VEHICLE CONTROL DEVICE, VEHICLE CONTROL METHOD, AND STORAGE MEDIUM

Abstract

The vehicle control device perceives an object when an object located in front of the host vehicle satisfies a predetermined perception condition, and performs either or both of the following operations: giving a warning to notify an occupant of the host vehicle of a risk of collision with the perceived object, and performing vehicle control for controlling a traveling state of the host vehicle to reduce a risk of collision when a relationship between the host vehicle and the perceived object satisfies a predetermined collision condition. The vehicle control device makes the perception condition easier to be satisfied than the case where the specific condition is not satisfied, when the specific condition including at least the condition that the restricted section in which traffic is restricted exists in front of the host vehicle in the adjacent lane adjacent to the own lane in which the host vehicle travels is satisfied.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2024-023340 filed on Feb. 20, 2024, incorporated herein by reference in its entirety.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to a vehicle control device configured to: perceive an object that meets a predetermined perception condition; and perform either or both of the following operations when a relationship between a host vehicle and the perceived object meets a collision condition: giving a warning, and performing vehicle control. The present disclosure also relates to a vehicle control method in which a computer mounted on a host vehicle perceives an object that meets the perception condition, and performs either or both of the following operations when the collision condition is satisfied: giving a warning, and performing vehicle control. The present disclosure also relates to a storage medium storing a program that causes a computer mounted on a host vehicle to perceive an object that meets the perception condition, and causes the computer to perform either or both of the following operations when the collision condition is satisfied: giving a warning, and performing vehicle control.

2. Description of Related Art

[0003] Conventionally, there has been known a vehicle control device that performs either or both of the following operations when a collision condition is satisfied: giving a warning, and performing vehicle control. For example, a vehicle control device described in Japanese Unexamined Patent Application Publication No. 2020-170278 (JP 2020-170278 A) (hereinafter, referred to as the "conventional device") performs vehicle control earlier than normal against a cut-in vehicle that cuts in an own lane from an adjacent lane.

SUMMARY

[0004] A cut-in vehicle cuts in front of a host vehicle diagonally from behind the host vehicle. Therefore, the cut-in vehicle is more likely to be perceived when it gets closer to the host vehicle than a preceding vehicle and an oncoming vehicle. Accordingly, when the conventional device perceives the cut-in vehicle, it may already be past the timing to perform the vehicle control. In this case, the conventional device is unable to give a warning and/or perform the vehicle control against the cut-in vehicle at the above timing.

[0005] The present disclosure was made to address the above issue. In other words, an object of the present disclosure is to provide a vehicle control device that increases the possibility that the vehicle control device can give a warning and/or perform vehicle control against a cut-in vehicle at an appropriate timing.

[0006] A vehicle control device of the present disclosure (hereinafter also referred to as the "device of the present disclosure") perceives an object located in front of a host vehicle when the object meets a predetermined perception condition (steps **500** to **595**, steps **600** to **695**). When a relationship between the host vehicle and the perceived object meets a predetermined collision condition ("Yes" in step **330**), the vehicle control device performs either or both of following

operations: giving a warning to notify an occupant of the host vehicle of a risk of collision with the perceived object (step **335**), and performing vehicle control for controlling a traveling state of the host vehicle in order to reduce the risk of collision (step **340**).

[0007] The vehicle control device is configured to, when a specific condition is satisfied ("No" in step **310**), make the perception condition easier to be satisfied (step **345**) than when the specific condition is not satisfied ("Yes" in step **310**). The specific condition includes at least a condition that a restricted section (RS) where traffic is restricted is present in front of the host vehicle in an adjacent lane (NL) located adjacent to an own lane in which the host vehicle travels.

