of traveling straight or the area A at the time of turning right or turning left which will be described later) and the driver does not see the risky object entering a re-notification area. The notification controller **120** performs notification when a risky object moving faster than the aforementioned risky object is predicted to be present (or move) in a surrounding area after a first predetermined time and the driver does not see the risky object, and then performs re-notification when the risky object is predicted to enter the moving area when the driver has seen the risky object or when a second predetermined time has elapsed after the notification has been performed and the driver does not see the risky object predicted to enter the moving area. In the following description, for example, it is assumed that the notification is stopped when the driver sees a risky object after notification has been performed.

[0103] Notification area and re-notification area on straight road FIG. **11** is a diagram showing a notification area and a re-notification area on a straight road. It is assumed that the vehicle M travels in a direction D in a lane LA on the lane LA and a road including the lane LA. The direction D indicates the traveling direction of the vehicle M with respect to the center of gravity P of the vehicle M.

[0104] An area C is an area including the lane LA in which the vehicle M travels and is an area formed by straight lines extending a first predetermined distance in the traveling direction from the center of gravity P with a predetermined angle on the right and left sides about the direction D, straight lines extending a second predetermined distance in parallel to the direction D from the tips of the straight lines, and a straight line connecting the tips of the two straight lines extending the second predetermined distance in parallel to the direction D. The length in the traveling direction of the area C is a distance by which the vehicle M travels for a predetermined time. The predetermined time is in a range of from 4 seconds to 5 seconds and is, for example, 4.5 seconds. Here, the length is equal to or greater than a set minimum distance and less than a set maximum distance. The area C is a re-notification area.

[0105] An area A is an area including the area C and is an area formed by straight lines extending a third predetermined distance in the traveling direction from the center of gravity P with a predetermined angle on the right and left sides about the direction D, straight lines extending a fourth predetermined distance in parallel to the traveling direction D from the tips of the straight lines, and a straight line connecting the tips of the two straight lines extending the fourth predetermined distance in parallel to the traveling direction D.

[0106] An area B is an area adjacent to the area A and the area C. The area B is an area formed by straight lines extending a predetermined distance in the traveling direction from the center of gravity P with a predetermined angle on the right and left sides about the direction D, straight lines extending a fifth predetermined distance in antiparallel to the direction D from the tips of the straight lines, and a straight line connecting the tips of the two straight lines extending the fifth predetermined distance in parallel to the traveling direction D. The areas A, B, and C are notification areas.

[0107] Notification area and re-notification area at crossing FIG. **12** is a diagram showing a notification area and a re-notification area at a crossing. It is assumed that the vehicle M is going to turn left at a crossing. An area A is an area formed by straight lines extending a sixth predetermined distance in the traveling direction from the center of gravity P with a predetermined angle (α) on the right and left sides about the direction D, straight lines extending a seventh predetermined distance in parallel to the traveling direction D from the tips of the straight lines, and a straight line connecting the tips of the two straight lines extending the seventh predetermined distance in parallel to the direction D. A length L**1** in the traveling direction of the area A is a distance by which the vehicle M travels for a predetermined time. The predetermined time is in a range of from 4 seconds to 5 seconds and is, for example, 4.5 seconds. Here, the length is equal to or greater than a set minimum distance and less than a set maximum distance. The area A is a re-notification area.

[0108] An area D is an area adjacent to the area A. The area D is formed by a straight line extending an eighth predetermined distance in the traveling direction from the center of gravity P with a predetermined angle on the left side about the direction D, a straight line extending a ninth predetermined distance in parallel to the direction D from the tip of the straight line, and a straight line connecting the tip of the straight line and the tip of the straight line extending the seventh predetermined distance in the area A, and the straight line extending the seventh predetermined distance.

[0109] An area C is a rectangular area which is set, for example, on the left side of the vehicle M. The area C is an area including a space on the left-front and left-rear sides of the vehicle. A length L**2** in the lateral direction of the area C is, for example, in a range of from 15 m to 20 m. The areas A, D, and D are notification areas.

[0110] FIG. **13** is a diagram showing a notification area and a re-notification area at a crossing. It is assumed that the vehicle M is going to turn right at a crossing. The notification area includes areas A, C, and D. The areas A, C, and D when the vehicle M is going to turn right are inversion of the areas A, C, and D when the vehicle M is going to turn left and thus detailed description thereof will be omitted.

[0111] In the aforementioned example, the driving support device **100** sets areas preset with respect to the vehicle M as the notification area and the re-notification area, but may set the notification area or the re-notification area on the basis

of edges or lane markings of a road, road markings, structures, and the like instead thereof (in addition thereto).

