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(54) **DRIVING ASSISTANCE DEVICE, DRIVING ASSISTANCE METHOD, AND STORAGE MEDIUM**

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(57) **ABSTRACT**

The present invention provides a driving assistance device configured to perform driving assistance for a self-vehicle, comprising: an acquisition unit configured to acquire peripheral vehicle information of a peripheral vehicle present around the self-vehicle, from the peripheral vehicle by vehicle-to-vehicle communication; a first prediction unit configured to predict a collision possibility between the self-vehicle and the peripheral vehicle based on self-vehicle information of the self-vehicle and the acquired peripheral vehicle information; a first display unit configured to, when a first state is detected, display attention-calling information for calling attention to approach of the peripheral vehicle in a first period from a timing at which the first state is detected; and a second display unit configured to, when a second state is detected, display direction information indicating an approach direction of the peripheral vehicle.

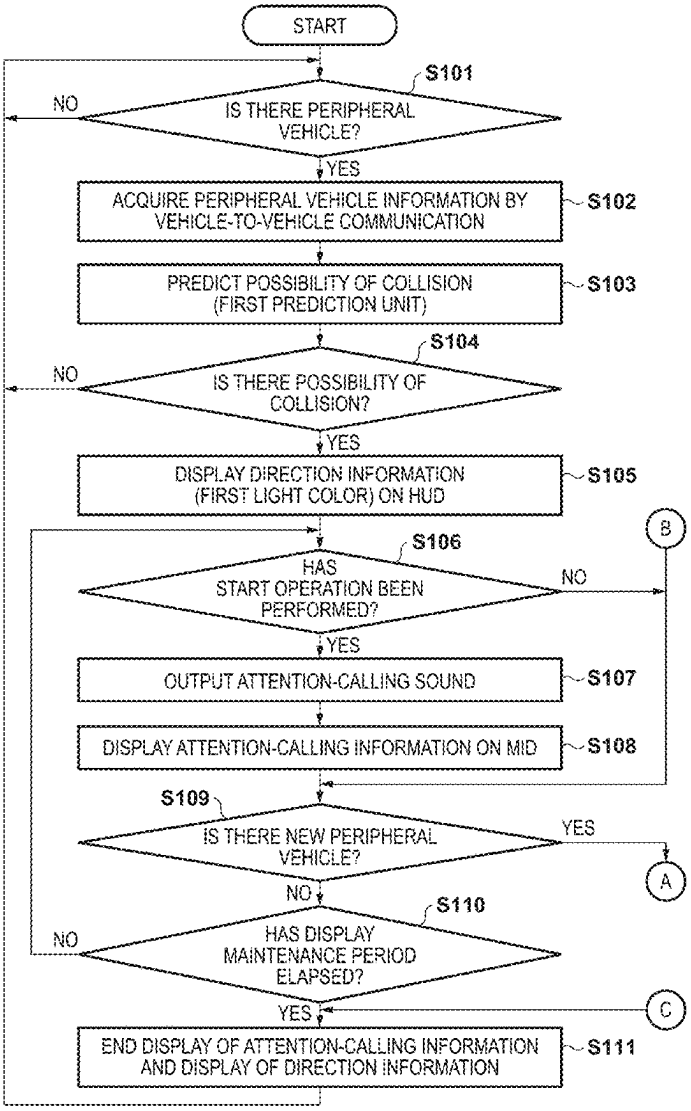


FIG. 1

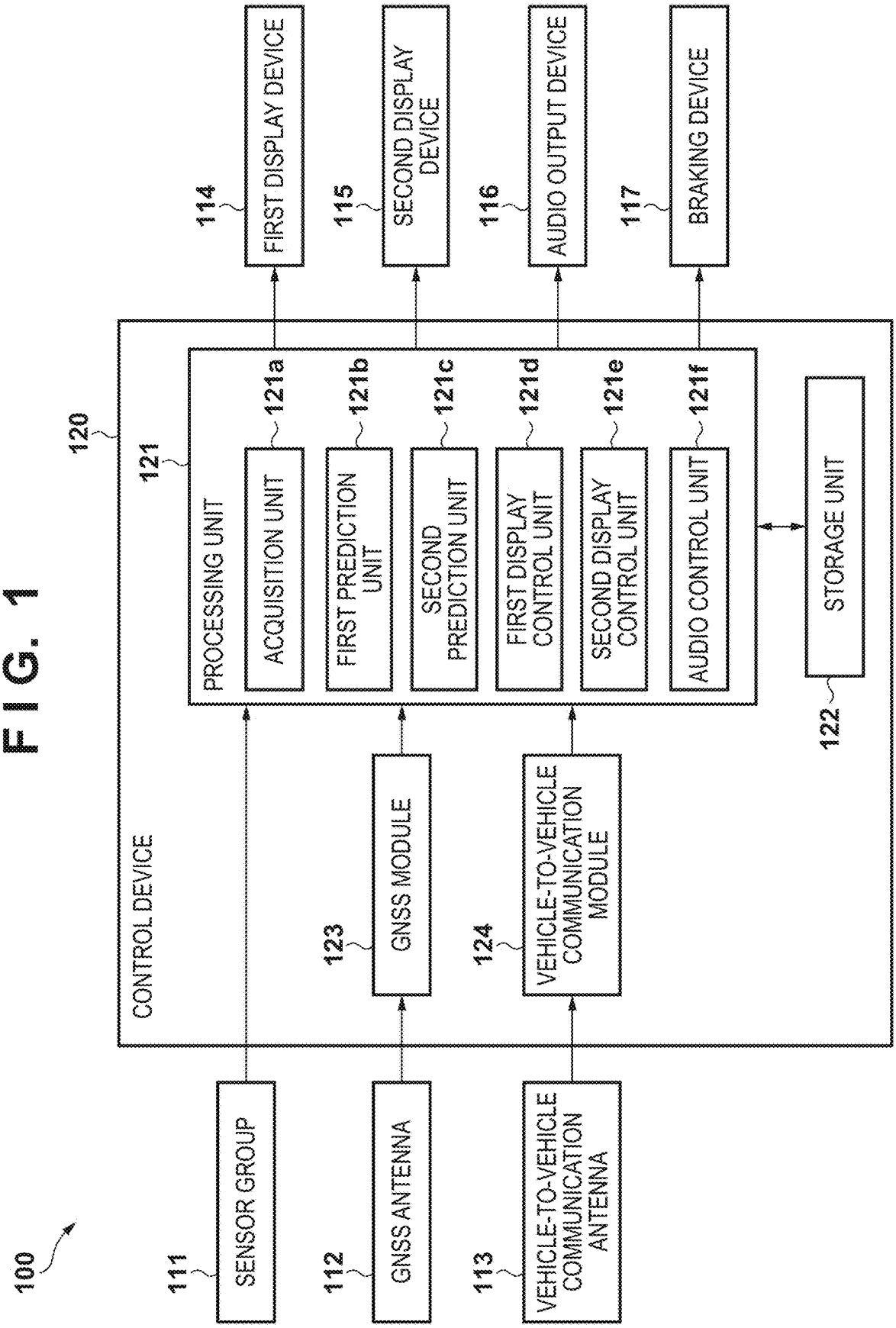

100
111
SENSOR GROUP
112
GNSS ANTENNA
113
VEHICLE-TO-VEHICLE COMMUNICATION ANTENNA
120
CONTROL DEVICE
121
PROCESSING UNIT
121a
ACQUISITION UNIT
121b
FIRST PREDICTION UNIT
121c
SECOND PREDICTION UNIT
121d
FIRST DISPLAY CONTROL UNIT
121e
SECOND DISPLAY CONTROL UNIT
121f
AUDIO CONTROL UNIT
122
STORAGE UNIT
123
GNSS MODULE
124
VEHICLE-TO-VEHICLE COMMUNICATION MODULE
114
FIRST DISPLAY DEVICE
115
SECOND DISPLAY DEVICE
116
AUDIO OUTPUT DEVICE
117
BRAKING DEVICE

FIG. 2

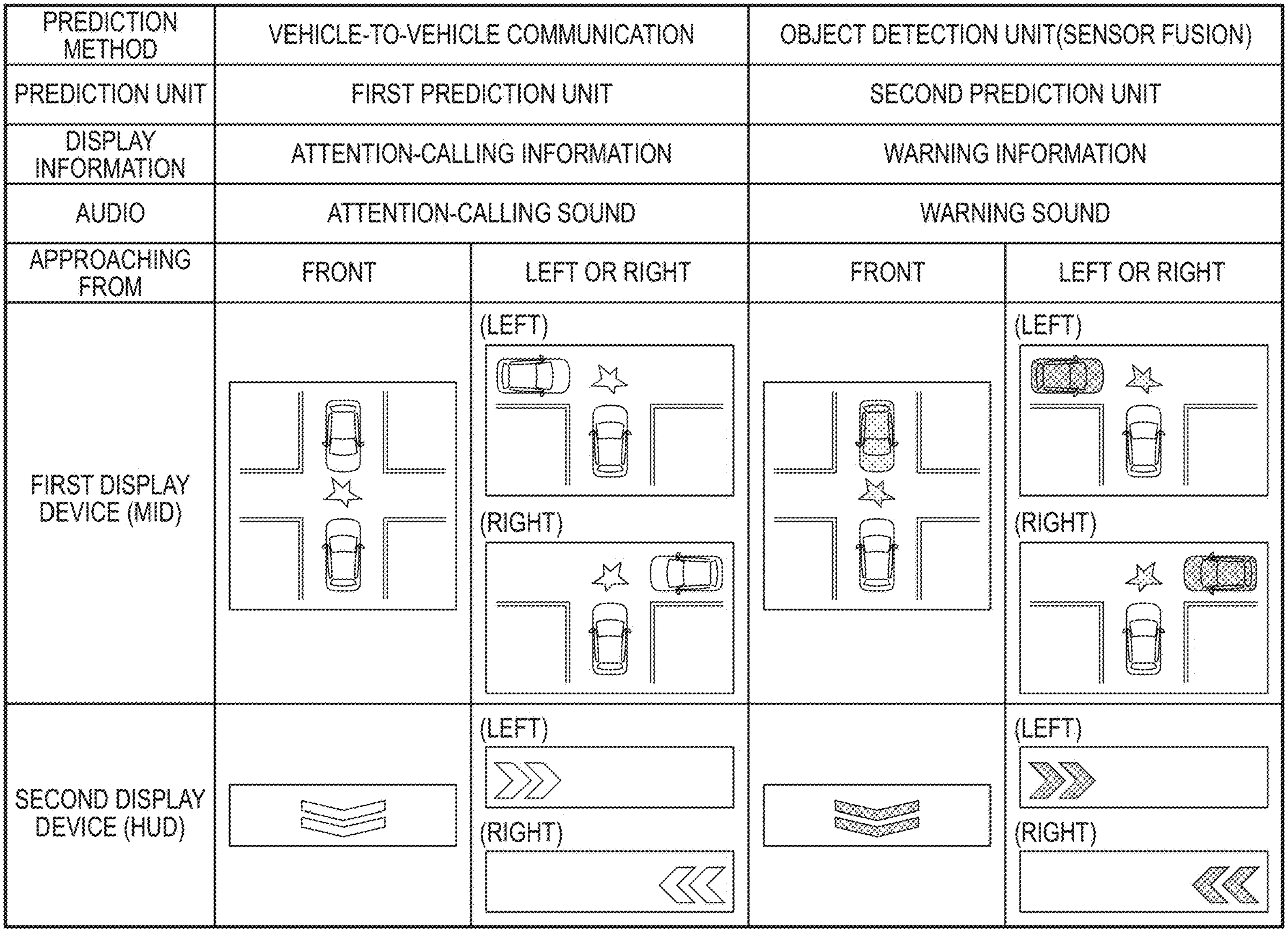

PREDICTION METHOD
VEHICLE-TO-VEHICLE COMMUNICATION
OBJECT DETECTION UNIT(SENSOR FUSION)
PREDICTION UNIT
FIRST PREDICTION UNIT
SECOND PREDICTION UNIT
DISPLAY INFORMATION
ATTENTION-CALLING INFORMATION
WARNING INFORMATION
AUDIO
ATTENTION-CALLING SOUND
WARNING SOUND
APPROACHING FROM
FRONT
LEFT OR RIGHT
FRONT
LEFT OR RIGHT
FIRST DISPLAY DEVICE (MID)
(LEFT)
(RIGHT)
(LEFT)
(RIGHT)
SECOND DISPLAY DEVICE (HUD)
(LEFT)
(RIGHT)
(LEFT)
(RIGHT)

FIG. 3

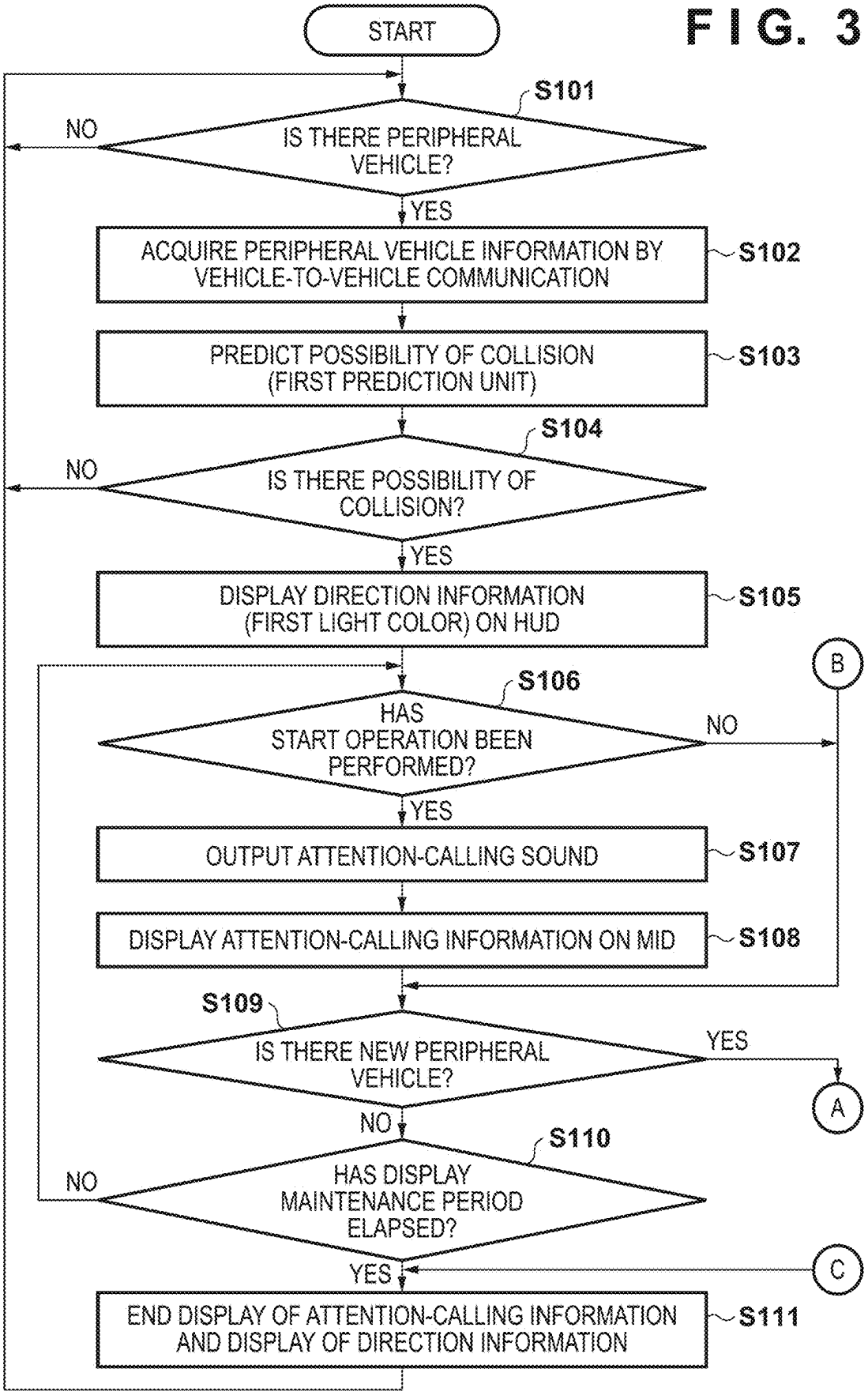

START
S101
IS THERE PERIPHERAL VEHICLE?
NO
YES
ACQUIRE PERIPHERAL VEHICLE INFORMATION BY VEHICLE-TO-VEHICLE COMMUNICATION
S102
PREDICT POSSIBILITY OF COLLISION (FIRST PREDICTION UNIT)
S103
S104
IS THERE POSSIBILITY OF COLLISION?
NO
YES
DISPLAY DIRECTION INFORMATION (FIRST LIGHT COLOR) ON HUD
S105
B
S106
HAS START OPERATION BEEN PERFORMED?
NO
YES
OUTPUT ATTENTION-CALLING SOUND
S107
DISPLAY ATTENTION-CALLING INFORMATION ON MID
S108
S109
IS THERE NEW PERIPHERAL VEHICLE?
YES
A
NO
S110
HAS DISPLAY MAINTENANCE PERIOD ELAPSED?
NO
YES
C
END DISPLAY OF ATTENTION-CALLING INFORMATION AND DISPLAY OF DIRECTION INFORMATION
S111