[0008] When the specific condition is satisfied, there is an increased possibility that an adjacent vehicle traveling in the adjacent lane may cut in front of the host vehicle from diagonally behind the host vehicle due to the restricted section that is present in the adjacent lane. Such a cut-in vehicle cuts in front of the host vehicle from behind the host vehicle. Therefore, when the perception condition for the cut-in vehicle is satisfied, it may already be past the timing to give a warning and/or perform the vehicle control against the cut-in vehicle. When the specific condition is satisfied, the device of the present disclosure makes the perception condition easier to be satisfied than when the specific condition is not satisfied. Therefore, the device of the present disclosure can perceive the cut-in vehicle earlier. This can increase the possibility that the device of the present disclosure can give a warning and/or perform the vehicle control against the cut-in vehicle at the above timing.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:

[0010] FIG. **1** is a schematic system configuration diagram of a vehicle control device according to an embodiment of the present disclosure;

[0011] FIG. **2** is an explanatory diagram of an outline of operation of a vehicle control device according to an embodiment of the present disclosure;

[0012] FIG. **3** is a flow chart of a vehicle control routine executed by CPU of ECU shown in FIG. **1**;

[0013] FIG. **4** is a flow chart of a specific condition determination subroutine executed by CPU of ECU shown in FIG. **1**;

[0014] FIG. **5** is a flow chart of a normal perception subroutine performed by CPU of ECU shown in FIG. **1**; and

[0015] FIG. **6** is a flow chart of a mitigation perception subroutine performed by CPU of ECU shown in FIG. **1**.

DETAILED DESCRIPTION OF EMBODIMENTS

[0016] As illustrated in FIG. **1**, the vehicle control device **10** (hereinafter, referred to as "the device **10**") according to the present embodiment is applied to the host vehicle SV and includes the components illustrated in FIG. **1**.

[0017] In the present specification, "ECU **20**" is an electronic control device including a microcomputer as a main part. ECU **20** are also referred to as control units, controllers, and computers. The microcomputer includes a CPU (processor), a ROM, RAM, interfaces, and the like. The function realized by ECU **20** may be realized by a plurality of ECU.

[0018] The front camera **22** captures a view in front of the host vehicle SV to acquire front image data. The rear-view camera **24** captures an image of a view behind the host vehicle SV. ECU **20** acquires front image data and rear image data from the front camera **22** and the rear-view camera

24, respectively.

[0019] The front millimeter-wave radar **26** specifies the position and the relative-velocity Vr of the object located in the front center of the host vehicle SV. The right front millimeter-wave radar **28** specifies the position and the relative-velocity Vr of the object located in the right front of the host vehicle SV. The left front millimeter-wave radar **30** specifies the position and the relative-velocity Vr of the object located in the left front of the host vehicle SV. When it is not necessary to distinguish the front millimeter wave radar **26**, the right front millimeter wave radar **28**, and the left front millimeter wave radar **30**, they are referred to as "millimeter wave radar".

[0020] The millimeter wave radar transmits a millimeter wave, and the transmitted millimeter wave receives the reflected wave reflected by the object, thereby specifying "reflection intensity S of the reflected wave", "position of the object with respect to the host vehicle SV", and "relative velocity Vr of the object with respect to the host vehicle SV". ECU **20** obtains radar object information from the millimeter-wave radar, the radar object information including the reflection intensity S, the position of the object, and the relative-velocity Vr.

[0021] The clearance sonar **32** determines the position of the object with respect to the host vehicle SV by transmitting the ultrasonic waves and receiving the reflected waves reflected by the object. ECU **20** obtains from the clearance sonar **32** sonar object information including the position of the object. Note that a plurality of clearance sonars **32** are disposed on the host vehicle SV, and ECU **20** can identify an object located in the vicinity of the host vehicle SV.

[0022] The vehicle speed sensor **34** measures a vehicle speed Vs representing the speed of the host vehicle SV. The acceleration sensor **36** measures an acceleration G in the front-rear axial direction of the host vehicle SV. ECU **20** obtains measurements of these sensors.

[0023] The navigational device **38** includes a GNSS receiver **38***a* and a map data storage unit **38***b*. GNSS receiver **38***a* receives signals from a plurality of satellites and identifies the present position (latitude and longitude) of the host vehicle SV based on the received signals. The map data storage unit **38***b* stores map data. The position of the restricted section RS (see FIG. **2**) in which the traffic of the vehicles is restricted is registered in the map data.