[0112] Outline of routine associated with notification A process of performing notification when a risky object is present in the notification area or the re-notification area and a notification (or warning) process associated with a look-sideways determining process will be described below.

[0113] For example, notification is performed when a risky object OB is present in the area C and the driver does not see the risky object at time T as shown in FIG. **14**, and the notification is stopped when the driver sees the risky object after the notification has been performed. Thereafter, when the risky object is present in the area A at time T+1 as shown in FIG. **15**, re-notification is performed. In this way, when a risky object seen by the driver due to the notification is present in the re-notification area (the area A), re-notification is performed and thus it is possible to more appropriately notify the driver of a nearby object.

[0114] When a first condition is satisfied, the notification controller **120** causes the HMI **30** to output a first warning. The first condition is a condition that the driver's sightline is out of a predetermined range in which the driver is considered to see a view in front of a mobile object M (for example, out of a range corresponding to the front windshield) and a state in which the sightline is out of the range is maintained for a first time (for example, 3 seconds). When a second condition is satisfied, the notification controller **120** causes the HMI **30** to output a second warning. The second condition is a condition that the driver's sightline is out of the range, a risky object to be noticed is present in a reference area (a re-notification area) set with respect to the mobile object M as shown in FIG. **16**, and the state in which the sightline is out of the range is maintained for a second time (for example, 1 second) shorter than the first time.

[0115] The first condition may be a condition that the driver's face direction is out of a predetermined range in which the driver is considered to see a view in front of the mobile object M and a state in which the face direction is out of the range is maintained for the first time. The second condition may be a condition that the driver's face direction is out of the range, a risky object to be noticed is present in a reference area set with respect to the mobile object M, and the state in which the face direction is out of the range is maintained for the second time shorter than the first time.

[0116] FIG. **17** is a diagram schematically showing a routine associated with notification.

[0117] 1. Switching Mode

[0118] The notification controller **120** sets a right turning mode, a left turning mode, or a straight moving mode on the basis of a direction indicator of the vehicle M and the driver's operating angle of the steering wheel. For example, the straight moving mode is set when the direction indicator does not flick, and the left turning mode is set when the direction indicator flicks such that the vehicle M move leftward. The right turning mode is set when the steering wheel is operated rightward and the operating angle is equal to or greater than a threshold value, the left turning mode is set when the steering wheel is operated leftward and the operating angle is equal to or greater than the threshold value, and the straight moving mode is set otherwise. When a flicking state of the direction indicator and an operating state of the steering wheel do not match, the mode is determined with higher priority given to the operation of the steering wheel.

[0119] 2. Setting of Area

[0120] The notification controller **120** sets areas based on the mode determined in (1. Switching of mode). Accordingly, a notification area and a re-notification area are set.

[0121] 3. Prediction of Risk

[0122] The notification controller **120** acquires a current position and a predicted position of an object on the basis of results of detection of the object (an ID, a position, a speed, and a type of the object). Examples of the type of an object include a vehicle with four wheels, a vehicle with two wheels, a bicycle, and a pedestrian.

[0123] 4. Matching Between Sightline and Object

[0124] The notification controller **120** determines whether the driver's sight line matches a direction in which an object is present.

[0125] 5. Notification/Re-Notification Filtering Process

[0126] The notification controller **120** performs a notification/re-notification filtering process on the basis of the result of matching between a sightline and an object for determining whether the sightline is directed to a risky object. The notification controller **120** selects a risky object of which an overlook notification or an overlook re-notification is provided.

[0127] 6. Look-Sideways Determining Process

[0128] The notification controller **120** determines whether the driver is looking off on the basis of the driver's sightline or face direction.

[0129] "Details of (2. Setting of Area)"

[0130] FIG. **18** is a diagram showing an area setting process. The notification controller **120** sets a notification area and a re-notification area at the time of turning right when the right turning mode is set in the (1. Switching of mode) (Step S**100**). The notification controller **120** sets the area A as the re-notification area (Step S**102**) and sets the areas A, C, and D as the notification area (Step S**104**).

[0131] The notification controller **120** sets a notification area and a re-notification area at the time of turning left when the left turning mode is set in the (1. Switching of mode) (Step S**110**). The notification controller **120** sets the area A as the re-notification area (Step S**112**) and sets the areas A, C, and D as the notification area (Step S**114**). The notification controller **120** sets a notification area and a re-notification area at the time of moving straight when the right turning mode and the left turning mode are not set in the (1. Switching of mode) (in the other case) (Step S**120**). The notification controller **120** sets the area C as the re-notification area (Step S**122**) and sets the areas A, B, and C as the notification area (Step S**124**).

