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Fukui et al.

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(54) **VEHICLE DRIVING ASSISTANCE APPARATUS**

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B60W 50/08 (2020.01)
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CPC ***B60W 30/09*** (2013.01); ***B60W 30/0956*** (2013.01); ***B60W 50/08*** (2013.01); ***B60W 50/14*** (2013.01); *B60W 2050/146* (2013.01); *B60W 2540/215* (2020.02)

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See application file for complete search history.

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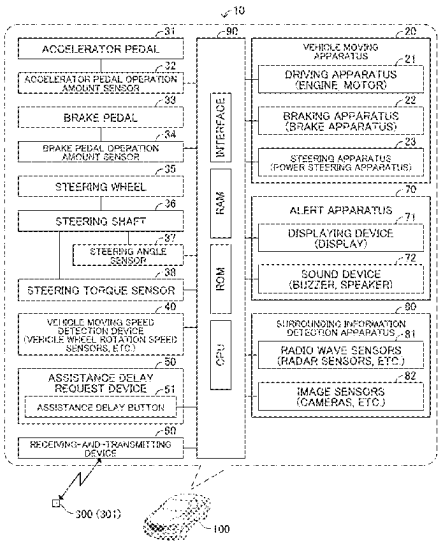
(57) **ABSTRACT**

A vehicle driving assistance apparatus executes a driving assistance control which provides a driver of an own vehicle with a driving assistance when a predetermined execution condition becomes satisfied. The apparatus performs an assistance delay function and a positive assistance function. The assistance delay function is a function to change the predetermined execution condition such that a timing of starting to execute the driving assistance control is later than a base timing. The positive assistance function is a function to change the predetermined execution condition such that the timing of starting to execute the driving assistance control is earlier than the base timing. The apparatus does not perform the assistance delay function even when the assistance delay function is requested to be performed while the positive assistance function is requested to be performed.