[0024] The powertrain actuator **40** changes a driving force generated by a driving device (for example, an internal combustion engine and/or an electric motor) of the host vehicle SV. The brake actuator **42** controls a braking force applied to the host vehicle SV.

[0025] The display **44** is disposed at a position visible to the driver in the vehicle cabin of the host vehicle SV, and displays a warning window to be described later. The speaker **46** is disposed in the vehicle cabin of the host vehicle SV, and emits an alarm sound to be described later.

Overview of Operation

[0026] ECU **20** perceives an object that meets a perception condition to be described later, and determines whether or not a relation between the host vehicle SV and the perceived object meets a predetermined collision condition. The collision condition is satisfied when the collision risk between the host vehicle SV and the object becomes equal to or greater than a predetermined value.

[0027] When the collision condition is satisfied, ECU **20** performs either or both of the following operations: giving a warning to notify an occupant (in particular, a driver) of the host vehicle SV of the risk of collision with the object, and performing vehicle control for controlling the traveling state of the host vehicle SV in order to reduce the collision risk with the object. Examples of the vehicle control include a deceleration control for decelerating the host vehicle SV, and an avoidance control for changing the steering angle of the host vehicle SV so as to avoid colliding with an object. In the present embodiment, an example in which the deceleration control is performed as the vehicle control will be described.

[0028] In the present embodiment, when a predetermined specific condition is satisfied, ECU **20** perceives the object using the relaxation perception condition that is more likely to be satisfied than when the specific condition is not satisfied. The specific condition includes at least a condition that the restricted section RS exists in the adjacent lane NL in front of the host vehicle SV. When the

specific condition is satisfied, the "possibility of interruption that the adjacent vehicle NV traveling in the adjacent lane NL due to the restricted section RS interrupts the front of the host vehicle SV from the rear side of the host vehicle SV" is higher than when the specific condition is not satisfied. The adjacent lane NL is a lane adjacent to the own lane SL on which the host vehicle SV is traveling. Details of the specific conditions will be described later.

[0029] When the object is perceived using the relaxation perception condition, the perception time required for the object to be perceived is shortened. Therefore, it is possible to shorten the time until the interruption vehicle is perceived, and it is possible to reduce the possibility that the warning and the execution timing at which the vehicle should be executed have already been exceeded when the interruption vehicle is perceived. Therefore, it is possible to increase the possibility that the warning or the vehicle control for the interrupting vehicle can be executed at an appropriate timing.

Specific Conditions

[0030] Specific conditions will be described with reference to FIG. **2**.
When the following condition S1 or condition S3 are satisfied, the specific condition is satisfied.
[0031] Condition S1: In the adjacent lane NL in front of the host vehicle SV, a restricted section RS exists, and a distance D**1** between a starting point of the restricted section RS and the host vehicle SV is equal to or less than a first threshold distance D**1**th. [0032] Condition S2: The adjacent vehicle NV is located behind the host vehicle SV, and the adjacent vehicle NV approaches the host vehicle SV. [0033] Condition S3: The host vehicle SV in front of the own lane SL has no preceding vehicle PV, or the inter-vehicle distance D**2** between the preceding vehicle PV and the host vehicle SV is equal to or greater than the second threshold distance D**2**th.
When the condition S1 or the condition S3 is satisfied, the traffic of the adjacent vehicle NV is restricted by the restricted section RS, so that the possibility that the adjacent vehicle NV interrupts the own lane SL ahead of the host vehicle SV is increased.

Normal Perception Conditions

[0034] If the specific condition is not satisfied, ECU **20** determines that the object satisfies the perception condition and perceives the object when the object satisfies all of the following condition N1 or condition N3. [0035] Condition N1: An object is detected based on the forward image data and the object is detected based on the radar object information. [0036] Condition N2: The detection time T at which the object is detected based on the forward image data is equal to or greater than the first threshold time Td**1**. [0037] Condition N3: The reflection intensity S of the object is greater than or equal to the first threshold intensity Sd**1**.
The perception condition used when the specific condition is not satisfied is referred to as a "normal perception condition".
A "configuration for detecting an object based on forward image data" of ECU **20** may be referred to as a "first detection unit", and a "configuration for detecting an object based on radar object information" of ECU **20** may be referred to as a "second detection unit".