[0132] "Details of 3. Prediction of Risk"

[0133] FIG. **19** is a diagram showing a risk predicting process. The notification controller **120** determines whether an object is present in a predetermined area and is moving at a predetermined speed or higher on the basis of results of detection of the object (Step S**130**). The predetermined area is an area including a notification area and a re-notification area and an area larger than the notification area and the re-notification area. The predetermined area is an area which is set in advance with respect to the vehicle M. The predetermined area may vary depending of the mode of the vehicle M.

[0134] When an object is present in the predetermined area and is moving at the predetermined speed or higher, the notification controller **120** predicts a position of the object after a predetermined time elapses (Step S**132**). For

example, the notification controller **120** predicts the position of the object (a fast object) at a plurality of time points in the future on the basis of the speed of the object. Accordingly, as shown in FIG. **20**, an object approaching the vehicle M from a location far from the vehicle M is recognized.

[0135] "Details of **5**. Notification/Re-Notification Filtering Process"

[0136] FIG. **21** is a diagram showing the notification/re-notification filtering process. The notification controller **120** acquires an object of which an overlook notification is to be provided (an object which is not seen by the driver) and an object of which an overlook re-notification is to be provided (an object which is not re-seen by the driver) with reference to a position of an object, information indicating whether an object is seen by the driver, a notification area, and a re-notification area (Step S**140**). The object which is not re-seen is an object that enters the re-notification area after the overlook notification has been provided and is not seen by the driver. The notification controller **120** has a forgetting function. For example, the forgetting function is a function of forgetting information correlated with a risky object entering the notification area (for example, information indicating that overlook notification has been performed or information indicating that overlook re-notification has been performed) when a predetermined time has elapsed after the risky object has exited the notification area. The same routine is performed when an object entering the re-notification area exits. The notification controller **120** selects an object of which an overlook notification is to be provided in the notification area with reference to the information acquired in Step S**140** and information indicating a current position and a predicted position of an object in the notification area (Step S**142**). For example, when an object present in the notification area or a predicted position of the object present in the notification area is present in the notification area for a predetermined time or longer, the object is selected as a notification target. Accordingly, an object which is present in the notification area and which is not seen is selected.

[0137] The notification controller **120** selects an object of which the overlook notification is to be provided outside of the notification area with reference to the information acquired in Step S**140** and the information indicating a current position and a predicted position of an object (Step S**144**). Accordingly, an object which is currently present outside of the notification area, is predicted to enter the notification area in the near future, and is not seen (for example, a fast object) is selected.

[0138] The notification controller **120** selects an object which is present in the re-notification area and an object which is predicted to enter the re-notification area with reference to the information acquired in Step S**140** and the information indicating a current position and a predicted position of an object (Step S**146**). Accordingly, an object which is currently present in the re-notification area or is predicted to be present close to the re-notification area in the near future and is not seen is selected. As described above, an object of which the overlook notification is to be provided and an object of which overlook re-notification is to be provided are selected.

[0139] "Details of process of selecting object for overlook notification outside of notification area (S**144**)"

[0140] FIG. **22** is a diagram showing the process (S**144**) of selecting an object of which an overlook notification is to be provided outside of the notification area. The notification controller **120** acquires information of a current position and a predicted position of a fast object and information of the notification area and determines whether the current position or the predicted position of the target object is continuously present in the notification area for predetermined frames or more (a predetermined time or longer) (Step S**150**).

[0141] When the current position or the predicted position of the target object is not continuously present in the notification area for the predetermined frames or more, the notification controller **120** stores the object along with the determination result as an object outside of the notification area in a list in the storage device (Step S**152**). When the current position or the predicted position of the target object is continuously present in the notification area for the predetermined frames or more, the notification controller **120** stores the object along with the determination result as an object in the notification area in a list in the storage device (Step S**154**).

[0142] The notification controller **120** determines whether the overlook notification and the overlook re-notification of the object are not performed and the determination result of Step S**150** is "YES" with reference to the overlook notification and the overlook re-notification stored for each object and the determination result of Step S**150** (Step S**156**). When this condition is satisfied, the notification controller **120** performs overlook notification of the object. When this condition is not satisfied, the notification controller **120** stores the object along with the determination result as an object outside of the notification area in a list in the storage device (Step S**158**). For example, this object is stored in a list as an object seen by the driver.