FIG. 4

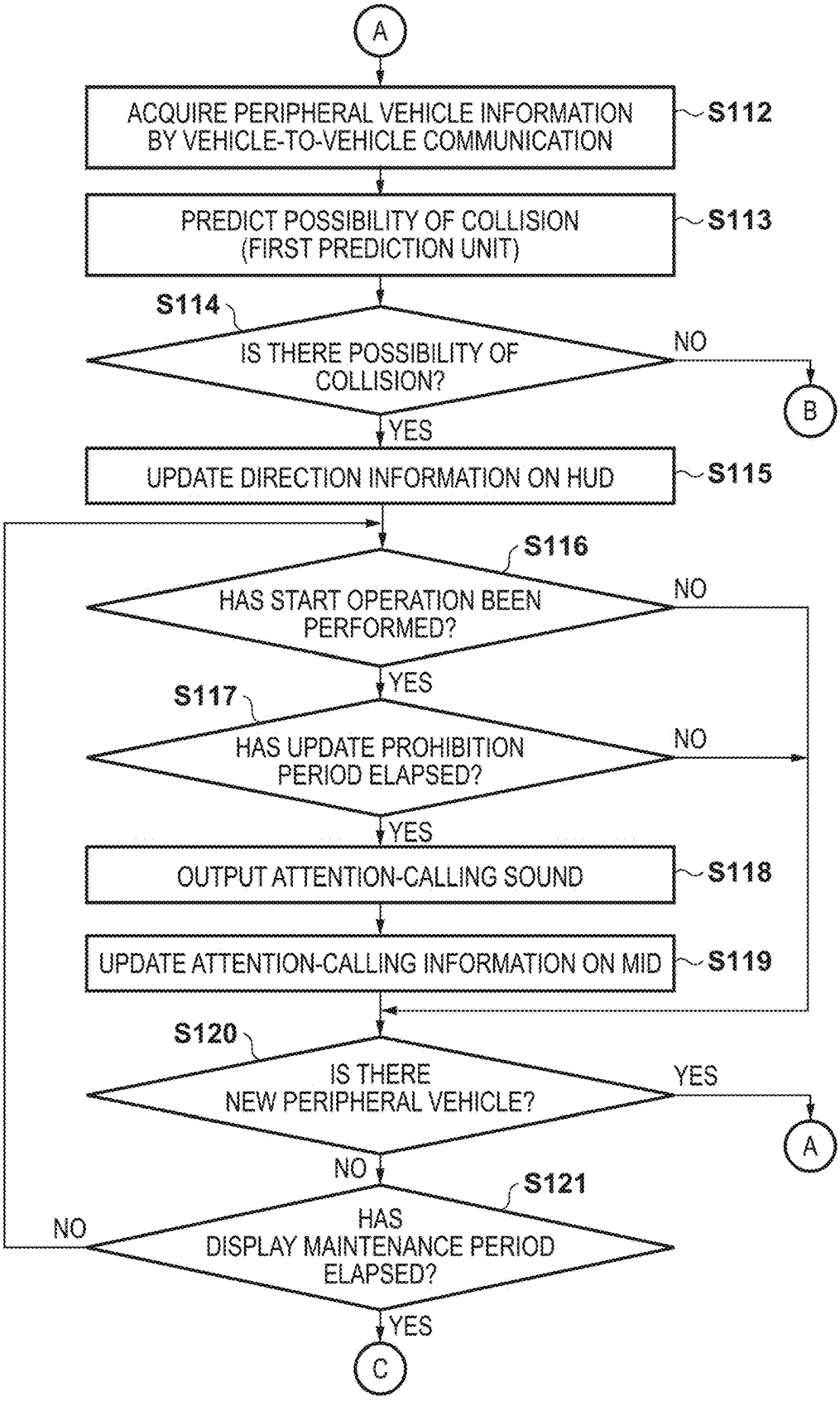

A
ACQUIRE PERIPHERAL VEHICLE INFORMATION BY VEHICLE-TO-VEHICLE COMMUNICATION
S112
PREDICT POSSIBILITY OF COLLISION (FIRST PREDICTION UNIT)
S113
S114
IS THERE POSSIBILITY OF COLLISION?
NO
B
YES
UPDATE DIRECTION INFORMATION ON HUD
S115
S116
HAS START OPERATION BEEN PERFORMED?
NO
YES
S117
HAS UPDATE PROHIBITION PERIOD ELAPSED?
NO
YES
OUTPUT ATTENTION-CALLING SOUND
S118
UPDATE ATTENTION-CALLING INFORMATION ON MID
S119
S120
IS THERE NEW PERIPHERAL VEHICLE?
YES
A
NO
S121
HAS DISPLAY MAINTENANCE PERIOD ELAPSED?
NO
YES
C

FIG. 5

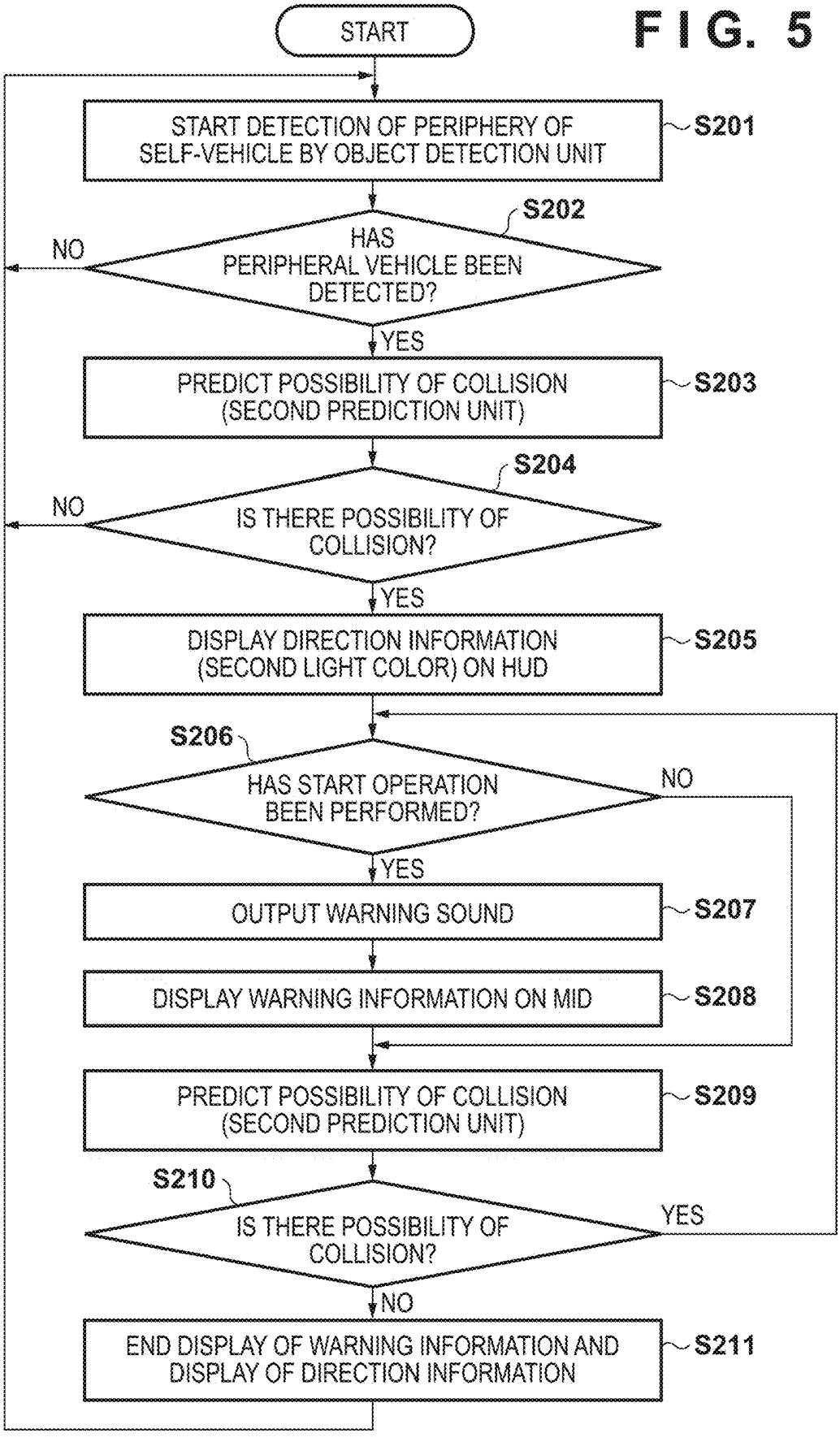

START
START DETECTION OF PERIPHERY OF SELF-VEHICLE BY OBJECT DETECTION UNIT
S201
S202
HAS PERIPHERAL VEHICLE BEEN DETECTED?
NO
YES
PREDICT POSSIBILITY OF COLLISION (SECOND PREDICTION UNIT)
S203
S204
IS THERE POSSIBILITY OF COLLISION?
NO
YES
DISPLAY DIRECTION INFORMATION (SECOND LIGHT COLOR) ON HUD
S205
S206
HAS START OPERATION BEEN PERFORMED?
NO
YES
OUTPUT WARNING SOUND
S207
DISPLAY WARNING INFORMATION ON MID
S208
PREDICT POSSIBILITY OF COLLISION (SECOND PREDICTION UNIT)
S209
S210
IS THERE POSSIBILITY OF COLLISION?
YES
NO
END DISPLAY OF WARNING INFORMATION AND DISPLAY OF DIRECTION INFORMATION
S211