4 Claims, 7 Drawing Sheets



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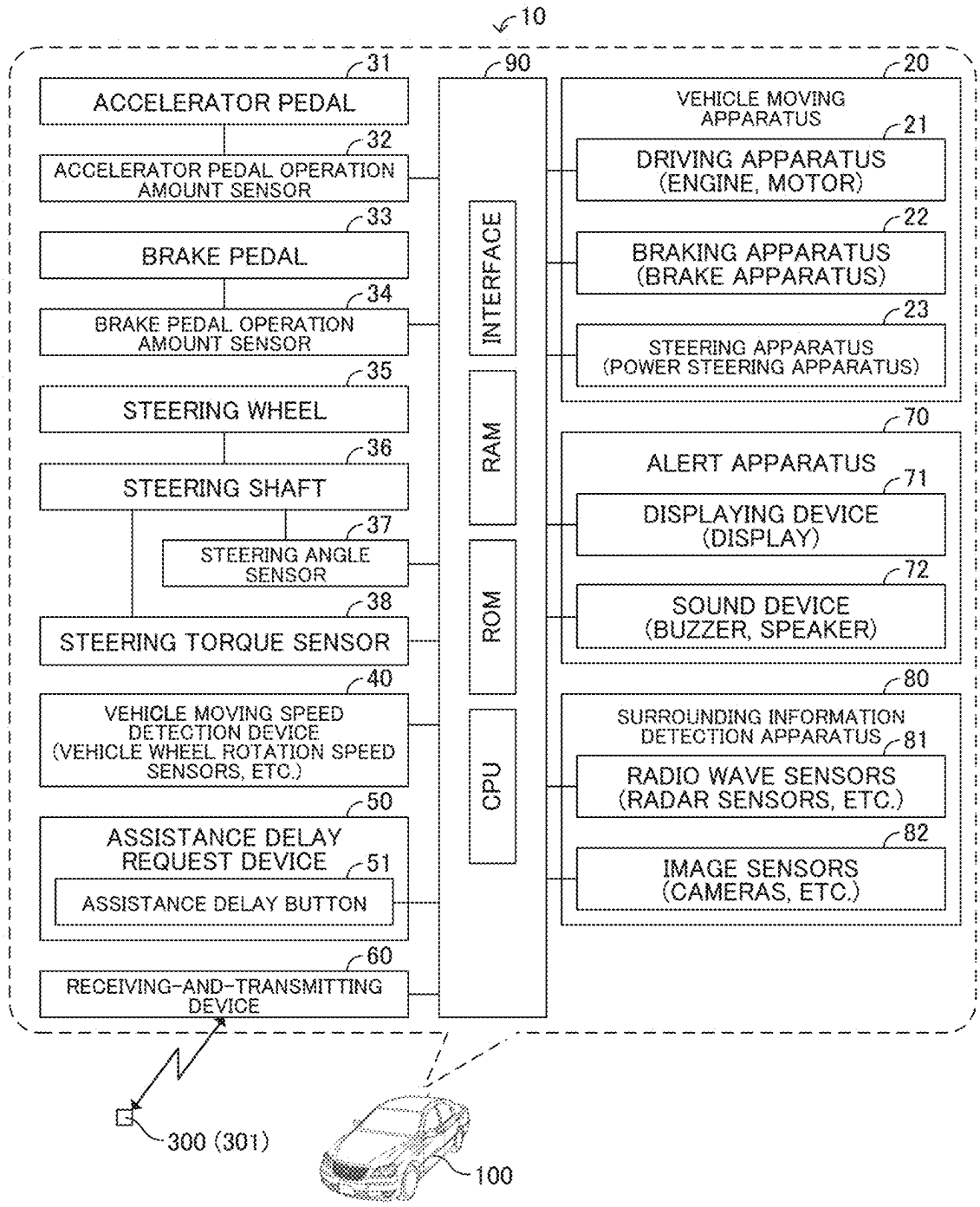
10
31
ACCELERATOR PEDAL
32
ACCELERATOR PEDAL OPERATION AMOUNT SENSOR
33
BRAKE PEDAL
34
BRAKE PEDAL OPERATION AMOUNT SENSOR
35
STEERING WHEEL
36
STEERING SHAFT
37
STEERING ANGLE SENSOR
38
STEERING TORQUE SENSOR
40
VEHICLE MOVING SPEED DETECTION DEVICE (VEHICLE WHEEL ROTATION SPEED SENSORS, ETC.)
50
ASSISTANCE DELAY REQUEST DEVICE
51
ASSISTANCE DELAY BUTTON
60
RECEIVING-AND-TRANSMITTING DEVICE
90
INTERFACE
RAM
ROM
CPU
20
VEHICLE MOVING APPARATUS
21
DRIVING APPARATUS (ENGINE, MOTOR)
22
BRAKING APPARATUS (BRAKE APPARATUS)
23
STEERING APPARATUS (POWER STEERING APPARATUS)
70
ALERT APPARATUS
71
DISPLAYING DEVICE (DISPLAY)
72
SOUND DEVICE (BUZZER, SPEAKER)
80
SURROUNDING INFORMATION DETECTION APPARATUS
81
RADIO WAVE SENSORS (RADAR SENSORS, ETC.)
82
IMAGE SENSORS (CAMERAS, ETC.)
300 (301)
100