Relaxation Perception Conditions

[0038] On the other hand, when the specific condition is satisfied, when the object satisfies any one of the following condition N4 or condition N6, ECU **20** determines that the object satisfies the perception condition and perceives the object. [0039] Condition N4: An object is detected based on the forward image data, and the detection time T is equal to or greater than a "second threshold time Td**2** shorter than the first threshold time Td**1**". [0040] Condition N5: An object is detected based on the radar object information, and the reflection intensity S is equal to or greater than a "second threshold intensity Sd**2** smaller than the first threshold intensity Sd**1**". [0041] Condition N6: An object is detected based on the sonar object data.
This perception condition used when the specific condition is satisfied is referred to as a "relaxation perception condition".
A "configuration for detecting an object based on the sonar object information" of ECU **20** may be

referred to as a "third detection unit".

[0042] When the specific condition is not satisfied, ECU **20** perceives an object existing in the detection area DA using the normal perception condition. The detection area DA includes a right detection area RDA and a left detection area LDA. When the specific condition is satisfied, ECU **20** perceives, using the relaxation perception condition, an object existing in the area where the restricted section RS is present among the right detection area RDA and the left detection area LDA. Then, ECU **20** perceives an object existing in the area where the restricted section TS does not exist using the normal perception condition. Accordingly, it is possible to increase a possibility that a warning or a vehicle control related to the interrupting vehicle can be executed at an appropriate timing. Further, it is possible to reduce the possibility of erroneously performing the warning and the vehicle control due to erroneously perceiving an object that does not exist in the area where the adjacent vehicle NV does not exist.

Specific Operation

Vehicle Control Routine

[0043] CPU of ECU **20** is executed every time a predetermined period elapses in the routine illustrated by the flow chart in FIG. **3**.

When the appropriate time point has arrived, CPU starts the process from step **300** of FIG. **3** and performs step **305** and step **310**. [0044] The step **305**: CPU executes a specific condition determination subroutine for determining whether or not the specific condition is satisfied. Details of the specific condition determination subroutine will be described later. [0045] The step **310**: CPU determines whether or not the particular flag Xspe is "0".

The specific flag Xspe is set to "1" when the specific condition is satisfied, and is set to "0" when the specific condition is not satisfied. The specified flag Xspe is set to "0" in the initial routine. The initialization routine is executed by CPU when the ignition-key switch (not shown) of the host vehicle SV is changed from the off-position to the on-position.

[0046] If the specified flag Xspe is "0", CPU determines "Yes" in step **310** and executes step **315** and step **320**. [0047] The step-by-step **315**: CPU executes a normal perception sub-routine for perceiving the object using the normal perception condition. The details of the normal perception subroutine will be described later. [0048] The stepping **320**: CPU determines whether or not there is an "object having a collision possibility that collides with the host vehicle SV" in the perceived object. Specifically, CPU estimates the moving direction of the object with respect to the host vehicle SV based on the history of the position of the object with respect to the host vehicle SV, and determines that the object has a collision possibility when the moving direction of the object intersects with the host vehicle SV.

[0049] If there are no objects that are likely to collide, CPU determines "No" at step **320**. After that, the process proceeds to step **395**, and CPU ends the routine once.

[0050] On the other hand, if there is an object having a collision possibility, CPU determines "Yes" in step **320**, and executes step **325** and step **330**. [0051] The stepping **325**: CPU obtains TTC (Time To Collision) of the object with collisional possibilities. TTC represents the period of time it takes for an object to collide with the host vehicle SV. CPU obtains TTC by dividing the distance between the object and the host vehicle SV by the relative-velocity Vr of the object. TTC is a collision index correlated with the collision risk, and the shorter TTC, the higher the collision risk. As such a collision index, the distance between the object and the host vehicle SV may be used instead of TTC. [0052] The step **330**: CPU determines whether TTC is less than or equal to a predetermined threshold time Tth.