FIG. 6A

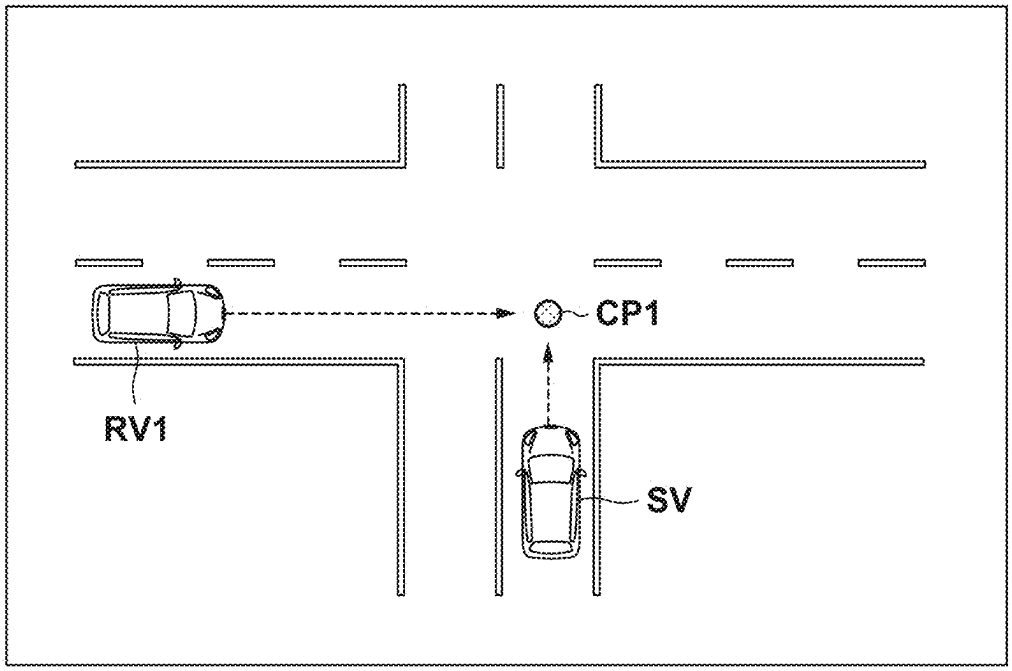


FIG. 6B

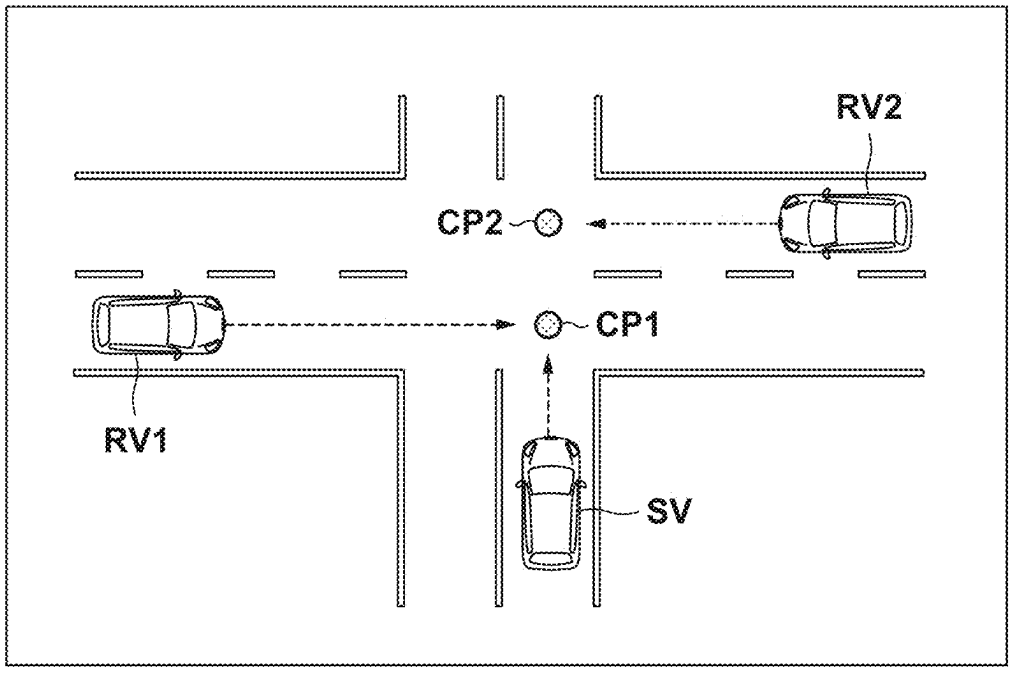


FIG. 7

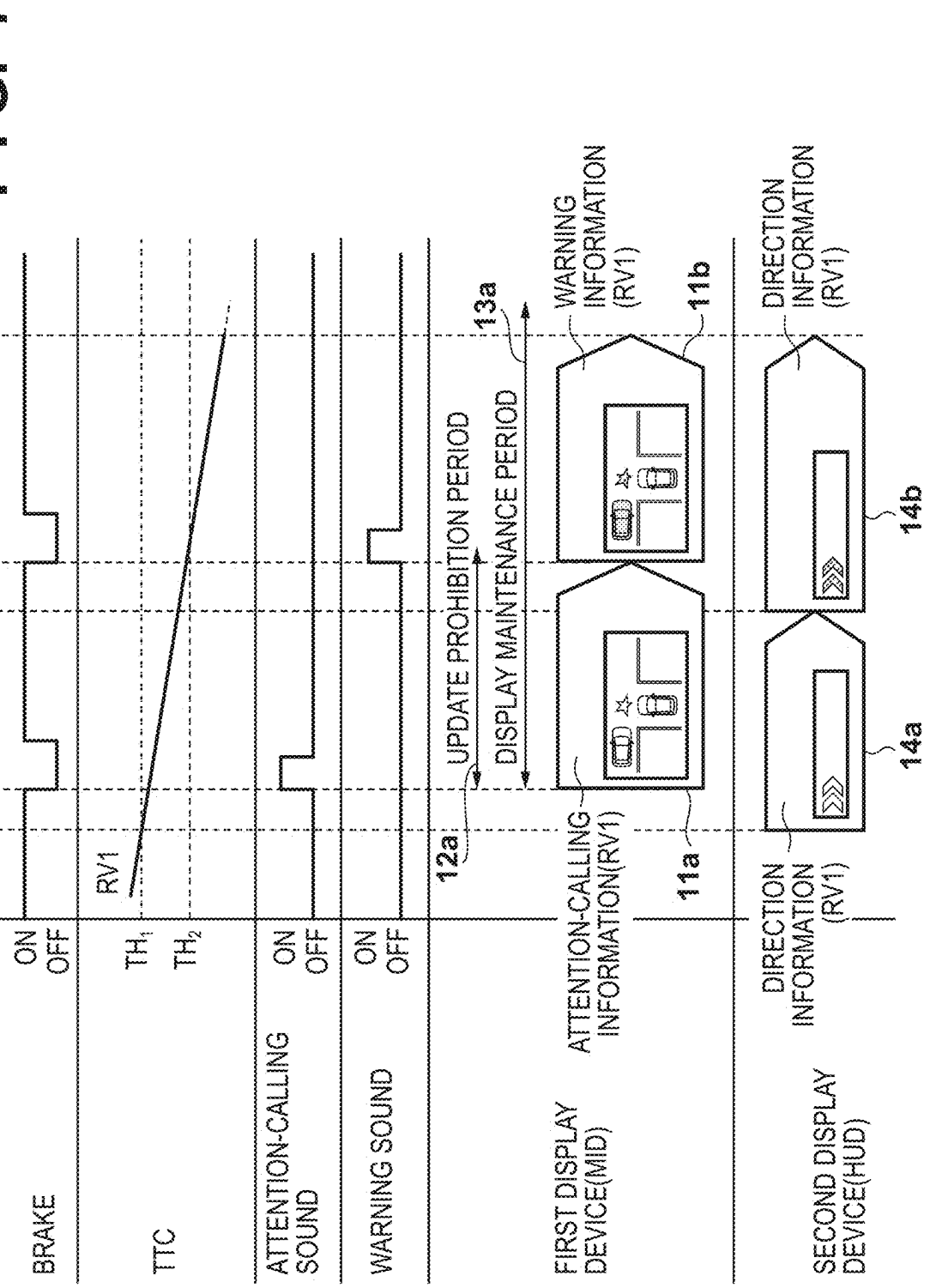

BRAKE
ON
OFF
TTC
RV1
TH1
TH2
ATTENTION-CALLING SOUND
ON
OFF
WARNING SOUND
ON
OFF
t11
t12
t13
t14
t15
12a
UPDATE PROHIBITION PERIOD
13a
DISPLAY MAINTENANCE PERIOD
FIRST DISPLAY DEVICE(MID)
ATTENTION-CALLING INFORMATION(RV1)
11a
WARNING INFORMATION (RV1)
11b
SECOND DISPLAY DEVICE(HUD)
DIRECTION INFORMATION (RV1)
14a
DIRECTION INFORMATION (RV1)
14b

FIG. 8

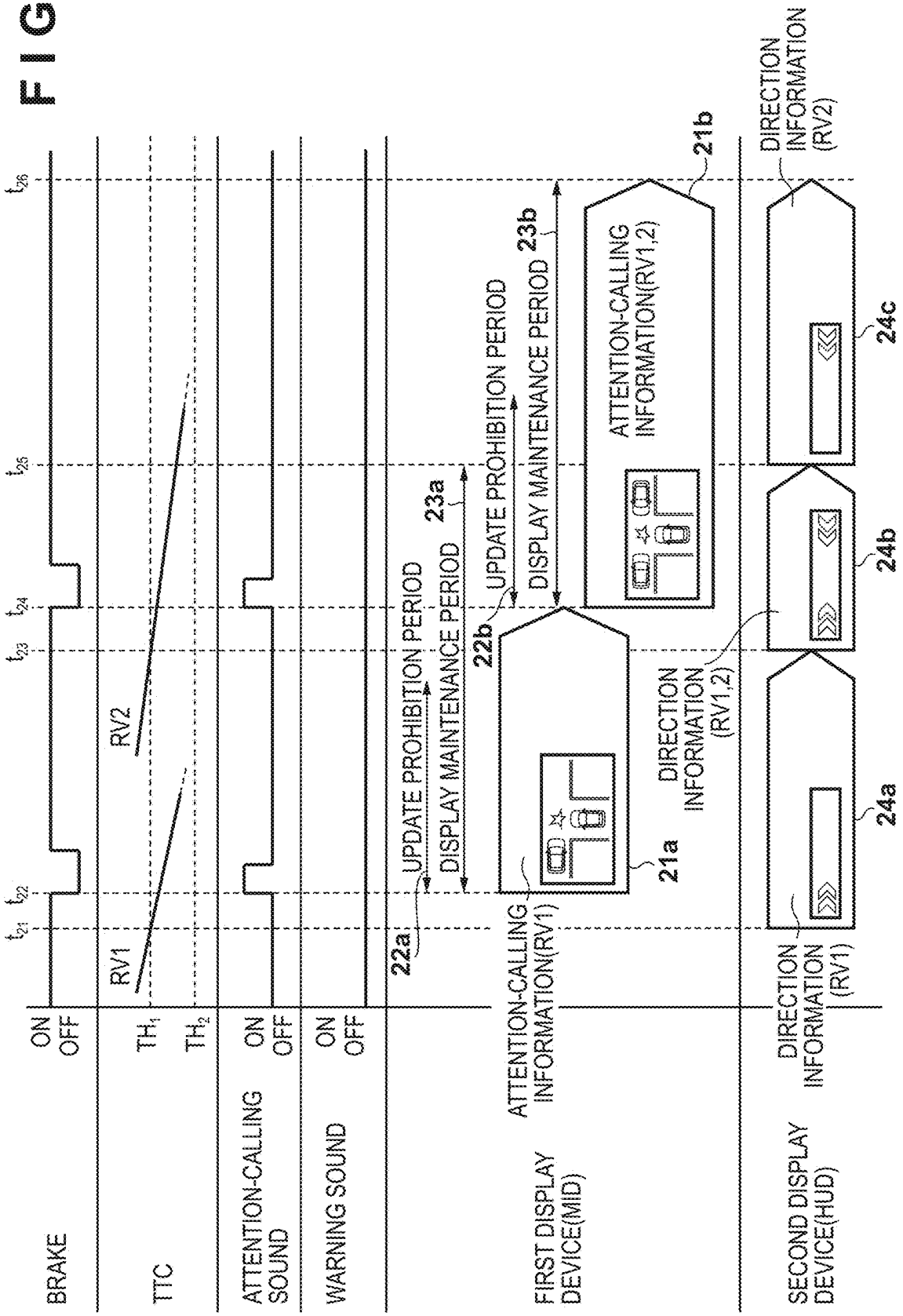

BRAKE
ON
OFF
TTC
RV1
RV2
TH1
TH2
ATTENTION-CALLING SOUND
ON
OFF
WARNING SOUND
ON
OFF
t21
t22
t23
t24
t25
t26
22a
UPDATE PROHIBITION PERIOD
DISPLAY MAINTENANCE PERIOD
23a
22b
UPDATE PROHIBITION PERIOD
DISPLAY MAINTENANCE PERIOD
23b
FIRST DISPLAY DEVICE(MID)
ATTENTION-CALLING INFORMATION(RV1)
21a
DIRECTION INFORMATION (RV1,2)
ATTENTION-CALLING INFORMATION(RV1,2)
21b
SECOND DISPLAY DEVICE(HUD)
DIRECTION INFORMATION (RV1)
24a
DIRECTION INFORMATION (RV1,2)
24b
DIRECTION INFORMATION (RV2)
24c

FIG. 9

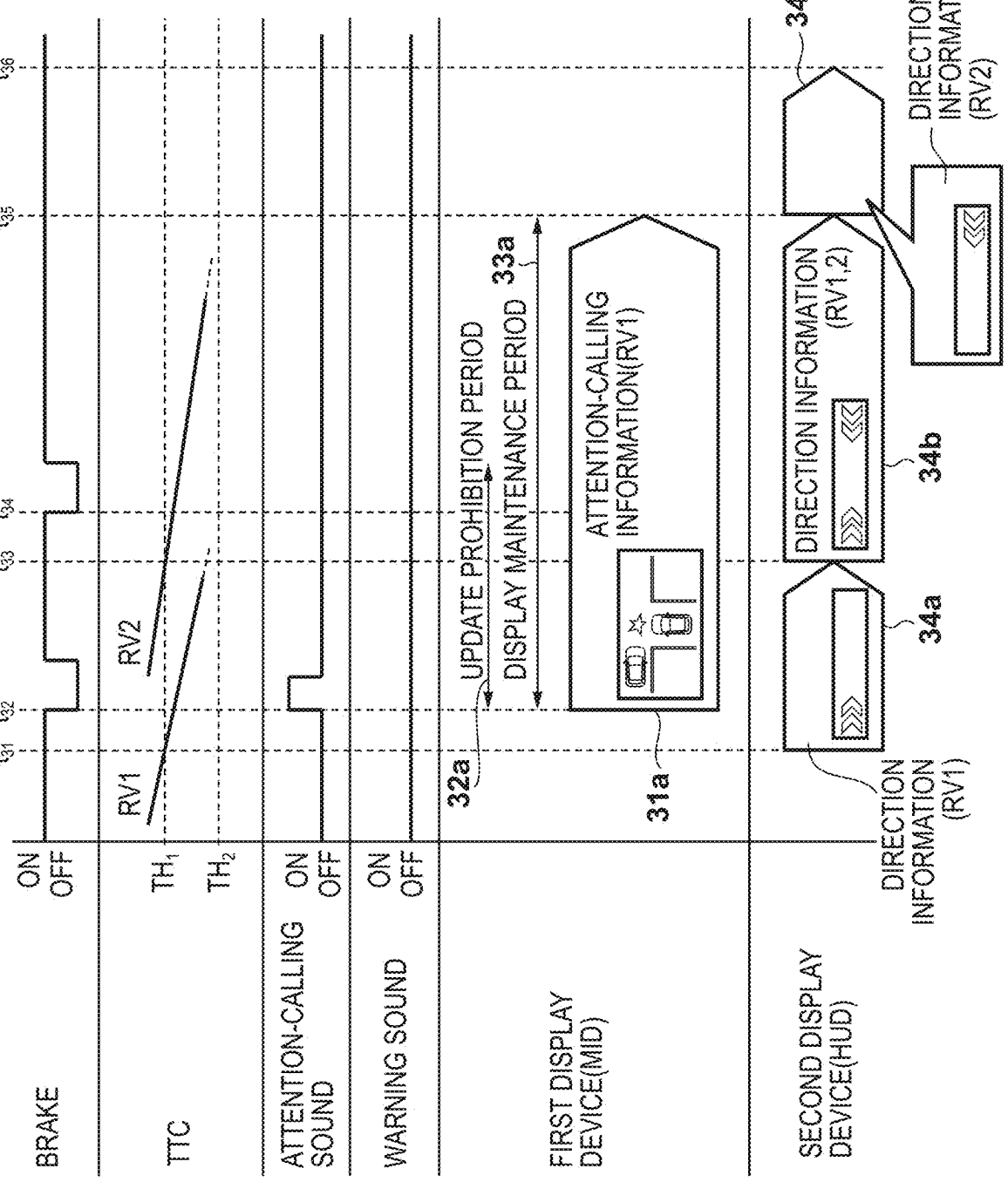

BRAKE
ON
OFF
TTC
RV1
RV2
TH1
TH2
ATTENTION-CALLING SOUND
ON
OFF
WARNING SOUND
ON
OFF
FIRST DISPLAY DEVICE(MID)
SECOND DISPLAY DEVICE(HUD)
t31
t32
t33
t34
t35
t36
32a
UPDATE PROHIBITION PERIOD
DISPLAY MAINTENANCE PERIOD
33a
ATTENTION-CALLING INFORMATION(RV1)
31a
DIRECTION INFORMATION (RV1)
34a
DIRECTION INFORMATION (RV1,2)
34b
34c
DIRECTION INFORMATION (RV2)