FIG.1

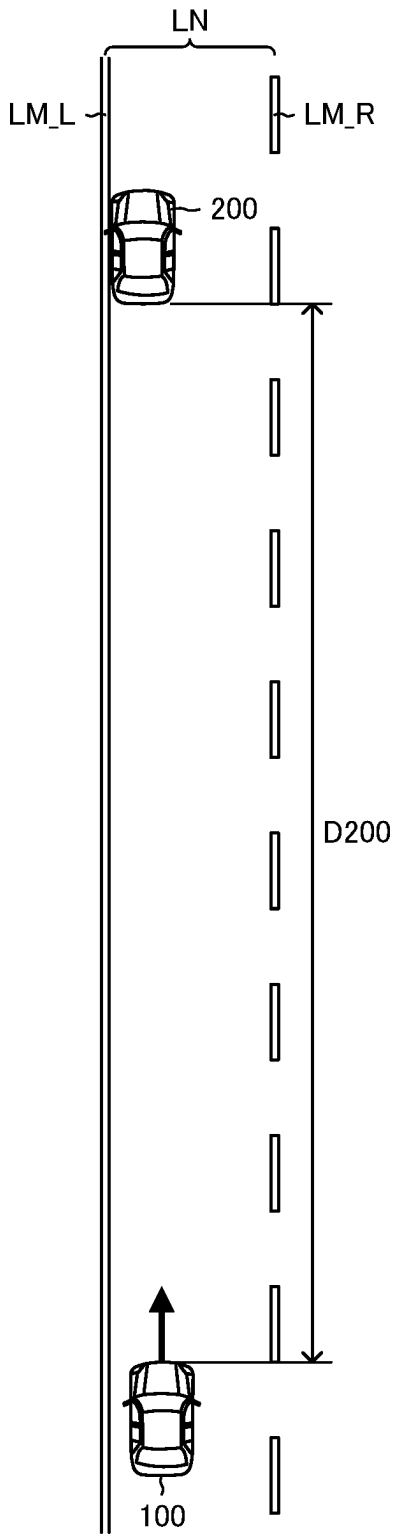

FIG.2

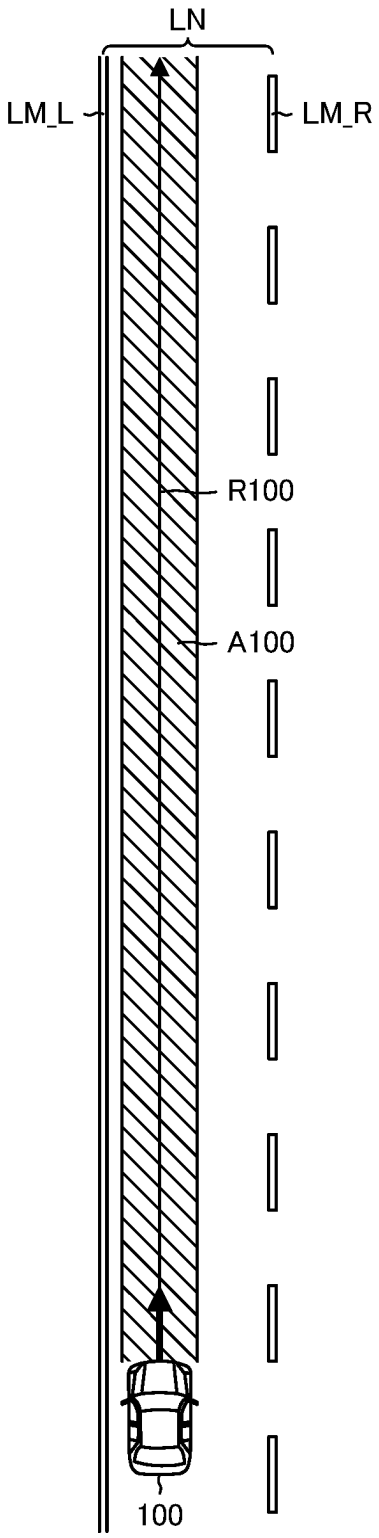

FIG.3A

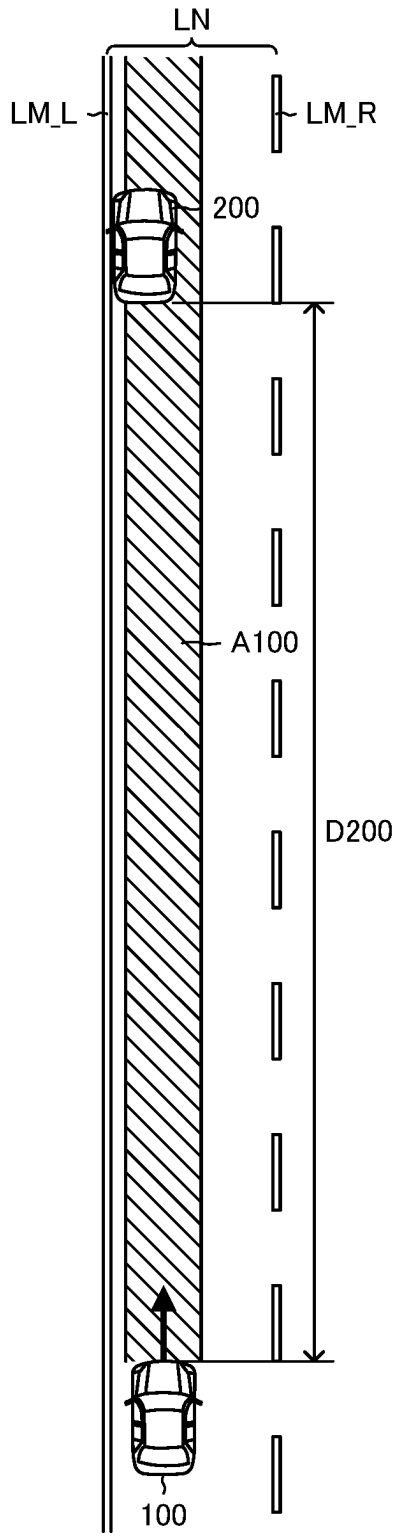

FIG.3B

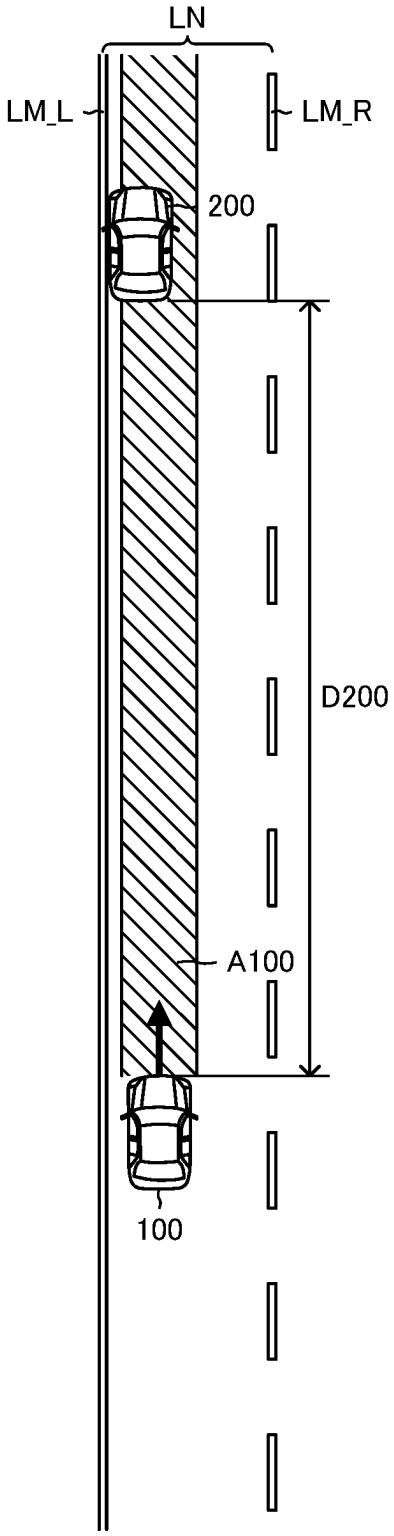

FIG.4A

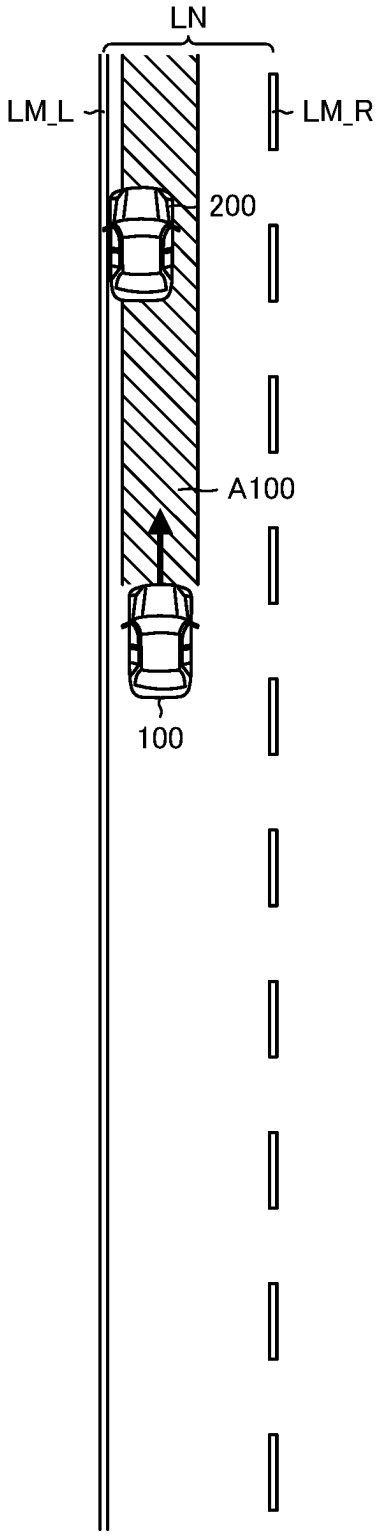