[0143] Even when a fast object outside of the notification area is predicted to enter the notification area as described above, an appropriate notification is provided to the driver. "Details of process of selecting object for re-notification (S**146**)"

[0144] FIG. **23** is a diagram showing the process (S**146**) of selecting an object for re-notification. The notification controller **120** acquires information of each object of which the overlook notification has been provided (information of an object which is present in the notification area and of which the overlook notification has been provided), information of the current position thereof, and information indicating whether the driver has seen the object and determines whether the object of which the overlook notification has been provided is seen again (matched with the sightline) after the driver has seen the object with reference to the information (Step S**160**).

[0145] When the driver does not see the object again, the notification controller **120** determines whether an overlook re-notification of the object has been provided with reference to history information of the overlook re-notification of each object (Step S**162**). When the overlook re-notification has not been provided, the notification controller **120** determines whether the current position of the object is continuously present in the re-notification area for predetermined frames or more with reference to the information of the re-notification area (Step S**164**).

[0146] When the current position of the object is continuously present in the re-notification area for predetermined frames or more, the notification controller **120** provides an overlook re-notification of the object (Step S**164**). When the current position of the object is not continuously present in

the re-notification area for predetermined frames or more, the notification controller **120** stores the object as an object, which is seen after the overlook notification, of which the overlook re-notification has not been provided, and which is not present in the re-notification area, in a list in the storage device.

[0147] In the aforementioned example, when an overlook notification of an object has not been provided and the object is present in the re-notification area, an overlook notification thereof is provided. In the aforementioned example, for example, an overlook re-notification of an object which is continuously present in the re-notification area after a notification thereof has been provided because the object is present in the re-notification area in the notification area may not be provided or the overlook re-notification may be provided. In the aforementioned example, when a risky object in the notification area is continuously present in the notification area for a predetermined time after the overlook notification of the risky object in the notification area has been provided and thus the driver has seen the risky object, the notification thereof may not be performed or the notification may be performed again when a preset time has elapsed. For example, when an object is present outside of the re-notification area for a predetermined time after the overlook re-notification thereof has been provided, information indicating that the overlook re-notification of the object has been provided is forgotten. In this case, when the object re-enters the re-notification area, the overlook re-notification of the object is to be provided. For example, when an object is present outside of the notification area for a predetermined time after the overlook notification thereof has been provided, information indicating that the overlook notification of the object has been provided is forgotten. In this case, when the object re-enters the notification area, the overlook notification of the object is to be provided.

[0148] "Details of **6**. Look-sideways determining process" FIG. **24** is a diagram showing the look-sideways determining process. The notification controller **120** determines whether a sightline has been detected on the basis of an image in which the driver appears (Step S**170**). When it is determined in Step S**170** that the sightline has been detected, determination using the sightline direction or determination using the sightline direction and the face direction is performed. When it is determined in Step S**170** that the sightline has not been detected, determination using the face direction is performed.

[0149] The notification controller **120** determines whether the face is directed to the front on the basis of the image (Step S**172**). For example, the notification controller **120** determines whether a yaw angle and a pitch angle of the face direction (the reference direction) are in the corresponding angle ranges thereof.

[0150] When it is determined that the face is directed to the front, the notification controller **120** sets up a flag indicating that the face is directed to the front (Step S**174**). When it is determined that the face is not directed to the front, the notification controller **120** determines whether a predetermined has elapsed after the determination has been performed (Step S**176**). The predetermined time is, for example, 3 seconds.

[0151] The notification controller **120** determines whether the sightline is directed to the front on the basis of the image (Step S**178**). For example, the notification controller **120** determines whether a yaw angle and a pitch angle of the sightline direction (the reference direction) are in the corresponding angle ranges thereof.

[0152] When it is determined that the sightline is directed to the front, the notification controller **120** sets up a flag indicating that the sightline is directed to the front (Step S**180**). When it is determined that the sightline is not directed to the front, the notification controller **120** determines whether a predetermined has elapsed after the determination has been performed (Step S**182**). The predetermined time is, for example, 3 seconds.

[0153] The notification controller **120** determines whether an object is present in a predetermined area and whether a condition (1) or (2) is satisfied with reference to the detection result of an object and the mode (Step S**184**). The predetermined area is an area which should be recognized by the driver as an area corresponding to each of the right turning mode, the left turning mode, and the straight moving mode. The predetermined area may be, for example, the same as the re-notification area or may be an area including the re-notification area. The condition (1) is a condition that the determination result of Step S**176** is negative, and the condition (2) is a condition that the determination result of S**182** is negative.