FIG. 10

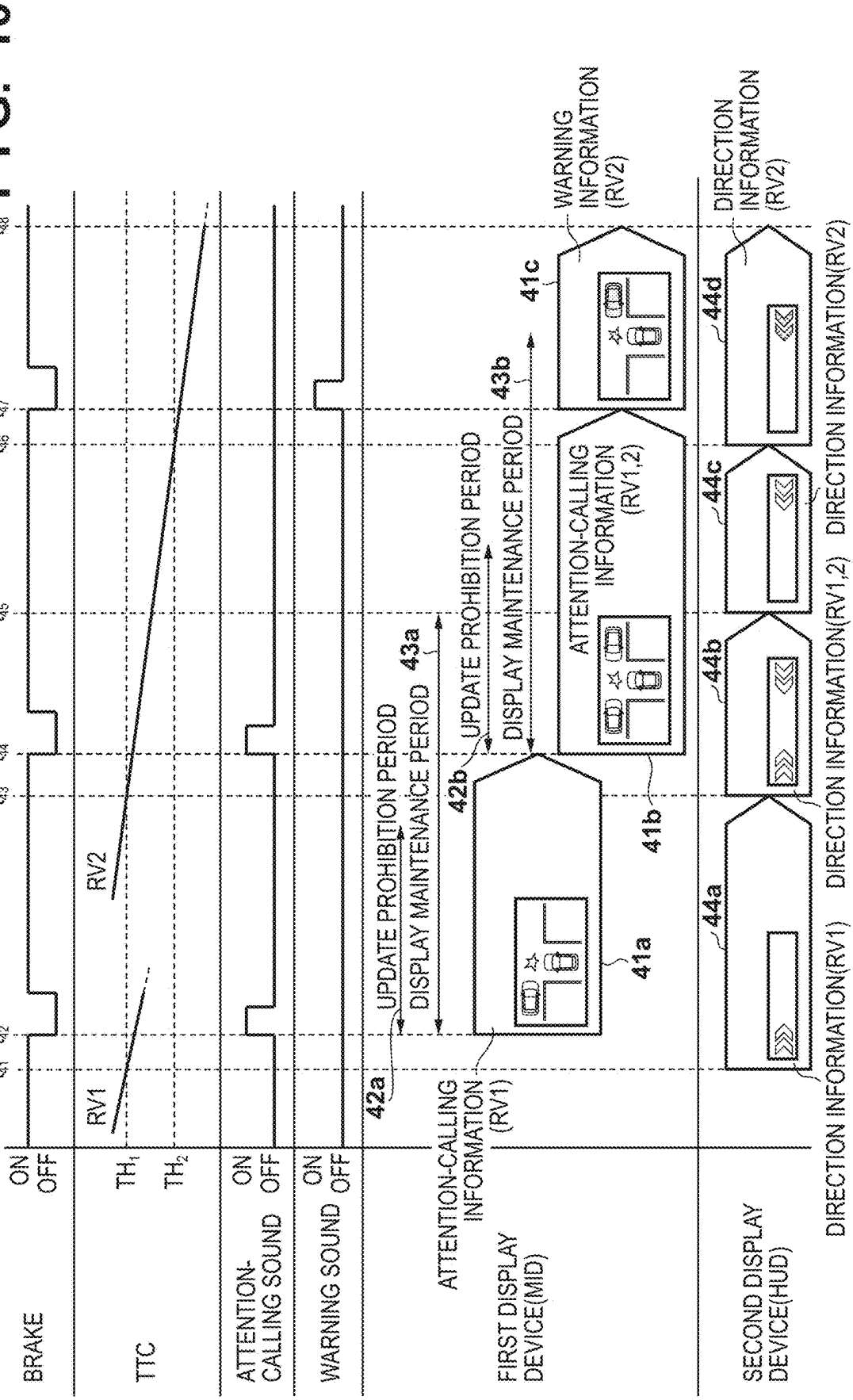
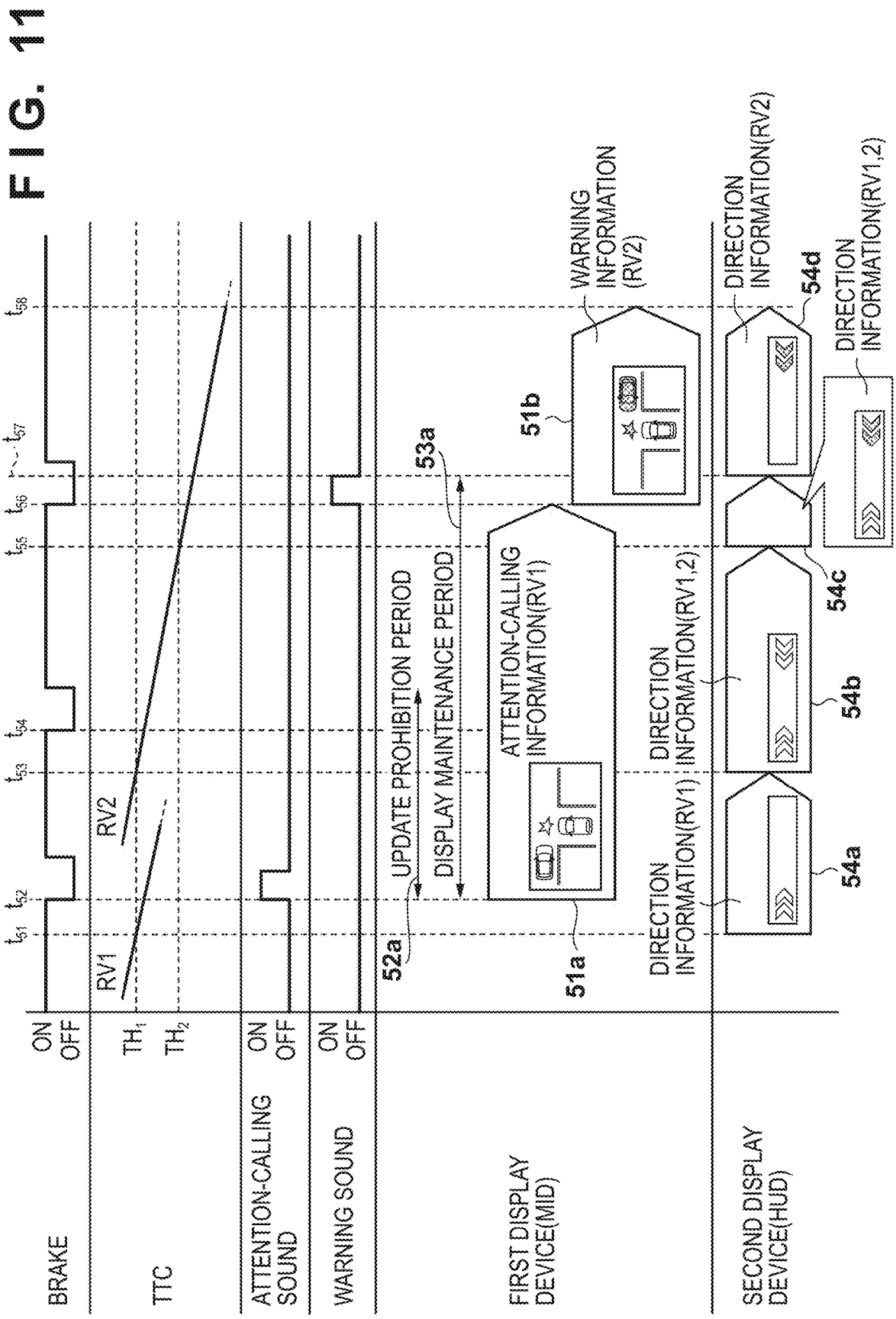

BRAKE
ON
OFF
TTC
RV1
RV2
TH1
TH2
ATTENTION-CALLING SOUND
ON
OFF
WARNING SOUND
ON
OFF
t41
t42
t43
t44
t45
t46
t47
t48
42a
UPDATE PROHIBITION PERIOD
DISPLAY MAINTENANCE PERIOD
43a
42b
UPDATE PROHIBITION PERIOD
DISPLAY MAINTENANCE PERIOD
43b
41c
ATTENTION-CALLING INFORMATION (RV1)
FIRST DISPLAY DEVICE(MID)
41a
41b
ATTENTION-CALLING INFORMATION (RV1,2)
WARNING INFORMATION (RV2)
SECOND DISPLAY DEVICE(HUD)
44a
44b
44c
44d
DIRECTION INFORMATION (RV2)
DIRECTION INFORMATION(RV1)
DIRECTION INFORMATION(RV1,2)
DIRECTION INFORMATION(RV2)

FIG. 11


BRAKE
ON
OFF
TTC
RV1
RV2
TH1
TH2
ATTENTION-CALLING SOUND
ON
OFF
WARNING SOUND
ON
OFF
FIRST DISPLAY DEVICE(MID)
SECOND DISPLAY DEVICE(HUD)
t51
t52
t53
t54
t55
t56
t57
t58
52a
UPDATE PROHIBITION PERIOD
53a
DISPLAY MAINTENANCE PERIOD
51a
ATTENTION-CALLING INFORMATION(RV1)
51b
WARNING INFORMATION (RV2)
DIRECTION INFORMATION(RV1)
DIRECTION INFORMATION(RV1,2)
DIRECTION INFORMATION(RV2)
DIRECTION INFORMATION(RV1,2)
54a
54b
54c
54d

DRIVING ASSISTANCE DEVICE, DRIVING ASSISTANCE METHOD, AND STORAGE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority to and the benefit of Japanese Patent Application No. 2024-017994 filed on Feb. 8, 2024, the entire disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

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

Description of the Related Art

[0003] In recent years, efforts to provide access to sustainable transportation systems in consideration of vulnerable people among traffic participants have been gaining momentum. In order to realize this, research and development for further improving traffic safety and convenience is focused on research and development related to preventive safety technique. As such preventive safety technique, a device that provides driving assistance for preventing collision with peripheral vehicles (other vehicles) and the like has been known. Japanese Patent Laid-Open No. 2020-16950 describes that another vehicle present on the front lateral side of a self-vehicle is detected based on a captured image from an image capturing unit mounted on the self-vehicle, and collision between the self-vehicle and the other vehicle is determined. In addition, Japanese Patent No. 7054636 describes that position information of an intersection where a traveling trajectory of a self-vehicle and a traveling trajectory of another vehicle intersect is registered in a storage unit to perform driving assistance for the self-vehicle when the self-vehicle passes through the intersection again.

[0004] In driving assistance for a self-vehicle, it is annoying and inappropriate for a driver of the self-vehicle when display of information for preventing collision with other vehicles is frequently updated (switched), such as when there are a plurality of other vehicles predicted to collide with the self-vehicle.

SUMMARY OF THE INVENTION

[0005] The present invention provides, for example, an advantageous technique for appropriately performing driving assistance for a self-vehicle. Accordingly, the present disclosure contributes to development of a sustainable transportation system.

[0006] According to one aspect of the present invention, there is provided a driving assistance device configured to perform driving assistance for a self-vehicle, comprising: an acquisition unit configured to acquire peripheral vehicle information including a current position, a speed, and a traveling trajectory of a peripheral vehicle present around the self-vehicle, from the peripheral vehicle by vehicle-to-vehicle communication; a first prediction unit configured to predict a collision possibility between the self-vehicle and the peripheral vehicle based on self-vehicle information including a current position, a speed, and a traveling trajectory of the self-vehicle and the peripheral vehicle information acquired by the acquisition unit; a first display unit configured to, when a first state is detected, display attention-calling information for calling attention to approach of the peripheral vehicle in a first period from a timing at which the first state is detected, the first state being a state in which the collision possibility is predicted by the first prediction unit and a start operation is performed by a driver of the self-vehicle; and a second display unit configured to, when a second state is detected, display direction information indicating an approach direction of the peripheral vehicle, the second state being a state in which the collision possibility is predicted by the first prediction unit, wherein the first display unit suppresses update of the attention-calling information until a second period shorter than the first period elapses from the timing even in a case where the first state is newly detected, and wherein the second display unit updates the direction information when the second state is newly detected even in a case where the second period has not elapsed from the timing.

[0007] Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a diagram illustrating a configuration example of a driving assistance device of an embodiment according to the present invention;

[0009] FIG. **2** is a view illustrating a display example of information in first and second display devices and an output example of audio in an audio output device;

[0010] FIG. **3** is a flowchart illustrating driving assistance processing according to a prediction method using vehicle-to-vehicle communication;

[0011] FIG. **4** is a flowchart illustrating the driving assistance processing according to the prediction method using the vehicle-to-vehicle communication;

[0012] FIG. **5** is a flowchart illustrating driving assistance processing according to a prediction method using an object detection unit;

[0013] FIGS. **6**A and **6**B are views illustrating a positional relationship between a self-vehicle and peripheral vehicles;

[0014] FIG. **7** is a time chart illustrating driving assistance processing of Example 1;

[0015] FIG. **8** is a time chart illustrating driving assistance processing of Example 2;

[0016] FIG. **9** is a time chart illustrating driving assistance processing of Example 3;

[0017] FIG. **10** is a time chart illustrating driving assistance processing of Example 4; and

[0018] FIG. **11** is a time chart illustrating driving assistance processing of Example 5.

DESCRIPTION OF THE EMBODIMENTS

[0019] Hereinafter, embodiments will be described in detail with reference to the attached drawings. Note that the following embodiments are not intended to limit the scope of the claimed invention, and limitation is not made an invention that requires all combinations of features described in the embodiments. Two or more of the multiple features described in the embodiments may be combined as appropriate. Furthermore, the same reference numerals are

given to the same or similar configurations, and redundant description thereof is omitted.

Configuration of Driving Assistance Device

[0020] A configuration example of a driving assistance device **100** of an embodiment according to the present invention will be described with reference to FIG. **1**. FIG. **1** is a diagram illustrating a configuration example of a driving assistance device **100** of the present embodiment. The driving assistance device **100** is a device mounted on a self-vehicle in order to perform driving assistance for the self-vehicle. Although FIG. **1** illustrates components referred to in the following description, a vehicle on which the driving assistance device **100** is mounted may include other components for operating as the vehicle, such as a driving device and a transmission. Hereinafter, a four-wheeled vehicle will be described as an example of the vehicle on which the driving assistance device **100** is mounted, but the vehicle may be a two-wheeled vehicle or a vehicle of another type without being limited thereto. In addition, in the following description, in order to facilitate discrimination of vehicles, the vehicle on which the driving assistance device **100** is mounted may be referred to as a "self-vehicle", and vehicles different from the self-vehicle may be referred to as "other vehicles". Among other vehicles, a vehicle that currently is present around the self-vehicle may be referred to as a "peripheral vehicle". The peripheral vehicle may be understood as a vehicle that can currently perform vehicle-to-vehicle communication with the self-vehicle.

[0021] The driving assistance device **100** performs collision prevention assistance for preventing (reducing) collision with a peripheral vehicle as driving assistance for the self-vehicle without using map information. As illustrated in FIG. **1**, the driving assistance device **100** of the present embodiment may include a sensor group **111**, a global navigation satellite system (GNSS) antenna **112**, a vehicle-to-vehicle communication antenna **113**, a first display device **114**, a second display device **115**, an audio output device **116**, a braking device **117**, and a control device **120**. Hereinafter, a driver of the self-vehicle may be simply referred to as the "driver".

[0022] The sensor group **111** includes various sensors mounted on the self-vehicle in order to perform driving assistance for the self-vehicle. For example, the sensor group **111** may include a speed sensor that detects the speed of the self-vehicle, an acceleration sensor that detects the acceleration of the self-vehicle, and the like. In addition, the sensor group **111** includes an external detection sensor, such as a camera, a millimeter wave radar, or a light detection and ranging (LIDAR), as an object detection unit that detects an object around the self-vehicle without using vehicle-to-vehicle communication. The sensor group **111** outputs the detection result to the control device **120**.

[0023] The GNSS antenna **112** receives a radio wave for position measurement transmitted from a GNSS satellite. For example, the GNSS antenna **112** may be used to acquire information regarding the current position of the self-vehicle. The vehicle-to-vehicle communication antenna **113** is an antenna that transmits and receives various types of data to and from a peripheral vehicle. For example, the vehicle-to-vehicle communication antenna **113** may be used to acquire information regarding the current position, speed, and traveling trajectory of the peripheral vehicle from the peripheral vehicle.