[0053] If TTC is greater than the threshold time Tth, CPU determines that the impact risk is less than the threshold. CPU then determines "No" in step **330**. After that, the process proceeds to step **395**, and CPU ends the routine once.

[0054] On the other hand, if TTC is less than or equal to the threshold time Tth, CPU determines that the collision-risk is greater than or equal to the threshold. CPU then determines "Yes" in step

330 and performs steps **335** and **340**. [0055] The stepping **335**: CPU provides an alert to notify the occupant of the host vehicle SV of the risk of collision with the object. Specifically, CPU causes the display **44** to display an alert window. The warning screen is a screen indicating the orientation of an object whose TTC is less than or equal to the threshold time Tth. Further, CPU emits an alert sound from the speaker **46**. [0056] The stepping **340**: CPU controls the powertrain actuator **40** and the brake actuator **42** so that the acceleration G of the host vehicle SV coincides with a predetermined deceleration.

After that, the process proceeds to step **395**, and CPU ends the routine once.

[0057] If the specified flag Xspe is "1" when the process proceeds to step **310**, CPU determines "No" in step **310**, and the process proceeds to step **345**. At step **345**, CPU executes a relaxation perception subroutine to perceive the object using the relaxation perception condition. Details of the relaxation perception subroutine will be described later. After that, the process proceeds to step **395**, and CPU ends the routine once.

Specific Condition Determination Subroutine

[0058] When the process proceeds to step **305**, CPU starts the process from step **400** shown in FIG. **4**, and the process proceeds to step **405**. In step **405**, CPU determines whether or not the host vehicle SV is traveling on a road of two lanes or more on one side. For example, when CPU determines that the adjacent lane NL is present and the traveling direction of the adjacent vehicle NV traveling in the adjacent lane NL is the same direction as the host vehicle SV, it determines that the host vehicle SV is traveling on a road having two or more lanes on one side.

[0059] If the host vehicle SV is traveling on a road of two lanes or more on one side, CPU determines "Yes" in step **405**, and the process proceeds to step **410**. In step **410**, CPU determines whether or not the restricted section RS exists in the adjacent lane NL in the traveling direction of the host vehicle SV. For example, CPU determines whether or not the restricted section RS exists in the adjacent lane NL. As another example, CPU may determine that the restricted section RS exists in the adjacent lane NL when a road surface marking RP (see FIG. **2**), a sign, a signboard, or the like indicating that the restricted section RS exists in advance is detected based on the forward image data.

[0060] If there is a restricted section RS in the adjacent lane NL, CPU determines "Yes" in step **410**, and the process proceeds to step **415**. In step **415**, CPU determines whether the distance D**1** is less than or equal to the first threshold distance D**1**th. In one embodiment, CPU obtains the distance D**1** based on the map data.

[0061] When the distance D**1** is equal to or smaller than the first threshold distance D**1**th, the condition S1 is satisfied. In this instance, CPU determines "Yes" in step **415**, and the process proceeds to step **420**. In step **420**, CPU determines whether or not the adjacent vehicle NV is approaching from the rear of the host vehicle SV where the restricted section RS exists, based on the radar object data from the right rear millimeter wave radar and the left rear millimeter wave radar, which are not illustrated.

[0062] When the adjacent vehicle NV is approaching from the rear of the host vehicle SV where the restricted section RS exists, the above-described condition S2 is satisfied. In this instance, CPU determines "Yes" in step **420**, and the process proceeds to step **425**. In step **425**, CPU determines whether the distance D**2** is greater than or equal to the second threshold distance D**2**th. As an illustration, CPU obtains the distance D**2** based on the front camera images and the radar object data from the front millimeter wave radar **26**.

[0063] When the preceding vehicle PV does not exist or the distance D**2** is equal to or larger than the second threshold distance D**2**th, the condition S3 is satisfied. In this case, all of the condition S1 to the condition S3 are satisfied, and the specific condition is satisfied. In this instance, CPU determines "Yes" in step **425**, and the process proceeds to step **430**. In step **430**, CPU sets the specified flag Xspe to "1". After that, the process proceeds to step **495**, and CPU ends the routine once.