[0154] When the determination result of Step S**184** is positive, the notification controller **120** determines whether this state has been maintained for a predetermined time (Step S**186**). When the determination result of Step S**184** is positive, the notification controller **120** sets up a flag indicating that an object is present in the predetermined area. The predetermined time in Step S**186** is a time (for example, 1 second) shorter than the predetermined time in Step S**176** or S**182**.

[0155] When the determination result of Step S**186** is positive, when the determination result of Step S**176** is positive, or when the determination result of Step S**182** is positive, the notification controller **120** determines whether a reset flag is set up and a look-sideways flag is set up (Step S**190**). When the reset flag is set up and the look-sideways is not set up, the notification controller **120** determines whether the look-sideways flags is set up and the look-sideways has not been set up in the previous step (Step S**192**). When this condition is satisfied, the notification controller **120** sets up the look-sideways flag. When the look-sideways flag is set up, a look-sideways notification is provided.

[0156] When this condition is not satisfied, the notification controller **120** sets up the reset flag when a predetermined time has elapsed after the look-sideways flag has been set up (Step S**194**). Accordingly, when the condition that the look-sideways notification is provided is satisfied again (the driver does not see the object) after the look-sideways notification has been provided, notification is curbed until a predetermined time (for example, 3 seconds) elapses after the look-sideways notification has been provided. The predetermined time has only to be equal to or greater than the predetermined time in Step S**186**.

[0157] For example, after a look-sideways notification has been provided, the driver may see the surroundings of the vehicle M which are different from the direction of the position at which the object is present and be going to recognize a space for avoiding the object. Accordingly, since the look-sideways notification is curbed as described above, it is possible to curb troubling of the driver.

[0158] As described above, the notification controller **120** can issue an appropriate notification or warning for the driver's look-sideways.

[0159] According to the aforementioned embodiment, the notification controller **120** can more appropriately notify of a nearby object on the basis of a current position or a predicted position of the object, a notification area, and a re-notification area. The notification controller **120** can more appropriately issue a warning on the basis of the driver's sightline or face direction and a position of a risky object.

[0160] The aforementioned embodiment can be described as follows.

[0161] A control device including:

[0162] a storage medium storing computer-readable instructions; and

[0163] at least one processor connected to the storage medium,

[0164] wherein the at least one processor executes the computer-readable instructions to perform:

[0165] setting a moving area including a trajectory along which a mobile object is scheduled to move with behavior of the mobile object and a surrounding area near the mobile object when the mobile object moves straight, turns right, or turns left;

[0166] controlling an information provision device configured to provide a driver of the mobile object with information such that the driver is notified of presence of a first type of object when a first type of object is present in the surrounding area and the driver does not see the first type of object; and

[0167] controlling the information provision device such that the driver is re-notified of the first type of object when the first type of object is present in the moving area and the driver does not see the first type of object after the driver has seen the first type of object through the notification.

[0168] The aforementioned embodiment can also be described as follows.

[0169] A control device including:

[0170] a storage medium storing computer-readable instructions; and

[0171] at least one processor connected to the storage medium,

[0172] wherein the at least one processor executes the computer-readable instructions to perform:

[0173] detecting a sight line of a driver of a mobile object;

[0174] causing an information output device, which is configured to output a warning to a driver, to output a first warning when a first condition is satisfied; and

[0175] causing the information output device to output a second warning when a second condition is satisfied,

[0176] wherein the first condition is a condition that the driver's sight line is out of a predetermined range in which the driver is considered to see a view in front of the mobile object and a state in which the sightline is out of the range is maintained for a first time, and

[0177] wherein the second condition is a condition that the driver's sightline is out of the range, a risky object to be noticed is present in a reference area set with respect to the mobile object, and the state in which the sightline is out of the range is maintained for a second time shorter than the first time.

[0178] While exemplary embodiments of the present invention have been described above, the present invention is not limited to the embodiments and can be subjected various modifications and substitutions without departing from the gist of the present invention.

What is claimed is:

1. A notification control device comprising:

a storage medium storing computer-readable instructions; and

one or more processors connected to the storage medium,

wherein the one or more processors execute the computer-readable instructions to perform:

detecting a sightline of a driver of a mobile object;

causing an information output device, which is configured to output a warning to a driver, to output a first warning when a first condition is satisfied; and

causing the information output device to output a second warning when a second condition is satisfied,

wherein the first condition is a condition that the driver's sight line is out of a predetermined range in which the driver is considered to see a view in front of the mobile object and a state in which the sightline is out of the range is maintained for a first time, and

wherein the second condition is a condition that the driver's sightline is out of the range, a risky object to be noticed is present in a reference area set with respect to the mobile object, and the state in which the sightline is out of the range is maintained for a second time shorter than the first time.