[0024] The first display device **114** and the second display device **115** are devices that display information to an occupant (for example, the driver) of the self-vehicle. The first display device **114** and the second display device **115** may be provided at different locations in the interior of the self-vehicle. For example, the first display device **114** may be configured as a multi-information display (hereinafter, may be referred to as MID) provided on an instrument panel. The second display device **115** may be configured as a head-up display (hereinafter, may be referred to as HUD) projected on a windshield in front of the driver's seat. In addition, the audio output device **116** is a device that outputs audio to the occupant (for example, the driver) of the self-vehicle. When there is a possibility that the self-vehicle collides with a peripheral vehicle, the driving assistance device **100** of the present embodiment can notify the occupant of the self-vehicle of the possibility of collision with the peripheral vehicle, as driving assistance, through the first display device **114**, the second display device **115**, and/or the audio output device **116**.

[0025] The braking device **117** is a device, such as a brake, for performing a braking operation of the self-vehicle. When there is a possibility that the self-vehicle collides with a peripheral vehicle, the driving assistance device **100** of the present embodiment can perform deceleration assistance for the self-vehicle by operating the braking device **117** as driving assistance, thereby avoiding collision with the peripheral vehicle.

[0026] The control device **120** is a device (computer) that controls driving assistance for the self-vehicle, and may be, for example, an electronic control unit (ECU). The control device **120** can perform driving assistance by vehicle-to-vehicle communication with other vehicles (peripheral vehicles) and processing in the self-vehicle. For example, the control device **120** can perform driving assistance without using map information. The control device **120** includes a processing unit **121**, a storage unit **122**, a GNSS module **123**, and a vehicle-to-vehicle communication module **124**, which are connected to each other by a bus (not illustrated).

[0027] The processing unit **121** is a processor represented by a central processing unit (CPU), and executes a program stored in the storage unit **122**. The storage unit **122** includes, for example, a random access memory (RAM), a read only memory (ROM), a hard disk, and the like, and stores various types of data in addition to a program (driving assistance program) for the processing unit **121** to perform driving assistance processing of the self-vehicle. In addition, the GNSS module **123** receives position information and the like of the self-vehicle from the GNSS satellite through the GNSS antenna **112**. The vehicle-to-vehicle communication module **124** receives various types of information from other vehicles through the vehicle-to-vehicle communication antenna **113**.

[0028] The processing unit **121** of the present embodiment may include an acquisition unit **121***a*, a first prediction unit **121***b*, a second prediction unit **121***c*, a first display control unit **121***d*, a second display control unit **121***e*, and an audio control unit **121***f* in order to perform driving assistance (collision prevention assistance) of the self-vehicle. Note that the processing unit **121** is not limited to the configuration including the units **121***a* to **121***f*, and another unit may

be added or some units may be omitted according to the type of driving assistance performed by the self-vehicle.

[0029] The acquisition unit **121***a* acquires peripheral vehicle information including the current position, speed, and traveling trajectory of a peripheral vehicle from the peripheral vehicle through the vehicle-to-vehicle communication antenna **113** (vehicle-to-vehicle communication module **124**). In the following description, the peripheral vehicle information may be defined as information acquired from the peripheral vehicle by vehicle-to-vehicle communication. In addition, the acquisition unit **121***a* may also have a function of acquiring self-vehicle information including the current position, speed, and traveling trajectory of the self-vehicle through the sensor group **111** and the GNSS antenna **112** (GNSS module **123**).

[0030] The first prediction unit **121***b* predicts a possibility of collision between the self-vehicle and the peripheral vehicle (hereinafter, may be referred to as the possibility of collision) based on the self-vehicle information and the peripheral vehicle information acquired by the acquisition unit **121***a*. The first prediction unit **121***b* of the present embodiment can predict the possibility of collision between the self-vehicle and the peripheral vehicle by calculating a time to collision (TTC) which is a time estimated to be required until the collision between the self-vehicle and the peripheral vehicle occurs.

[0031] The second prediction unit **121***c* predicts the possibility of collision between the self-vehicle and the peripheral vehicle based on the self-vehicle information acquired by the acquisition unit **121***a* and the detection result of the object detection unit of the sensor group **111**. As described above, the object detection unit of the sensor group **111** may include the external detection sensor (camera, millimeter wave radar, LIDAR, or the like) that detects an object around the self-vehicle without using vehicle-to-vehicle communication. The detection result of the object detection unit may include the position and speed of the peripheral vehicle detected by the object detection unit (which may be understood as the relative position and relative speed of the peripheral vehicle with respect to the self-vehicle). The second prediction unit **121***c* of the present embodiment can predict the possibility of collision between the self-vehicle and the peripheral vehicle by calculating the time to collision (TTC) between the self-vehicle and the peripheral vehicle.

[0032] The first display control unit **121***d* controls display of information on the first display device **114**. In the case of the present embodiment, when a state in which the first prediction unit **121***b* predicts that there is a possibility of collision between the self-vehicle and a peripheral vehicle and a start operation of the self-vehicle has been performed by the driver (hereinafter, may be referred to as a first state) is detected, the first display control unit **121***d* causes the first display device **114** to display attention-calling information for calling attention to approach of the peripheral vehicle. In addition, when a state in which the second prediction unit **121***c* predicts that there is the possibility of collision between the self-vehicle and the peripheral vehicle and the start operation of the self-vehicle has been performed by the driver (hereinafter, may be referred to as a third state) is detected, the first display control unit **121***d* causes the first display device **114** to display warning information for warning against approach of the peripheral vehicle.

[0033] Here, the attention-calling information is displayed on the first display device **114** for a predetermined display maintenance period (first period) from a timing at which the first state is detected. The display maintenance period may be arbitrarily set, and may be set to, for example, 6 seconds. The warning information is configured such that a degree of recognition of the driver (that is, a degree of warning to the driver) is higher than that of the attention-calling information. For example, the attention-calling information is displayed on the first display device **114** in a first light color (first color, for example, white). On the other hand, the warning information is displayed on the first display device **114** in a second light color (second color, for example, amber) which is different from the first light color and has a high degree of recognition of the driver. In addition, examples of the start operation of the self-vehicle by the driver include an operation of the driver releasing a brake pedal of the self-vehicle and an operation of the driver stepping on an accelerator pedal of the self-vehicle. In the present embodiment, the operation of the driver releasing the brake pedal of the self-vehicle (hereinafter, may be referred to as a brake release operation) will be described as an example of the start operation of the self-vehicle by the driver.

[0034] The second display control unit **121***e* controls display of information on the second display device **115**. In the case of the present embodiment, when a state in which the first prediction unit **121***b* predicts that there is a possibility of collision between the self-vehicle and a peripheral vehicle (hereinafter, may be referred to as a second state) is detected, the second display control unit **121***e* causes the second display device **115** to display direction information indicating an approach direction of the peripheral vehicle. In addition, when a state in which the second prediction unit **121***c* predicts that there is the possibility of collision between the self-vehicle and the peripheral vehicle (hereinafter, may be referred to as a fourth state) is detected, the second display control unit **121***e* causes the second display device **115** to display direction information indicating an approach direction of the peripheral vehicle.

[0035] Here, the direction information displayed in response to the detection of the fourth state is configured such that a degree of recognition of the driver (that is, a degree of warning to the driver) is higher than that of the direction information displayed in response to the detection of the second state. For example, when the second state is detected, the direction information is displayed on the second display device **115** in the first light color (first color, for example, white). On the other hand, when the fourth state is detected, the direction information is displayed on the second display device **115** in the second light color (second color, for example, amber) which is different from the first light color and has a high degree of recognition of the driver.

[0036] The audio control unit **121***f* controls the audio output in the audio output device **116**. In the case of the present embodiment, when the attention-calling information is displayed or updated by the first display device **114**, the audio control unit **121***f* causes the audio output device **116** to output an attention-calling sound for calling attention to the approach of the peripheral vehicle. In addition, when the warning information is displayed by the first display device **114**, the audio control unit **121***f* causes the audio output device **116** to output a warning sound for warning against the approach of the peripheral vehicle. Here, the warning sound

is configured such that a degree of recognition of the driver (that is, a degree of warning to the driver) is higher than that of the attention-calling sound.

[0037] FIG. **2** illustrates a display example of information in the first display device **114** and the second display device **115**, and an output example of audio in the audio output device **116**. In the present embodiment, a prediction method using vehicle-to-vehicle communication and a prediction method using the object detection unit (sensor fusion) of the sensor group **111** are applied as methods of predicting a possibility of collision between the self-vehicle and a peripheral vehicle.

[0038] In the prediction method using vehicle-to-vehicle communication, the first prediction unit **121***b* predicts a possibility of collision between the self-vehicle and a peripheral vehicle. Then, on the first display device **114** (MID), an image corresponding to an approach direction of the peripheral vehicle is displayed in the first light color (white) as the attention-calling information. On the second display device **115** (HUD), an image (arrow) corresponding to the approach direction of the peripheral vehicle is displayed in the first light color (white). In addition, an attention-calling sound is output from the audio output device **116**.

[0039] On the other hand, in the prediction method using the object detection unit, the second prediction unit **121***c* predicts a possibility of collision between the self-vehicle and a peripheral vehicle. Then, on the first display device **114** (MID), an image corresponding to an approach direction of the peripheral vehicle is displayed in the second light color (amber) as the warning information. On the second display device **115** (HUD), an image (arrow) corresponding to the approach direction of the peripheral vehicle is displayed in the second light color (amber). In addition, the warning sound is output from the audio output device **116**.

[0040] Here, the above-described function of the control device **120** can be implemented by both hardware and software. For example, the function of the control device **120** may be implemented by the processing unit **121** (CPU) executing the driving assistance program as described above, or may be implemented by a known semiconductor device such as a programmable logic device (PLD) or an application specific integrated circuit (ASIC). In the present embodiment, the control device **120** is illustrated as a single element, but may be divided into two or more elements as necessary.

Driving Assistance Processing

[0041] Driving assistance processing of the present embodiment will be described with reference to FIGS. **3** to **5**. FIGS. **3** and **4** are flowcharts illustrating driving assistance processing according to the prediction method using vehicle-to-vehicle communication. FIG. **5** is a flowchart illustrating driving assistance processing according to the prediction method using the object detection unit (sensor fusion). The flowcharts of FIGS. **3** and **4** and the flowchart of FIG. **5** are performed in parallel and independently. In addition, the driving assistance processing illustrated in the flowcharts of FIGS. **3** to **5** is executed by the processing unit **121** in accordance with the driving assistance program read from the storage unit **122** in the driving assistance device **100**. The flowcharts of FIGS. **3** to **5** may be repeatedly executed, for example, until the setting of driving assistance is turned off or the ignition of a self-vehicle SV is turned off.

[0042] First, the driving assistance processing according to the prediction method using vehicle-to-vehicle communication will be described with reference to FIGS. **3** and **4**. FIG. **3** illustrates driving assistance processing for the first peripheral vehicle RV identified by vehicle-to-vehicle communication. FIG. **4** illustrates driving assistance processing for the second and subsequent peripheral vehicles RV (hereinafter, may be referred to as a new peripheral vehicle RV) identified by vehicle-to-vehicle communication during the driving assistance processing for the first peripheral vehicle RV.

[0043] In step S**101**, the processing unit **121** determines whether or not there is a peripheral vehicle RV. For example, the processing unit **121** can determine that the peripheral vehicle RV is present when vehicle-to-vehicle communication can be performed through the vehicle-to-vehicle communication antenna **113** (vehicle-to-vehicle communication module **124**). When it is determined that there is no peripheral vehicle RV for which vehicle-to-vehicle communication can be performed, step S**101** is repeated, and when it is determined that the peripheral vehicle RV is present, the processing proceeds to step S**102**.

[0044] In step S**102**, the processing unit **121** (acquisition unit **121***a*) acquires peripheral vehicle information from the peripheral vehicle RV by vehicle-to- vehicle communication. As described above, the peripheral vehicle information is information including the current position, speed, and traveling trajectory of the peripheral vehicle RV, and may be acquired through the vehicle-to-vehicle communication antenna **113** (vehicle-to-vehicle communication module **124**). In addition, in this step S**102**, the processing unit **121** (acquisition unit **121***a*) can also acquire self-vehicle information including the current position, speed, and traveling trajectory of the self-vehicle SV through the sensor group **111** and the GNSS antenna **112** (GNSS module **123**).

[0045] In step S**103**, the processing unit **121** (first prediction unit **121***b*) predicts a possibility of collision between the self-vehicle SV and the peripheral vehicle RV. As described above, the first prediction unit **121***b* of the present embodiment calculates a time to collision (TTC) between the self-vehicle SV and the peripheral vehicle RV to predict the possibility of collision between the self-vehicle SV and the peripheral vehicle RV. As an example, as illustrated in FIGS. **6**A and **6**B, the first prediction unit **121***b* obtains an intersection position (CP**1**, CP**2**) at which the self-vehicle SV and the peripheral vehicle RV (RV**1**, RV**2**) are estimated to intersect based on the self-vehicle information and the peripheral vehicle information, and calculates a time required for the peripheral vehicle RV to reach the intersection position as the time to collision. Then, the first prediction unit **121***b* can predict that there is the possibility of collision between the self-vehicle SV and the peripheral vehicle RV when the calculated time to collision is equal to or less than a first threshold. Here, the first threshold can be arbitrarily set. Note that FIG. **6**A illustrates an example in which one peripheral vehicle RV**1** is present around the self-vehicle SV, and FIG. **6**B illustrates an example in which two peripheral vehicles RV**1** and RV**2** are present around the self-vehicle SV.

[0046] In step S**104**, the processing unit **121** determines whether or not there is a possibility of collision between the self-vehicle SV and the peripheral vehicle RV based on the prediction result in step S**103**. When where it is determined that there is no possibility of collision, the processing returns

to step S**101**. On the other hand, when it is determined that there is the possibility of collision, the processing proceeds to step S**105** assuming that the second state in which the possibility of collision between the self-vehicle SV and the peripheral vehicle RV is predicted is detected.

[0047] In step S**105**, the processing unit **121** (second display control unit **121***e*) causes the second display device **115** (HUD) to display direction information indicating an approach direction of the peripheral vehicle RV with respect to the self-vehicle SV in the first light color (white). As an example, the second display control unit **121***e* causes the second display device **115** to display an image (arrow) selected according to the approach direction of the peripheral vehicle RV, as the direction information, in the first light color as described above with reference to FIG. **2**. The approach direction of the peripheral vehicle RV can be obtained based on the peripheral vehicle information.

[0048] In step S**106**, the processing unit **121** determines whether or not the brake release operation (start operation) has been performed by the driver. When the brake release operation has been performed, the processing proceeds to step S**107** assuming that the first state in which the possibility of collision between the self-vehicle SV and the peripheral vehicle RV is predicted and the start operation has been performed by the driver is detected. On the other hand, when the brake release operation has not been performed, the processing proceeds to step S**109**.

[0049] In step S**107**, the processing unit **121** (audio control unit **121***f*) causes the audio output device **116** to output the attention-calling sound. Next, in step S**108**, the processing unit **121** (first display control unit **121***d*) causes the first display device **114** (MID) to display attention-calling information for calling attention to approach of the peripheral vehicle RV in the first light color (white). As an example, the first display control unit **121***d* causes the first display device **114** to display an image selected according to the approach direction of the peripheral vehicle RV, as the attention-calling information, in the first light color as described above with reference to FIG. **2**.