[0064] In the following case, since the specific condition is not satisfied, the processing proceeds to step **435**. In step **435**, CPU sets the specified flag Xspe to "0". After that, the process proceeds to step **495**, and CPU ends the routine once. [0065] When the host vehicle SV is not traveling on a road of two lanes or more on one side ("No" in Step **405**) [0066] When there is no restricted section RS in the adjacent lane NL ("No" in step **410**) [0067] When the above distance D**1** is longer than the first threshold distance D**1**th ("No" in step **415**) [0068] If there is no adjacent vehicle NV behind the host vehicle SV on the side where the restricted section RS exists ("No" in step **420**), and if the adjacent vehicle NV does not approach behind the host vehicle SV on the side where the restricted section RS exists ("No" in step **420**) [0069] When the above distance D**2** is less than the second threshold distance D**2**th ("No" in step **425**) [0070] When the distance D**2** is less than the second threshold distance D**2**th, the distance between the preceding vehicle PV and the host vehicle SV is short, and therefore, it is unlikely that the adjacent vehicle NV will be interrupted in front of the host vehicle SV, so that the specific condition is not satisfied.

Normal Perception Subroutine

[0071] When the process proceeds to step **315**, CPU starts the process from step **500** shown in FIG. **5**, and the process proceeds to step **505**. In step **505**, CPU detects the object in the front-camera images and determines whether the object has been detected based on the radar object data. Specifically, when the difference between the position of the object detected based on the front camera image and the position of the object detected based on the radar object information is equal to or smaller than a predetermined value, CPU determines that these objects are the same object. [0072] When an object is detected in the front-camera image and the object is detected based on the radar object information, the condition N1 is satisfied. In this instance, CPU determines "Yes" in step **505**, and the process proceeds to step **510**. In step **510**, CPU determines whether the detection time T of the object is greater than or equal to the first threshold time Td**1**.

[0073] When the detection time T is equal to or greater than the first threshold time Td**1**, the condition N2 is satisfied. In this instance, CPU determines "Yes" in step **510**, and the process proceeds to step **515**. In step **515**, CPU determines, based on the radar object data, whether the reflection intensity S of the object is greater than or equal to the first threshold intensity Sd**1**.

[0074] When the reflection intensity S is equal to or greater than the first threshold intensity Sd**1**, the condition N3 is satisfied, and the object satisfies the normal perception condition. In this instance, CPU determines "Yes" in step **515** and perceives the object. After that, the process proceeds to step **595**, and CPU ends the routine once.

[0075] In the following cases, since the object does not satisfy the normal perception condition, CPU does not perceive the object, the process proceeds to step **595**, and CPU ends the routine once. [0076] When an object is not detected in at least one of the front camera image and the radar object information ("No" in step **505**). [0077] If the detection time T is less than the 1 threshold time Td**1** ("No" in step **510**) [0078] When the reflection intensity S is less than the 1 threshold intensity Sd**1** ("No" in step **515**)

Mitigation Perception Subroutine

[0079] When the process proceeds to step **345**, CPU starts the process from step **600** shown in FIG. **6**, and the process proceeds to step **605**. In step **605**, CPU determines whether an object has been detected based on at least one of the forward camera images and radar object data.

[0080] If an object is detected based on at least one of the front camera image and the radar object information, CPU determines "Yes" in step **605**, and the process proceeds to step **610**. In step **610**, CPU determines whether an object has been detected based on the front-camera images.

[0081] If an object is detected based on the front-camera images, CPU determines "Yes" in step **610** and the process proceeds to step **615**. In step **615**, CPU determines whether the detection time T of the detected object is greater than or equal to the second threshold time Td**2** based on the forward camera-image.