2. The notification control device according to claim **1**, wherein the one or more processors execute the computer-readable instructions to perform detecting a face direction of the driver,

wherein the first condition is a condition that the face direction of the driver is out of a predetermined range in which the driver is considered to see a view in front of the mobile object and a state in which the face direction is out of the range is maintained for a first time, and

wherein the second condition is a condition that the face direction of the driver is out of the range, a risky object to be noticed is present in a reference area set with respect to the mobile object, and the state in which the face direction is out of the range is maintained for a second time shorter than the first time.

3. The notification control device according to claim **1**, wherein the one or more processors execute the computer-readable instructions to perform:

causing the information output device to output the first warning when the first condition is satisfied after the information output device has output the first warning and a third time longer than the second time elapses after the first warning has been output; and

causing the information output device not to output the first warning when the first condition is satisfied after the information output device has output the first warning and the third time does not elapse after the first warning has been output.

4. The notification control device according to claim **1**, wherein the one or more processors execute the computer-readable instructions to perform:

causing the information output device to output the second warning when the second condition is satisfied after the information output device has output the first warning and a third time longer than the second time elapses after the first warning has been output; and

causing the information output device not to output the second warning when the second condition is satisfied after the information output device has output the first warning and the third time does not elapse after the first warning has been output.

5. The notification control device according to claim **1**, wherein the one or more processors execute the computer-readable instructions to perform:

causing the information output device to output the first warning when the first condition is satisfied after the information output device has output the second warning and a third time longer than the second time elapses after the second warning has been output; and

causing the information output device not to output the first warning when the first condition is satisfied after the information output device has output the second warning and the third time does not elapse after the second warning has been output.

6. The notification control device according to claim **1**, wherein the one or more processors execute the computer-readable instructions to perform:

causing the information output device to output the second warning when the second condition is satisfied after the information output device has output the second warning and a third time longer than the second time elapses after the second warning has been output; and

causing the information output device not to output the second warning when the second condition is satisfied after the information output device has output the second warning and the third time does not elapse after the second warning has been output.

7. The notification control device according to claim **1**, wherein the reference area set with respect to the mobile object is a reference area including a trajectory along which the mobile object is scheduled to move.

8. The notification control device according to claim **7**, wherein the one or more processors execute the computer-readable instructions to perform setting a length of the reference area on the basis of a speed of the mobile object.

9. The notification control device according to claim **8**, wherein the one or more processors execute the computer-readable instructions to perform:

setting the reference area according to behavior of the mobile object when the mobile object moves straight, turns right, or turns left; and

setting a width of the reference area in a traveling direction of the mobile object when the mobile object turns right or left to be longer than a width of the reference area in the traveling direction of the mobile object when the mobile object moves straight.

10. A notification control method that is performed by a computer, the notification control method comprising:

a step of detecting a sightline of a driver of a mobile object;

a step of causing an information output device, which is configured to output a warning to a driver, to output a first warning when a first condition is satisfied; and

a step of causing the information output device to output a second warning when a second condition is satisfied,

wherein the first condition is a condition that the driver's sight line is out of a predetermined range in which the driver is considered to see a view in front of the mobile object and a state in which the sightline is out of the range is maintained for a first time, and

wherein the second condition is a condition that the driver's sightline is out of the range, a risky object to be noticed is present in a reference area set with respect to the mobile object, and the state in which the sightline is out of the range is maintained for a second time shorter than the first time.

11. A non-transitory computer storage medium storing a program, the program causing a computer perform:

a process of detecting a sightline of a driver of a mobile object;

a process of causing an information output device, which is configured to output a warning to a driver, to output a first warning when a first condition is satisfied; and

a process of causing the information output device to output a second warning when a second condition is satisfied,

wherein the first condition is a condition that the driver's sight line is out of a predetermined range in which the driver is considered to see a view in front of the mobile object and a state in which the sightline is out of the range is maintained for a first time, and

wherein the second condition is a condition that the driver's sightline is out of the range, a risky object to be noticed is present in a reference area set with respect to the mobile object, and the state in which the sightline is out of the range is maintained for a second time shorter than the first time.

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