[0050] In step S**109**, the processing unit **121** determines whether or not there is a new peripheral vehicle RV. For example, similarly to step S**101** described above, the processing unit **121** can determine that the new peripheral vehicle RV is present when vehicle-to-vehicle communication can be performed through the vehicle-to-vehicle communication antenna **113** (vehicle-to-vehicle communication module **124**). The processing proceeds to step S**110** when it is determined that there is no new peripheral vehicle RV or proceeds to step S**112** of FIG. **4** when it is determined that the new peripheral vehicle RV is present.

[0051] In step S**110**, the processing unit **121** determines whether or not the display maintenance period (first period) has elapsed. The display maintenance period is a period in which the display of the attention-calling information on the first display device **114** and the display of the direction information on the second display device **115** are maintained, and time measurement may be started from the timing at which the first state is detected. In the present embodiment, as an example, the display maintenance period is set to **6** seconds. When the display maintenance period has not elapsed, the processing returns to step S**106**. In this case, steps S**106** to S**108** may be skipped when steps S**107** and S**108** have already been performed. On the other hand, when the display maintenance period has elapsed, the processing proceeds to step S**111**, and the processing unit **121** ends the display of the attention-calling information on the first display device **114** and the display of the direction information on the second display device **115**.

[0052] Proceeding to FIG. **4**, in step S**112**, the processing unit **121** (acquisition unit **121***a*) acquires peripheral vehicle information from the new peripheral vehicle RV by vehicle-to-vehicle communication. Next, in step S**113**, the processing unit **121** (first prediction unit **121***b*) predicts a possibility of collision between the self-vehicle SV and the new peripheral vehicle RV. Since steps S**112** and S**113** are steps similar to steps S**102** and S**103** described above, and thus detailed description thereof will be omitted herein.

[0053] In step S**114**, the processing unit **121** determines whether or not there is a possibility of collision between the self-vehicle SV and the new peripheral vehicle RV based on the prediction result in step S**113**. When it is determined that there is no possibility of collision, the processing proceeds to step S**109** in FIG. **3**. The "new peripheral vehicle RV" in step S**109** in this case does not necessarily include the peripheral vehicle RV for which the possibility of collision is predicted in steps S**112** and S**113** described above. On the other hand, when it is determined that there is the possibility of collision, the processing proceeds to step S**115** assuming that the second state in which the possibility of collision between the self-vehicle SV and the peripheral vehicle RV is predicted is newly detected.

[0054] In step S**115**, the processing unit **121** (second display control unit **121***e*) updates the direction information displayed on the second display device **115** (HUD). For example, the second display control unit **121***e* updates the direction information by additionally displaying an approach direction of the peripheral vehicle RV based on the newly detected second state, that is, the approach direction of the new peripheral vehicle RV on the second display device **115** in the first light color (white). The second display control unit **121***e* may update the direction information by superimposing an image (arrow) selected according to the approach direction of the new peripheral vehicle RV on the second display device **115** in the first light color.

[0055] In step S**116**, the processing unit **121** determines whether or not the brake release operation (start operation) has been performed by the driver. When the brake release operation has been performed, the processing proceeds to step S**117** assuming that the first state in which the possibility of collision between the self-vehicle SV and the peripheral vehicle RV is predicted and the start operation has been performed by the driver is newly detected. On the other hand, when the brake release operation has not been performed, the processing proceeds to step S**120**.

[0056] In step S**117**, the processing unit **121** determines whether or not an update prohibition period (second period) has elapsed. The processing proceeds to step S**118** when the update prohibition period has elapsed or proceeds to step S**120** when the update prohibition period has not elapsed.

[0057] The update prohibition period is a period in which update of the attention-calling information displayed on the first display device **114** is prohibited (suppressed), and time measurement may be started from the timing at which the first state is detected. The update prohibition period is set to a period shorter than the display maintenance period, and is set to 3 seconds as an example in the present embodiment. Since the update prohibition period is provided in this manner, the attention-calling information displayed on the

first display device **114** is not updated in a certain period, and thus it is possible to reduce annoyance of the driver, such as update of the attention-calling information executed every time a possibility of collision with a new peripheral vehicle RV is predicted. Here, the direction information displayed on the second display device **115** is updated when the second state is newly detected even if the update prohibition period has not elapsed since only the approach direction of the new peripheral vehicle RV is additionally displayed using the arrow. Note that the update prohibition period may be understood as a re-notification prohibition period in which re-notification (re-display) of the attention-calling information is prohibited.

[0058] In step S**118**, the processing unit **121** (audio control unit **121***f*) causes the audio output device **116** to output the attention-calling sound. Next, in step S**119**, the processing unit **121** (first display control unit **121***d*) updates the attention-calling information displayed on the first display device **114** (MID). For example, the first display control unit **121***d* updates the attention-calling information by displaying attention-calling information for calling attention to the new peripheral vehicle RV on the first display device **114** in the first light color (white) in addition to or instead of the attention-calling information displayed on the first display device **114**. That is, the first display control unit **121***d* causes the first display device **114** to perform interrupt display of the attention-calling information for calling attention to approach of the new peripheral vehicle RV in the first light color (white).

[0059] In step S**120**, the processing unit **121** determines whether or not there is a new peripheral vehicle RV. The "new peripheral vehicle RV" in step S**120** does not necessarily include the peripheral vehicle RV for which the possibility of collision is predicted in steps S**112** and S**113** described above. When it is determined that there is no new peripheral vehicle RV, the processing proceeds to step S**121** or proceeds to step S**112** when the new peripheral vehicle RV is present. Since step S**120** is a step similar to step S**109** described above, and thus detailed description thereof will be omitted herein.

[0060] In step S**121**, the processing unit **121** determines whether or not the display maintenance period (first period) has elapsed. When the display maintenance period has not elapsed, the processing returns to step S**116**. In this case, steps S**116** to S**119** may be skipped when steps S**118** and S**119** have already been performed. On the other hand, when the display maintenance period has elapsed, the processing proceeds to step S**111** of FIG. **3**, and the processing unit **121** ends the display of the attention-calling information on the first display device **114** and the display of the direction information on the second display device **115**. Note that the display of the attention-calling information and the display of the direction information corresponding thereto may be ended when the display maintenance period of the attention-calling information displayed on the first display device **114** (MID) in step S**108** of FIG. **3** has elapsed while steps S**116** to S**119** are repeated. Since step S**121** is a step similar to step S**110** described above, and thus detailed description thereof will be omitted herein.

[0061] Next, the driving assistance processing according to the prediction method using the object detection unit will be described with reference to FIG. **5**. As described above, the flowchart of FIG. **5** is performed in parallel and independently of the flowcharts of FIGS. **3** and **4**.

[0062] In step S**201**, the processing unit **121** starts detection of the periphery of the self-vehicle SV by the object detection unit (sensor group **111**). Next, in step S**202**, the processing unit **121** determines whether or not the peripheral vehicle RV has been detected by the object detection unit. The processing returns to step S**201** when the peripheral vehicle RV has not been detected by the object detection unit or proceeds to step S**203** when the peripheral vehicle RV has been detected by the object detection unit.

[0063] In step S**203**, the processing unit **121** (second prediction unit **121***c*) predicts a possibility of collision between the self-vehicle SV and the peripheral vehicle RV. As described above, the second prediction unit **121***c* of the present embodiment calculates a time to collision (TTC) between the self-vehicle SV and the peripheral vehicle RV to predict the possibility of collision between the self-vehicle SV and the peripheral vehicle RV. As an example, as illustrated in FIGS. **6**A and **6**B, the second prediction unit **121***c* obtains the intersection position (CP**1**, CP**2**) at which the self-vehicle SV and the peripheral vehicle RV (RV**1**, RV**2**) are estimated to intersect based on the self-vehicle information acquired by the acquisition unit **121***a* and the detection result of the object detection unit, and calculates a time required for the peripheral vehicle RV to reach the intersection position as the time to collision. Then, the second prediction unit **121***c* can predict that there is the possibility of collision between the self-vehicle SV and the peripheral vehicle RV when the calculated time to collision is equal to or less than a second threshold. Here, the second threshold is a value smaller than the first threshold, and can be arbitrarily set.

[0064] In step S**204**, the processing unit **121** determines whether or not there is a possibility of collision between the self-vehicle SV and the peripheral vehicle RV based on the prediction result in step S**203**. When it is determined that there is no possibility of collision, the processing returns to step S**201**. On the other hand, when it is determined that there is the possibility of collision, the processing proceeds to step S**205** assuming that the fourth state in which the possibility of collision between the self-vehicle SV and the peripheral vehicle RV is predicted is detected.

[0065] In step S**205**, the processing unit **121** (second display control unit **121***e*) causes the second display device **115** (HUD) to display direction information indicating an approach direction of the peripheral vehicle RV with respect to the self-vehicle SV in the second light color (amber). As an example, the second display control unit **121***e* causes the second display device **115** to display an image (arrow) selected according to the approach direction of the peripheral vehicle RV, as the direction information, in the second light color as described above with reference to FIG. **2**. The approach direction of the peripheral vehicle RV can be obtained based on the detection result of the object detection unit.

[0066] Here, there is a case where the direction information in the first light color is already displayed on the second display device **115** in the "driving assistance processing according to the prediction method using vehicle-to-vehicle communication" described above. In this case, the second display control unit **121***e* causes the second display device **115** to display the direction information indicating the approach direction of the peripheral vehicle RV determined to have the possibility of collision in step S**204** in the second light color additionally (in a superimposed manner). That is,

even in a case where the direction information in the first light color has already been displayed on the second display device **115**, the second display control unit **121***e* causes the second display device **115** to perform interrupt display of the direction information indicating the approach direction of the peripheral vehicle RV determined to have the possibility of collision in step S**204** in the second light color.

[0067] In step S**206**, the processing unit **121** determines whether or not the brake release operation (start operation) has been performed by the driver. When the brake release operation has been performed, the processing proceeds to step S**207** assuming that the third state in which the possibility of collision between the self-vehicle SV and the peripheral vehicle RV is predicted and the start operation has been performed by the driver is detected. On the other hand, when the brake release operation has not been performed, the processing proceeds to step S**209**.

[0068] In step S**207**, the processing unit **121** (audio control unit **121***f*) causes the audio output device **116** to output the warning sound. Next, in step S**208**, the processing unit **121** (first display control unit **121***d*) causes the first display device **114** (MID) to display warning information for warning against the approach of the peripheral vehicle RV in the second light color (amber). As an example, the first display control unit **121***d* causes the first display device **114** to display an image selected according to the approach direction of the peripheral vehicle RV, as the warning information, in the second light color as described above with reference to FIG. **2**.

[0069] Here, there is a case where the attention-calling information is already displayed on the first display device **114** in the "driving assistance processing according to the prediction method using vehicle-to-vehicle communication" described above. In this case, the first display control unit **121***d* causes the first display device **114** to display the warning information for warning against the approach of the peripheral vehicle RV determined to have the possibility of collision in step S**204** instead of the attention-calling information. That is, the first display control unit **121***d* causes the first display device **114** to perform interrupt display of the warning information for warning against the approach of the peripheral vehicle RV in a case where it is determined in step S**204** that there is the possibility of collision even if the attention-calling information is already displayed on the first display device **114** and the update prohibition period of the attention-calling information has not elapsed. In addition, the display of the warning information is not limited to the above example. For example, the processing unit **121** may display the warning information in a case where there is the possibility of collision even if a brake with a predetermined deceleration (for example, 0.8 G) or more is operated when the brake has not been stepped on.

[0070] In step S**209**, the processing unit **121** (second prediction unit **121***c*) predicts a possibility of collision between the self-vehicle SV and the peripheral vehicle RV. Similarly to step S**203** described above, the second prediction unit **121***c* can calculate a time to collision (TTC) between the self-vehicle SV and the peripheral vehicle RV, and predict the possibility of collision between the self-vehicle SV and the peripheral vehicle RV based on whether or not the calculated time to collision is equal to or less than the second threshold.

[0071] In step S**210**, the processing unit **121** determines whether or not there is a possibility of collision between the self-vehicle SV and the peripheral vehicle RV based on the prediction result in step S**209**. When where it is determined that there is the possibility of collision, the processing returns to step S**206**. In this case, steps S**206** to S**208** may be skipped when steps S**207** and S**208** have already been performed. On the other hand, when it is determined that there is no possibility of collision, the processing proceeds to step S**211**.

[0072] In step S**211**, the processing unit **121** ends the display of the warning information on the first display device **114** and the display of the direction information on the second display device **115**. That is, when the second prediction unit **121***c* determines that there is no possibility of collision, that is, when the second prediction unit **121***c* no longer calculates the time to collision (TTC), for example, when the self-vehicle SV and the peripheral vehicle RV has passed each other without collision, the processing unit **121** ends the display of the warning information and the direction information. Here, in a case where warning information is displayed on the first display device **114** instead of attention-calling information for the same peripheral vehicle RV, the attention-calling information is not displayed again even before a lapse of the display maintenance period of the attention-calling information.

[0073] Hereinafter, Examples 1 to 5 related to the driving assistance processing according to the present embodiment will be described. Although a case where the peripheral vehicle RV approaches from the left and/or right of the self-vehicle SV, as illustrated in FIGS. **6**A and **6**B, will be described as an example in each of Examples 1 to 5, the same applies to a case where the peripheral vehicle RV approaches from the front of the self-vehicle SV.

Example 1

[0074] In Example 1, as illustrated in FIG. **6**A, an example of driving assistance processing in a case where one peripheral vehicle RV**1** approaches from the left of the self-vehicle SV will be described. FIG. **7** is a time chart illustrating the driving assistance processing of Example 1.

[0075] In Example 1, first, at timing t_{11} at which a time to collision (TTC) calculated by the first prediction unit **121***b* for the peripheral vehicle RV**1** reaches a first threshold TH_1, direction information **14***a* indicating an approach direction (left) of the peripheral vehicle RV**1** is displayed on the second display device **115** (HUD) in the first light color (white). The timing t_{11} may be understood as a timing at which the second state for the peripheral vehicle RV**1** is detected. In addition, at timing t_{12} at which the brake release operation (start operation) is performed by the driver, the attention-calling sound for calling attention to the approach of the peripheral vehicle RV**1** is output from the audio output device **116**, and attention-calling information **11***a* for calling attention to the approach of the peripheral vehicle RV**1** is displayed on the first display device **114** (MID) in the first light color (white). Then, at the timing t_{12}, time measurement for an update prohibition period **12***a* and a display maintenance period **13***a* of the attention-calling information **11***a* is started. The timing t_{12} may be understood as a timing at which the first state for the peripheral vehicle RV**1** is detected.

[0076] Next, at timing t_{13} at which a time to collision (TTC) calculated by the second prediction unit **121***c* for the peripheral vehicle RV**1** reaches a second threshold TH_2, direction information **14***b* indicating the approach direction

(left) of the peripheral vehicle RV**1** is displayed on the second display device **115** (HUD) in the second light color (amber). The timing t_{13} may be understood as a timing at which the fourth state for the peripheral vehicle RV**1** is detected. In addition, at timing t_{14} at which the brake release operation (start operation) is performed by the driver, the warning sound for warning against the approach of the peripheral vehicle RV**1** is output from the audio output device **116**, and warning information **11***b* for warning against the approach of the peripheral vehicle RV**1** is displayed on the first display device **114** (MID) in the second light color (amber). The timing t_{14} may be understood as a timing at which the third state for the peripheral vehicle RV**1** is detected. The timing t_{14} is before the update prohibition period **12***a* of the attention-calling information **11***a* elapses, but the warning information **11***b* is displayed on the first display device **114** in an interruptive manner, instead of the attention-calling information **11***a*, even before the update prohibition period **12***a* elapses.