FIG.4B

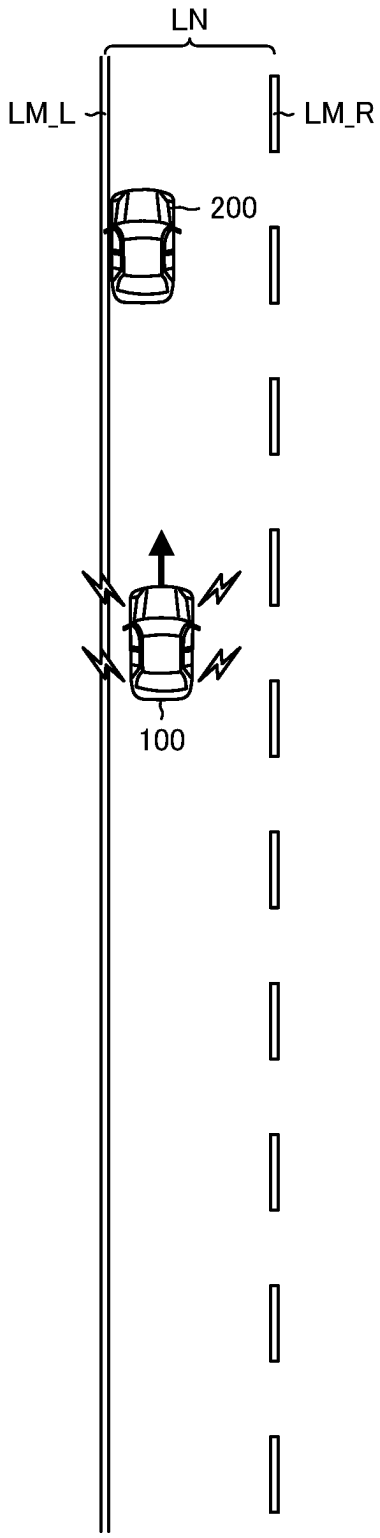

FIG.5A

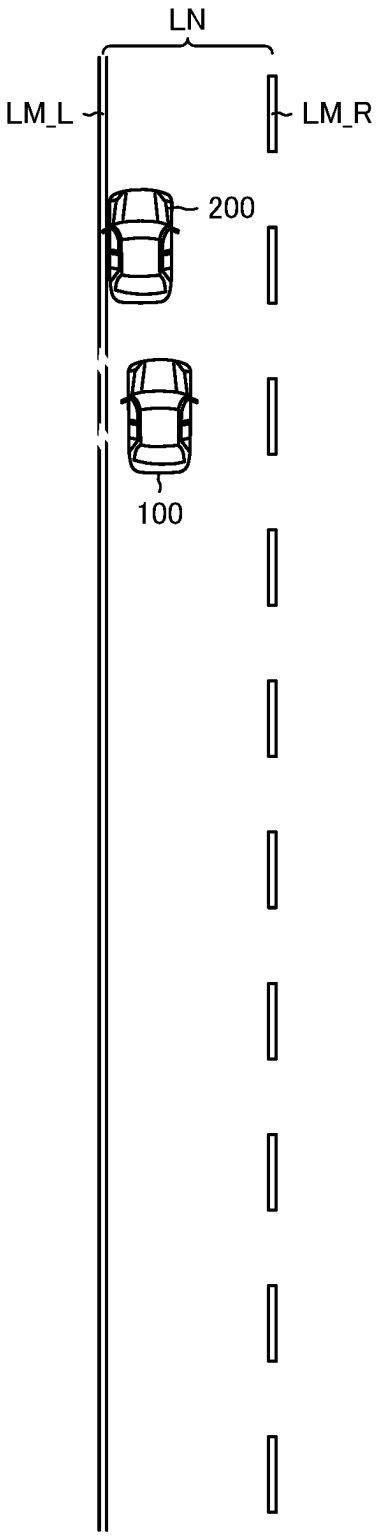

FIG.5B

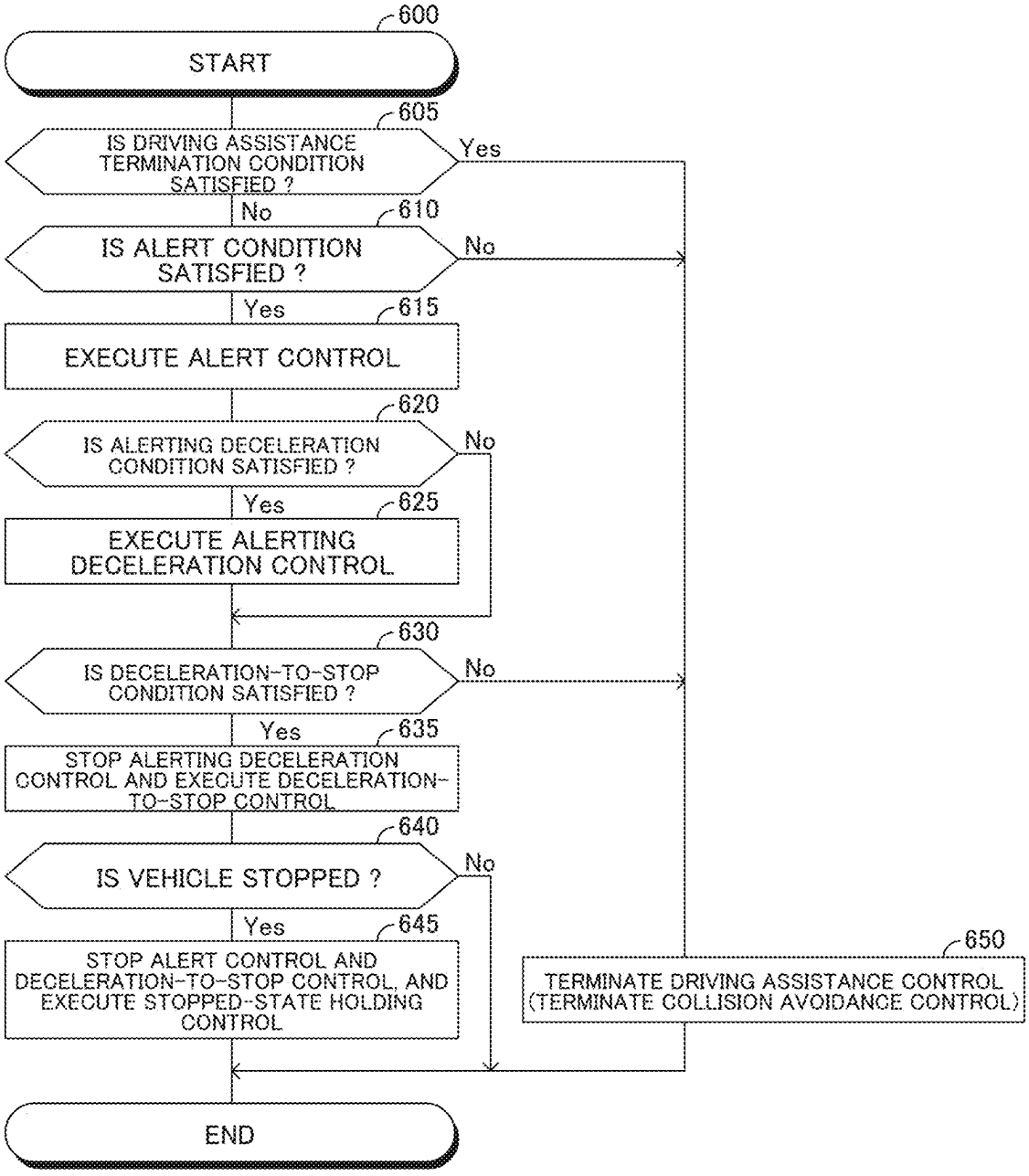
600
START
605
IS DRIVING ASSISTANCE TERMINATION CONDITION SATISFIED ?
Yes
No
610
IS ALERT CONDITION SATISFIED ?
No
Yes
615
EXECUTE ALERT CONTROL
620
IS ALERTING DECELERATION CONDITION SATISFIED ?
No
Yes
625
EXECUTE ALERTING DECELERATION CONTROL
630
IS DECELERATION-TO-STOP CONDITION SATISFIED ?
No
Yes
635
STOP ALERTING DECELERATION CONTROL AND EXECUTE DECELERATION-TO-STOP CONTROL
640
IS VEHICLE STOPPED ?
No
Yes
645
STOP ALERT CONTROL AND DECELERATION-TO-STOP CONTROL, AND EXECUTE STOPPED-STATE HOLDING CONTROL
650
TERMINATE DRIVING ASSISTANCE CONTROL (TERMINATE COLLISION AVOIDANCE CONTROL)
END