[0082] When the detection time T is equal to or greater than the second threshold time Td**2**, the

condition N4 is satisfied, and the relaxation perception condition is satisfied. In this instance, CPU determines "Yes" in step **615**, and the process proceeds to step **620**. At step **620**, CPU perceives the object. After that, the process proceeds to step **695**, and CPU ends the routine once.

[0083] If no object is detected based on the front camera-image, CPU determines "No" at step **610** and the process proceeds to step **625**. In step **625**, CPU determines whether the reflection intensity S is greater than or equal to the second threshold intensity Sd**2**.

[0084] When the reflection intensity S is equal to or greater than the second threshold intensity Sd**2**, the condition N5 is satisfied, and the relaxation perception condition is satisfied. CPU then determines "Yes" in step **625** and perceives the object in step **620**. After that, the process proceeds to step **695**, and CPU ends the routine once.

[0085] If the reflection intensity S is less than the second threshold intensity Sd**2**, CPU determines "No" in step **625**, and the process proceeds to step **630**. In step **630**, CPU determines whether the clearance sonar **32** has detected an object.

[0086] When an object is detected by the clearance sonar **32**, the above-described condition N6 is satisfied and the relaxation perception condition is satisfied. CPU then determines "Yes" in step **630** and perceives the object in step **620**. After that, the process proceeds to step **695**, and CPU ends the routine once.

[0087] On the other hand, when no object is detected by the clearance sonar **32**, the relaxation perception condition is not satisfied. If CPU does not perceive the object, the process proceeds to step **695**, and CPU ends the routine once.

[0088] If the detection time T is less than the second threshold time Td**2** when the process proceeds to step **615**, CPU determines "No" in step **615**, and the process proceeds to step **635**. In step **635**, CPU determines whether an object has been detected based on the radar object data.

[0089] If an object is detected based on the radar object data, CPU determines "Yes" in step **635**, and the process proceeds to step **625**. On the other hand, if no object is detected based on the radar object data, CPU determines "No" in step **635**, and the process proceeds to step **630**.

[0090] As described above, according to the present embodiment, since the object is perceived using the relaxation perception condition when the specific condition is satisfied, it is possible to increase the possibility that the warning or the vehicle control related to the interrupting vehicle can be executed at an appropriate timing.

[0091] Instead of the millimeter wave radar, the device **10** may include a radar that transmits an electromagnetic wave and detects an object by receiving a reflected wave reflected by the object.

[0092] The device **10** need only perform either or both of giving a warning and performing vehicle control.

[0093] In step **410** illustrated in FIG. **4**, when there is a restricted section RS that satisfies the following condition in front of the host vehicle SV in the adjacent lane NL, CPU may determine "Yes" in step **410**. [0094] Condition: The elapsed time after the restricted section RS is provided is less than a certain period.
It is assumed that the elapsed period is stored in the map data.

[0095] Many drivers are likely not to know the presence of a restricted section RS that has not elapsed days since being provided. For this reason, in a road in which such a restricted section RS is present, there is a high possibility that the number of interrupting vehicles interrupting in front of the host vehicle SV increases. Since the specific condition is established only when the possibility of interruption is high, the possibility that the warning and/or the vehicle control is erroneously executed due to the erroneous perception of the object can be reduced.

[0096] The first detection unit, the second detection unit, and the third detection unit have been described as ECU **20** configurations, but may be configurations of the front camera **22**, the millimeter wave radar, and the clearance sonar **32**, respectively.

[0097] The device **10** is applicable to vehicles such as engine vehicles, hybrid electric vehicle, plug-in hybrid electric vehicles, fuel cell electric vehicle, and battery electric vehicle. Furthermore,

the present disclosure can be regarded as a non-transitory storage medium in which a program for realizing the functions of the device **10** is stored and which is readable by a computer.

Claims

1. A vehicle control device that, when an object located in front of a host vehicle meets a predetermined perception condition, perceives the object, and when a relationship between the host vehicle and the perceived object meets a predetermined collision condition, perform either or both of following operations: giving a warning to notify an occupant of the host vehicle of a risk of collision with the perceived object, and performing vehicle control for controlling a traveling state of the host vehicle in order to reduce the risk of collision, wherein the vehicle control device is configured to, when a specific condition is satisfied, make the perception condition easier to be satisfied than when the specific condition is not satisfied, the specific condition including at least a condition that a restricted section where traffic is restricted is present in front of the host vehicle in an adjacent lane located adjacent to an own lane in which the host vehicle travels.