[0077] The display of the warning information **11***b* on the first display device **114** and the display of the direction information **14***b* on the second display device **115** end at timing t_{15} at which the second prediction unit **121***c* no longer calculates the time to collision. Although the timing tis is before the display maintenance period **13***a* of the attention-calling information **11***a* elapses, since the warning information **11***b* is displayed for the peripheral vehicle RV**1** that is the same target as that of the attention-calling information **11***a*, the attention-calling information **11***a* is not displayed again.

Example 2

[0078] In Example 2, as illustrated in FIG. **6**B, an example of driving assistance processing in a case where one peripheral vehicle RV**1** approaches from the left of the self-vehicle SV and the other peripheral vehicle RV**2** approaches from the right of the self-vehicle SV will be described. FIG. **8** is a time chart illustrating the driving assistance processing of Example 2.

[0079] In Example 2, first, at timing t_{21} at which a time to collision (TTC) calculated by the first prediction unit **121***b* for the peripheral vehicle RV**1** reaches the first threshold TH_1, direction information **24***a* indicating an approach direction (left) of the peripheral vehicle RV**1** is displayed on the second display device **115** (HUD) in the first light color (white). The timing t_{21} may be understood as a timing at which the second state for the peripheral vehicle RV**1** is detected. In addition, at timing t_{22} at which the brake release operation (start operation) is performed by the driver, the attention-calling sound for calling attention to the approach of the peripheral vehicle RV**1** is output from the audio output device **116**, and attention-calling information **21***a* for calling attention to the approach of the peripheral vehicle RV**1** is displayed on the first display device **114** (MID) in the first light color (white). Then, at the timing t_{22}, time measurement for an update prohibition period **22***a* and a display maintenance period **23***a* of the attention-calling information **21***a* is started. The timing t_{22} may be understood as a timing at which the first state for the peripheral vehicle RV**1** is detected.

[0080] Next, at timing t_{23} at which a time to collision (TTC) calculated by the first prediction unit **121***b* for the peripheral vehicle RV**2** reaches the first threshold TH_1, direction information **24***b* in which an approach direction (right) of the peripheral vehicle RV**2** is added is displayed on the second display device **115** (HUD) in the first light color (white). The timing t_{23} may be understood as a timing at which a new second state for the peripheral vehicle RV**2** is detected. In addition, timing t_{24} at which the brake release operation (start operation) is performed by the driver is after a lapse of the update prohibition period **22***a* of the attention-calling information **21***a* for the peripheral vehicle RV**1**. Therefore, at the timing t_{24}, the attention-calling sound for calling attention to the approach of the peripheral vehicle RV**2** is output from the audio output device **116**, and attention-calling information **21***b* in which display for calling attention to the approach of the peripheral vehicle RV**2** is added is displayed on the first display device **114** (MID) in the first light color (white), instead of the attention-calling information **21***a*. The attention-calling information **21***b* is information for calling attention to the approach of both the peripheral vehicles RV**1** and RV**2**. Then, at the timing t_{24}, time measurement for an update prohibition period **22***b* and a display maintenance period **23***b* of the attention-calling information **21***b* is started. The timing t_{24} may be understood as a timing at which a new first state for the peripheral vehicle RV**2** is detected.

[0081] Next, at timing t_{25} at which the display maintenance period **23***a* of the attention-calling information **21***a* for the peripheral vehicle RV**1** has elapsed, the display indicating the approach direction of the peripheral vehicle RV**1** ends, and direction information **24***c* indicating only the approach direction of the peripheral vehicle RV**2** is displayed on the second display device **115**. At the timing t_{25}, since the display maintenance period **23***b* has not elapsed, the display of the attention-calling information **21***b* on the first display device **114** is maintained. Then, at timing t_{26} at which the display maintenance period **23***b* has elapsed, the display of the attention-calling information **21***b* on the first display device **114** and the display of the direction information **24***c* on the second display device **115** end.

[0082] Here, in Example 2, the attention-calling information **21***b* for calling attention to the approach of both the peripheral vehicles RV**1** and RV**2** is maintained even after the timing t_{25} at which the display maintenance period **23***a* of the attention-calling information **21***a* for the peripheral vehicle RV**1** has elapsed, but the present invention is not limited thereto. For example, at the timing t_{25}, the display for calling attention to the approach of the peripheral vehicle RV**1** may be ended, and the attention-calling information may be updated to call attention only to the approach of the peripheral vehicle RV**2**. That is, the attention-calling information **21***b* for calling attention to the approach of both of the peripheral vehicles RV**1** and RV**2** may be displayed on the first display device **114** between the timings t_{24} and t_{25}, and attention-calling information for calling attention only to the approach of the peripheral vehicle RV**2** may be displayed on the first display device **114** between the timings t_{25} and t_{26}.

Example 3

[0083] In Example 3, as illustrated in FIG. **6**B, an example of driving assistance processing in a case where one peripheral vehicle RV**1** approaches from the left of the self-vehicle SV and the other peripheral vehicle RV**2** approaches from the right of the self-vehicle SV will be described. FIG. **9** is a time chart illustrating the driving assistance processing of Example 3.

[0084] In Example 3, first, at timing t_{31} at which a time to collision (TTC) calculated by the first prediction unit **121***b* for the peripheral vehicle RV**1** reaches a first threshold TH_1, direction information **34***a* indicating an approach direction (left) of the peripheral vehicle RV**1** is displayed on the second display device **115** (HUD) in the first light color (white). The timing t_{31} may be understood as a timing at which the second state for the peripheral vehicle RV**1** is detected. In addition, at timing t_{32} at which the brake release operation (start operation) is performed by the driver, the attention-calling sound for calling attention to the approach of the peripheral vehicle RV**1** is output from the audio output device **116**, and attention-calling information **31***a* for calling attention to the approach of the peripheral vehicle RV**1** is displayed on the first display device **114** (MID) in the first light color (white). Then, at the timing t_{32}, time measurement for an update prohibition period **32***a* and a display maintenance period **33***a* of the attention-calling information **31***a* is started. The timing t_{32} may be understood as a timing at which the first state for the peripheral vehicle RV**1** is detected.

[0085] Next, at timing t_{33} at which a time to collision (TTC) calculated by the first prediction unit **121***b* for the peripheral vehicle RV**2** reaches the first threshold TH_1, direction information **34***b* in which an approach direction (right) of the peripheral vehicle RV**2** is added is displayed on the second display device **115** (HUD) in the first light color (white). The timing t_{33} may be understood as a timing at which a new second state for the peripheral vehicle RV**2** is detected. Here, timing t_{34} at which the brake release operation (start operation) is performed by the driver is a timing at which a new first state for the peripheral vehicle RV**2** is detected, but the update prohibition period **32***a* of the attention-calling information **31***a* has not yet elapsed at the timing t_{34}. Therefore, output of the attention-calling sound for calling attention to the approach of the peripheral vehicle RV**2** and update of the attention-calling information are not performed.

[0086] Next, at timing t_{35} at which the display maintenance period **33***a* of the attention-calling information **31***a* for the peripheral vehicle RV**1** has elapsed, the display of the attention-calling information **31***a* on the first display device **114** ends. At the timing t_{35}, the display indicating the approach direction of the peripheral vehicle RV**1** ends, and direction information **34***c* indicating only the approach direction of the peripheral vehicle RV**2** is displayed on the second display device **115**. The display of the direction information **34***c* on the second display device **115** ends at timing t_{36} at which the display maintenance period (for example, 6 seconds) has elapsed since the timing t_{33} or the timing t_{34}

Example 4

[0087] In Example 4, as illustrated in FIG. **6**B, an example of driving assistance processing in a case where one peripheral vehicle RV**1** approaches from the left of the self-vehicle SV and the other peripheral vehicle RV**2** approaches from the right of the self-vehicle SV will be described. FIG. **10** is a time chart illustrating driving assistance processing of Example **4**.

[0088] In Example 4, first, at timing t_{41} at which a time to collision (TTC) calculated by the first prediction unit **121***b* for the peripheral vehicle RV**1** reaches a first threshold TH_1, direction information **44***a* indicating an approach direction (left) of the peripheral vehicle RV**1** is displayed on the second display device **115** (HUD) in the first light color (white). The timing t_{41} may be understood as a timing at which the second state for the peripheral vehicle RV**1** is detected. In addition, at timing t_{42} at which the brake release operation (start operation) is performed by the driver, the attention-calling sound for calling attention to the approach of the peripheral vehicle RV**1** is output from the audio output device **116**, and attention-calling information **41***a* for calling attention to the approach of the peripheral vehicle RV**1** is displayed on the first display device **114** (MID) in the first light color (white). Then, at the timing t_{42}, time measurement for an update prohibition period **42***a* and a display maintenance period **43***a* of the attention-calling information **41***a* is started. The timing t_{42} may be understood as a timing at which the first state for the peripheral vehicle RV**1** is detected.

[0089] Next, at timing t_{43} at which a time to collision (TTC) calculated by the first prediction unit **121***b* for the peripheral vehicle RV**2** reaches the first threshold TH_1, direction information **44***b* in which an approach direction (right) of the peripheral vehicle RV**2** is added is displayed on the second display device **115** (HUD) in the first light color (white). The timing t_{43} may be understood as a timing at which a new second state for the peripheral vehicle RV**2** is detected. In addition, timing t_{44} at which the brake release operation (start operation) is performed by the driver is after a lapse of the update prohibition period **42***a* of the attention-calling information **41***a* for the peripheral vehicle RV**1**. Therefore, at the timing t_{44}, the attention-calling sound for calling attention to the approach of the peripheral vehicle RV**2** is output from the audio output device **116**, and attention-calling information **41***b* in which display for calling attention to the approach of the peripheral vehicle RV**2** is added is displayed on the first display device **114** (MID) in the first light color (white), instead of the attention-calling information **41***a*. The attention-calling information **41***b* is information for calling attention to the approach of both the peripheral vehicles RV**1** and RV**2**. Then, at the timing t_{44}, time measurement for an update prohibition period **42***b* and a display maintenance period **43***b* of the attention-calling information **41***b* is started. The timing t_{44} may be understood as a timing at which a new first state for the peripheral vehicle RV**2** is detected.

[0090] Next, at timing t_{45} at which the display maintenance period **43***a* of the attention-calling information **41***a* for the peripheral vehicle RV**1** has elapsed, the display indicating the approach direction of the peripheral vehicle RV**1** ends, and direction information **44***c* indicating only the approach direction of the peripheral vehicle RV**2** is displayed on the second display device **115**. At the timing t_{45}, since the display maintenance period **43***b* has not elapsed, the display of the attention-calling information **41***b* on the first display device **114** is maintained.

[0091] Next, at timing t_{46} at which a time to collision (TTC) calculated by the second prediction unit **121***c* for the peripheral vehicle RV**2** reaches the second threshold TH_2, direction information **44***d* indicating the approach direction (right) of the peripheral vehicle RV**2** is displayed on the second display device **115** (HUD) in the second light color (amber). The timing t_{46} may be understood as a timing at which the fourth state for the peripheral vehicle RV**2** is detected. In addition, at timing t_{47} at which the brake release operation (start operation) is performed by the driver, the

warning sound for warning against the approach of the peripheral vehicle RV**2** is output from the audio output device **116**, and warning information **41***c* for warning against the approach of the peripheral vehicle RV**2** is displayed on the first display device **114** (MID) in the second light color (amber), instead of the attention-calling information **41***b*. That is, the warning information **41***c* is displayed on the first display device **114** in an interruptive manner, instead of the attention-calling information **41***b*. The timing t_{47} may be understood as a timing at which the third state for the peripheral vehicle RV**2** is detected.

[0092] The display of the warning information **41***c* on the first display device **114** is continuously performed even after a lapse of the display maintenance period **43***b* of the attention-calling information **41***b*, and ends at timing t_{48} at which the second prediction unit **121***c* no longer calculates the time to collision. Accordingly, the display of the direction information **44***d* on the second display device **115** also ends at the timing t_{48}.

[0093] Here, the attention-calling information **41***b* for calling attention to the approach of both the peripheral vehicles RV**1** and RV**2** is maintained even after the timing t_{45} at which the display maintenance period **43***a* of the attention-calling information **41***a* for the peripheral vehicle RV**1** has elapsed in Example 4, but the present invention is not limited thereto. For example, at the timing t_{45}, the display for calling attention to the approach of the peripheral vehicle RV**1** may be ended, and the attention-calling information may be updated to call attention only to the approach of the peripheral vehicle RV**2**. That is, the attention-calling information **41***b* for calling attention to the approach of both of the peripheral vehicles RV**1** and RV**2** may be displayed on the first display device **114** between the timings t_{44} and t_{45}, and attention-calling information for calling attention only to the approach of the peripheral vehicle RV**2** may be displayed on the first display device **114** between the timings t_{45} and t_{47}.

Example 5

[0094] In Example 5, as illustrated in FIG. **6**B, an example of driving assistance processing in a case where one peripheral vehicle RV**1** approaches from the left of the self-vehicle SV and the other peripheral vehicle RV**2** approaches from the right of the self-vehicle SV will be described. FIG. **11** is a time chart illustrating driving assistance processing of Example 5.

[0095] In Example 5, first, at timing t_{51} at which a time to collision (TTC) calculated by the first prediction unit **121***b* for the peripheral vehicle RV**1** reaches a first threshold TH_1, direction information **54***a* indicating an approach direction (left) of the peripheral vehicle RV**1** is displayed on the second display device **115** (HUD) in the first light color (white). The timing t_{51} may be understood as a timing at which the second state for the peripheral vehicle RV**1** is detected. In addition, at timing t_{52} at which the brake release operation (start operation) is performed by the driver, the attention-calling sound for calling attention to the approach of the peripheral vehicle RV**1** is output from the audio output device **116**, and attention-calling information **51***a* for calling attention to the approach of the peripheral vehicle RV**1** is displayed on the first display device **114** (MID) in the first light color (white). Then, at the timing t_{52}, time measurement for an update prohibition period **52***a* and a display maintenance period **53***a* of the attention-calling information **51***a* is started. The timing t_{52} may be understood as a timing at which the first state for the peripheral vehicle RV**1** is detected.

[0096] Next, at timing t_{53} at which a time to collision (TTC) calculated by the first prediction unit **121***b* for the peripheral vehicle RV**2** reaches the first threshold TH_1, direction information **54***b* in which an approach direction (right) of the peripheral vehicle RV**2** is added is displayed on the second display device **115** (HUD) in the first light color (white). The timing t_{53} may be understood as a timing at which a new second state for the peripheral vehicle RV**2** is detected. Here, timing t_{54} at which the brake release operation (start operation) is performed by the driver is a timing at which a new first state for the peripheral vehicle RV**2** is detected, but the update prohibition period **52***a* of the attention-calling information **51***a* has not yet elapsed at the timing t_{54}. Therefore, output of the attention-calling sound for calling attention to the approach of the peripheral vehicle RV**2** and update of the attention-calling information are not performed.