FIG.6

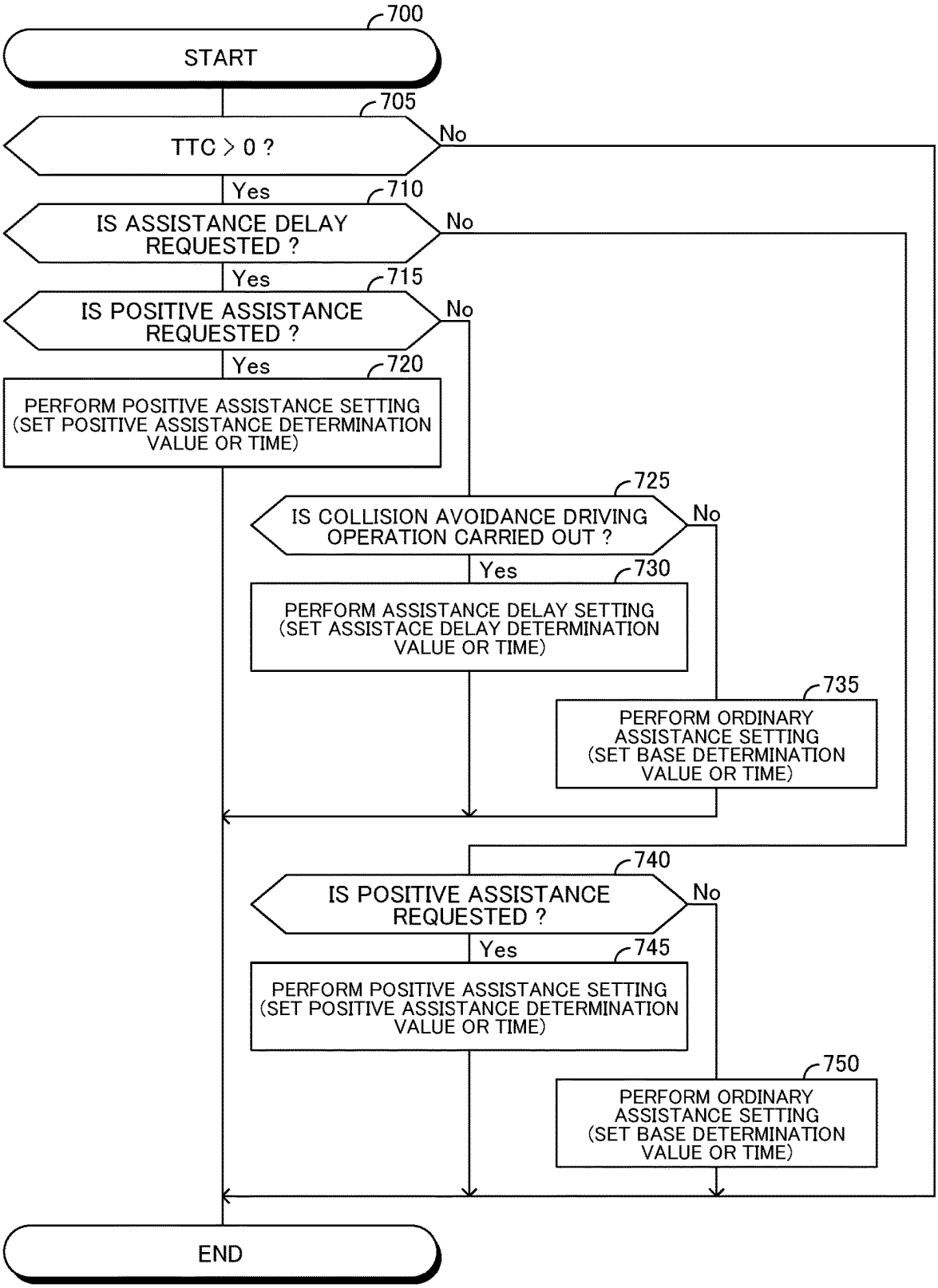
700
START
705
TTC > 0 ?
No
Yes
710
IS ASSISTANCE DELAY REQUESTED ?
No
Yes
715
IS POSITIVE ASSISTANCE REQUESTED ?
No
Yes
720
PERFORM POSITIVE ASSISTANCE SETTING (SET POSITIVE ASSISTANCE DETERMINATION VALUE OR TIME)
725
IS COLLISION AVOIDANCE DRIVING OPERATION CARRIED OUT ?
No
Yes
730
PERFORM ASSISTANCE DELAY SETTING (SET ASSISTACE DELAY DETERMINATION VALUE OR TIME)
735
PERFORM ORDINARY ASSISTANCE SETTING (SET BASE DETERMINATION VALUE OR TIME)
740
IS POSITIVE ASSISTANCE REQUESTED ?
No
Yes
745
PERFORM POSITIVE ASSISTANCE SETTING (SET POSITIVE ASSISTANCE DETERMINATION VALUE OR TIME)
750
PERFORM ORDINARY ASSISTANCE SETTING (SET BASE DETERMINATION VALUE OR TIME)
END