2. The vehicle control device according to claim 1, wherein the vehicle control device is configured to determine that the specific condition is satisfied when all of following conditions are satisfied: a condition that a distance between the host vehicle and a start point of the restricted section is equal to or less than a first threshold distance; a condition that an adjacent vehicle located behind the host vehicle in the adjacent lane in which the restricted section is present approaches the host vehicle; and a condition that there is no preceding vehicle in front of the host vehicle in the own lane or a distance between the preceding vehicle and the host vehicle is equal to or larger than a second threshold distance.

3. The vehicle control device according to claim 2, wherein the vehicle control device includes a first detection unit that detects the object based on image data acquired by capturing a view in front of the host vehicle, and a second detection unit that transmits an electromagnetic wave forward of the host vehicle and detects the object as the transmitted electromagnetic wave receives a reflected wave reflected by the object, and a third detection unit that transmits a sound wave to around the host vehicle and detects the object as the transmitted sound wave receives a reflected wave reflected by the object, when the specific condition is not satisfied, the vehicle control device determines that the object meets the perception condition when both of following conditions are satisfied: a condition that the first detection unit detects the object and the second detection unit detects the same object as the object detected by the first detection unit; and a condition that a detection time during which the first detection unit detects the object is equal to or longer than a first threshold time and a reflection intensity of the electromagnetic wave from the object is equal to or higher than a first threshold intensity, when the specific condition is satisfied, the vehicle control device determines that the object meets the perception condition when any one of following conditions is satisfied: a condition that the first detection unit detects the object and the detection time is equal to or longer than a second threshold time that is shorter than the first threshold time; a condition that the second detection unit detects the object and the reflection intensity is equal to or higher than a second threshold intensity that is lower than the first threshold intensity; and a condition when the third detection unit detects the object, the vehicle control device further determines whether the perception condition is satisfied for an object located in a detection area including a right detection area on a right side of the host vehicle and a left detection area on a left side of the host vehicle, and when the specific condition is satisfied, the vehicle control device makes the perception condition easier to be satisfied than when the specific condition is not satisfied in a region where the restricted section is present out of the right detection area and the left detection area.

4. A vehicle control method in which, when an object located in front of a host vehicle meets a predetermined perception condition, a computer mounted on the host vehicle perceives the object,

and when a relationship between the host vehicle and the perceived object meets a predetermined collision condition, the computer performs either or both of following operations: giving a warning to notify an occupant of the host vehicle of a risk of collision with the perceived object, and performing vehicle control for controlling a traveling state of the host vehicle in order to reduce the risk of collision, the vehicle control method comprising: determining, by the computer, whether a specific condition is satisfied, the specific condition including at least a condition that a restricted section where traffic is restricted is present in front of the host vehicle in an adjacent lane located adjacent to an own lane in which the host vehicle travels; and when the specific condition is satisfied, making, by the computer, the perception condition easier to be satisfied than when the specific condition is not satisfied.

5. A non-transitory storage medium storing a program that, when an object located in front of a host vehicle meets a predetermined perception condition, causes a computer mounted on the host vehicle to perceive the object, and when a relationship between the host vehicle and the perceived object meets a predetermined collision condition, causes the computer to perform either or both of following operations: giving a warning to notify an occupant of the host vehicle of a risk of collision with the perceived object, and performing vehicle control for controlling a traveling state of the host vehicle in order to reduce the risk of collision, the program causing the computer to perform determining whether a specific condition is satisfied, the specific condition including at least a condition that a restricted section where traffic is restricted is present in front of the host vehicle in an adjacent lane located adjacent to an own lane in which the host vehicle travels, and when the specific condition is satisfied, making the perception condition easier to be satisfied than when the specific condition is not satisfied.