[0097] Next, at timing t_{55} at which a time to collision (TTC) calculated by the second prediction unit **121***c* for the peripheral vehicle RV**2** reaches the second threshold TH_2, direction information **54***c* in which the approach direction of the peripheral vehicle RV**1** is maintained in the first light color and the approach direction of the peripheral vehicle RV**2** is changed to the second light color (amber) is displayed on the second display device **115** (HUD). The timing t_{55} may be understood as a timing at which the fourth state for the peripheral vehicle RV**2** is detected.

[0098] At timing t_{56} at which the brake release operation (start operation) is performed by the driver, the warning sound for warning against the approach of the peripheral vehicle RV**2** is output from the audio output device **116**, and warning information **51***b* for warning against the approach of the peripheral vehicle RV**2** is displayed on the first display device **114** (MID) in the second light color (amber), instead of the attention-calling information **51***a*. That is, the warning information **51***b* for warning against the approach of the peripheral vehicle RV**2** is displayed on the first display device **114** in an interruptive manner, instead of the attention-calling information **51***a*. The timing t_{56} may be understood as a timing at which the third state for the peripheral vehicle RV**2** is detected.

[0099] Next, at timing t_{57} at which the display maintenance period **53***a* of the attention-calling information **51***a* for the peripheral vehicle RV**1** has elapsed, the display indicating the approach direction of the peripheral vehicle RV**1** ends, and direction information **54***d* indicating only the approach direction of the peripheral vehicle RV**2** is displayed on the second display device **115** in the second light color.

[0100] The display of the warning information **51***b* on the first display device **114** ends at timing t_{58} at which the second prediction unit **121***c* no longer calculates the time to collision. Accordingly, the display of the direction information **54***d* on the second display device **115** also ends at the timing t_{58}.

[0101] Here, the warning information **51***b* for warning only the approach of the peripheral vehicle RV**2** is displayed on the first display device **114**, instead of the attention-calling information **51***a*, at the timing t_{56} in Example 5, but the present invention is not limited thereto. For example, since the timing t_{54} is before a lapse of the display mainte-

nance period **53***a* of the attention-calling information **51***a* for calling attention to the approach of the peripheral vehicle RV**1**, the attention-calling information **51***a* may be displayed until the timing t_{57} at which the display maintenance period **53***a* ends. That is, between the timings t_{56} and t_{57}, the attention-calling information **51***a* for calling attention to the approach of the peripheral vehicle RV**1** and the warning information **51***b* for warning against the approach of the peripheral vehicle RV**2** may be displayed on the first display device **114** in a superimposed manner. Then, the display of the attention-calling information **51***a* may be ended at the timing t_{57}, and only the warning information **51***b* for warning against the approach of the peripheral vehicle RV**2** may be displayed on the first display device **114** after the timing t_{57}.

[0102] As described above, in the driving assistance device **100** of the present embodiment, the update of the attention-calling information is suppressed (prohibited) until the update prohibition period (second period) elapses from the timing at which the first state is detected and the attention-calling information is displayed on the first display device **114** (MID) even in a case where the first state is newly detected. As a result, it is possible to reduce the annoyance of the driver, such as update of the attention-calling information executed every time a new first state is detected. On the other hand, the direction information displayed on the second display device **115** (HUD) after the second state is detected is updated when the second state is newly detected even if the update prohibition period has not elapsed from the timing. As a result, it is possible to cause the driver to grasp the approach direction of the peripheral vehicle predicted to have the possibility of collision with the self-vehicle. That is, it is possible to cause the driver to appropriately grasp information while reducing the annoyance of the driver according to the present embodiment.

Summary of Embodiment

(Item 1)

[0103] A driving assistance device (e.g. **100**) configured to perform driving assistance for a self-vehicle (e.g. SV), comprising:

[0104] an acquisition unit (e.g. **113**, **124**, **121***a*) configured to acquire peripheral vehicle information including a current position, a speed, and a traveling trajectory of a peripheral vehicle (e.g. RV) present around the self-vehicle, from the peripheral vehicle by vehicle-to-vehicle communication;

[0105] a first prediction unit (e.g. **121***b*) configured to predict a collision possibility between the self-vehicle and the peripheral vehicle based on self-vehicle information including a current position, a speed, and a traveling trajectory of the self-vehicle and the peripheral vehicle information acquired by the acquisition unit;

[0106] a first display unit (e.g. **114**, **121***d*) configured to, when a first state is detected, display attention-calling information for calling attention to approach of the peripheral vehicle in a first period from a timing at which the first state is detected, the first state being a state in which the collision possibility is predicted by the first prediction unit and a start operation is performed by a driver of the self-vehicle; and

[0107] a second display unit (e.g. **115**, **121***e*) configured to, when a second state is detected, display direction information indicating an approach direction of the peripheral vehicle, the second state being a state in which the collision possibility is predicted by the first prediction unit,

[0108] wherein the first display unit suppresses update of the attention-calling information until a second period shorter than the first period elapses from the timing even in a case where the first state is newly detected, and

[0109] wherein the second display unit updates the direction information when the second state is newly detected even in a case where the second period has not elapsed from the timing.

[0110] According to this item, it is possible to reduce the annoyance of the driver such as update of the attention-calling information executed every time a new first state is detected. In addition, since the direction information is updated when a new second state is detected, it is possible to cause the driver to grasp the approach direction of the peripheral vehicle predicted to have the possibility of collision with the self-vehicle. That is, it is possible to cause the driver to appropriately grasp information while reducing the annoyance of the driver, and driving assistance can be appropriately performed.

(Item 2)

[0111] The driving assistance device according to item 1, wherein the first display unit does not update the attention-calling information, when the first state is newly detected before the second period elapses from the timing.

[0112] According to this item, even in a case where the first state is newly detected before the second period elapses for the attention-calling information displayed on the first display unit, it is possible to reduce the annoyance of the driver.

(Item 3)

[0113] The driving assistance device according to item 1 or 2, wherein the second display unit updates the direction information by additionally displaying the approach direction of the peripheral vehicle when the second state is newly detected before the second period elapses from the timing.

[0114] According to this item, it is possible to cause the driver to appropriately grasp the approach direction of the peripheral vehicle predicted to have the possibility of collision with the self-vehicle while reducing the annoyance of the driver.

(Item 4)

[0115] The driving assistance device according to any one of items 1 to 3, wherein the second display unit ends the display of the direction information when the display of the attention-calling information by the first display unit is ended.

[0116] According to this item, it is possible to cause the driver to appropriately grasp information while reducing the annoyance of the driver, and driving assistance can be appropriately performed.

(Item 5)

[0117] The driving assistance device according to any one of items 1 to 4, further comprising:

[0118] an object detector (e.g. **111**) configured to detect an object around the self-vehicle without using vehicle-to-vehicle communication; and

[0119] a second prediction unit (e.g. **121***c*) configured to predict the collision possibility between the self-vehicle and the peripheral vehicle based on the self-vehicle information and a detection result of the object detector,

[0120] wherein the first display unit displays warning information for warning against the approach of the peripheral vehicle when a third state is detected, the third state being a state in which the collision possibility is predicted by the second prediction unit and the start operation is performed by the driver of the self-vehicle.

[0121] According to this item, it is possible to cause the driver to appropriately grasp the possibility of collision with the peripheral vehicle predicted using the object detector (sensor fusion).

(Item 6)

[0122] The driving assistance device according to item 5, wherein the first display unit displays the warning information, instead of the attention-calling information, when the third state is detected even in a case where the second period does not elapse from the timing.

[0123] According to this item, even in a case where the possibility of collision with the peripheral vehicle predicted using the vehicle-to-vehicle communication is displayed as the attention-calling information, it is possible to cause the driver to immediately grasp the possibility of collision with the peripheral vehicle predicted using the object detector (sensor fusion) as the warning information.

(Item 7)

[0124] The driving assistance device according to item 5 or 6, wherein

[0125] the second display unit

[0126] displays the direction information in a first color when the second state is detected, and

[0127] displays the direction information in a second color different from the first color when a fourth state is detected, the fourth state being a state in which the collision possibility is predicted by the second prediction unit.

[0128] According to this item, it is possible to cause the driver to appropriately grasp the approach direction of the peripheral vehicle obtained using the object detector (sensor fusion).

(Item 8)

[0129] The driving assistance device according to any one of items 5 to 7,

[0130] wherein the first prediction unit calculates a time to collision between the self-vehicle and the peripheral vehicle based on the self-vehicle information and the peripheral vehicle information, and predicts that there is the collision possibility when the time to collision is equal to or less than a first threshold (e.g. TH_1), and

[0131] wherein the second prediction unit calculates the time to collision based on the self-vehicle information and the detection result of the object detector, and predicts that there is the collision possibility when the time to collision is equal to or less than a second threshold (e.g. TH_2) smaller than the first threshold.

[0132] According to this item, the prediction of the possibility of collision using the vehicle-to-vehicle communication and the prediction of the possibility of collision using the object detector (sensor fusion) can be appropriately performed.

(Item 9)

[0133] The driving assistance device according to any one of items 5 to 8, further comprising

[0134] an audio output unit (e.g. **116**, **121***f*) configured to output audio,

[0135] wherein the audio output unit

[0136] outputs an attention-calling sound for calling attention to the approach of the peripheral vehicle when the attention-calling information is displayed or updated by the first display unit, and

[0137] outputs a warning sound for warning against the approach of the peripheral vehicle when the warning information is displayed by the first display unit, and

[0138] wherein the attention-calling sound and the warning sound are different from each other.

[0139] According to this item, it is possible to appropriately notify the driver of the attention-calling information and/or the warning information by audio.

[0140] The invention is not limited to the foregoing embodiments, and various variations/changes are possible within the spirit of the invention.

What is claimed is:

1. A driving assistance device configured to perform driving assistance for a self-vehicle, comprising:

an acquisition unit configured to acquire peripheral vehicle information including a current position, a speed, and a traveling trajectory of a peripheral vehicle present around the self-vehicle, from the peripheral vehicle by vehicle-to-vehicle communication;

a first prediction unit configured to predict a collision possibility between the self-vehicle and the peripheral vehicle based on self-vehicle information including a current position, a speed, and a traveling trajectory of the self-vehicle and the peripheral vehicle information acquired by the acquisition unit;

a first display unit configured to, when a first state is detected, display attention-calling information for calling attention to approach of the peripheral vehicle in a first period from a timing at which the first state is detected, the first state being a state in which the collision possibility is predicted by the first prediction unit and a start operation is performed by a driver of the self-vehicle; and

a second display unit configured to, when a second state is detected, display direction information indicating an approach direction of the peripheral vehicle, the second state being a state in which the collision possibility is predicted by the first prediction unit,

wherein the first display unit suppresses update of the attention-calling information until a second period

shorter than the first period elapses from the timing even in a case where the first state is newly detected, and

wherein the second display unit updates the direction information when the second state is newly detected even in a case where the second period has not elapsed from the timing.

2. The driving assistance device according to claim **1**, wherein the first display unit does not update the attention-calling information, when the first state is newly detected before the second period elapses from the timing.

3. The driving assistance device according to claim **1**, wherein the second display unit updates the direction information by additionally displaying the approach direction of the peripheral vehicle when the second state is newly detected before the second period elapses from the timing.

4. The driving assistance device according to claim **1**, wherein the second display unit ends the display of the direction information when the display of the attention-calling information by the first display unit is ended.

5. The driving assistance device according to claim **1**, further comprising:

an object detector configured to detect an object around the self-vehicle without using vehicle-to-vehicle communication; and

a second prediction unit configured to predict the collision possibility between the self-vehicle and the peripheral vehicle based on the self-vehicle information and a detection result of the object detector,

wherein the first display unit displays warning information for warning against the approach of the peripheral vehicle when a third state is detected, the third state being a state in which the collision possibility is predicted by the second prediction unit and the start operation is performed by the driver of the self-vehicle.

6. The driving assistance device according to claim **5**, wherein the first display unit displays the warning information, instead of the attention-calling information, when the third state is detected even in a case where the second period does not elapse from the timing.

7. The driving assistance device according to claim **5**, wherein

the second display unit

displays the direction information in a first color when the second state is detected, and

displays the direction information in a second color different from the first color when a fourth state is detected, the fourth state being a state in which the collision possibility is predicted by the second prediction unit.

8. The driving assistance device according to claim **5**,

wherein the first prediction unit calculates a time to collision between the self-vehicle and the peripheral vehicle based on the self-vehicle information and the peripheral vehicle information, and predicts that there is the collision possibility when the time to collision is equal to or less than a first threshold, and

wherein the second prediction unit calculates the time to collision based on the self-vehicle information and the detection result of the object detector, and predicts that there is the collision possibility when the time to collision is equal to or less than a second threshold smaller than the first threshold.

9. The driving assistance device according to claim **5**, further comprising

an audio output unit configured to output audio,

wherein the audio output unit

outputs an attention-calling sound for calling attention to the approach of the peripheral vehicle when the attention-calling information is displayed or updated by the first display unit, and

outputs a warning sound for warning against the approach of the peripheral vehicle when the warning information is displayed by the first display unit, and

wherein the attention-calling sound and the warning sound are different from each other.

10. A driving assistance method of performing driving assistance for a self-vehicle, comprising:

acquiring peripheral vehicle information including a current position, a speed, and a traveling trajectory of a peripheral vehicle present around the self-vehicle, from the peripheral vehicle by vehicle-to-vehicle communication;

predicting a collision possibility between the self-vehicle and the peripheral vehicle based on self-vehicle information including a current position, a speed, and a traveling trajectory of the self-vehicle and the acquired peripheral vehicle information;

performing, when a first state is detected, a first display of displaying attention-calling information for calling attention to approach of the peripheral vehicle in a first period from a timing at which the first state is detected, the first state being a state in which the collision possibility is predicted and a start operation is performed by a driver of the self-vehicle; and

performing, when a second state is detected, a second display of displaying direction information indicating an approach direction of the peripheral vehicle, the second state being a state in which the collision possibility is predicted,

wherein update of the attention-calling information is suppressed in the first display until a second period shorter than the first period elapses from the timing even in a case where the first state is newly detected, and

wherein the direction information is updated in the second display when the second state is newly detected even in a case where the second period does not elapse from the timing.

11. A non-transitory computer-readable storage medium storing a program for causing a computer to execute a driving assistance method of performing driving assistance for a self-vehicle,

the driving assistance method including:

acquiring peripheral vehicle information including a current position, a speed, and a traveling trajectory of a peripheral vehicle present around the self-vehicle, from the peripheral vehicle by vehicle-to-vehicle communication;

predicting a collision possibility between the self-vehicle and the peripheral vehicle based on self-vehicle information including a current position, a speed, and a traveling trajectory of the self-vehicle and the acquired peripheral vehicle information;

performing, when a first state is detected, a first display of displaying attention-calling information for calling attention to approach of the peripheral vehicle in

a first period from a timing at which the first state is detected, the first state being a state in which the collision possibility is predicted and a start operation is performed by a driver of the self-vehicle; and

performing, when a second state is detected, a second display of displaying direction information indicating an approach direction of the peripheral vehicle, the second state being a state in which the collision possibility is predicted,

wherein update of the attention-calling information is suppressed in the first display until a second period shorter than the first period elapses from the timing even in a case where the first state is newly detected, and

wherein the direction information is updated in the second display when the second state is newly detected even in a case where the second period does not elapse from the timing.

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