FIG.7

VEHICLE DRIVING ASSISTANCE APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to Japanese patent application No. JP 2021-191918 filed on Nov. 26, 2021, the content of which is hereby incorporated by reference in its entirety.

BACKGROUND

Field

The present disclosure relates to a vehicle driving assistance apparatus.

Description of the Related Art

There is known a vehicle driving assistance apparatus as an autonomous driving apparatus or an automatic driving apparatus which executes a collision avoidance control as a driving assistance control. The collision avoidance control is a control to perform (i) an alert to a driver to avoid a collision of an own vehicle with an object ahead thereof and/or (ii) a deceleration-to-stop to autonomously decelerate the own vehicle to stop.

Further, there is known a vehicle driving assistance apparatus which has an assistance delay function of rendering a timing of starting to perform the alert to the driver later than an ordinary timing when an operation to a steering wheel carried out by the driver to avoid the collision of the own vehicle with the object, is detected (for example, see JP 2019-202586 A). The ordinary timing is a timing of starting to perform the alert when the operation to a steering wheel carried out by the driver to avoid the collision of the own vehicle with the object, is not detected.

For example, when the driver is an aged person, the driver may desire to start to perform the alert to the driver at a timing earlier than the ordinary timing. Accordingly, there is known the vehicle driving assistance apparatus which has a positive assistance function to render the timing of starting to perform the alert to the driver earlier than the ordinary timing when the driver desires the timing of starting to perform the alert earlier than the ordinary timing. In this regard, if the positive assistance function is not performed but the assistance delay function is performed when a probability of the collision of the own vehicle with the object is increasing, the alert inconveniently starts to be performed at a timing later than the ordinary timing although the driver desires that the alert starts to be performed at a timing earlier than the ordinary timing. This is not preferred.

SUMMARY

An object of the present disclosure is to provide a vehicle driving assistance apparatus which provides the driver with a driving assistance as the driver desires.

According to the present disclosure, a vehicle driving assistance apparatus comprises an electronic control unit configured to execute a driving assistance control which provides a driver of an own vehicle with a driving assistance when a predetermined execution condition becomes satisfied. The electronic control unit is configured to perform an assistance delay function and a positive assistance function. The assistance delay function is a function to change the predetermined execution condition such that a timing of starting to execute the driving assistance control is later than a base timing. The positive assistance function is a function to change the predetermined execution condition such that the timing of starting to execute the driving assistance control is earlier than the base timing.

The electronic control unit is configured not to perform the assistance delay function even when the assistance delay function is requested to be performed while the positive assistance function is requested to be performed.

If the assistance delay function is performed when the driver requests to perform the positive assistance function, the timing of starting to execute the driving assistance control is rendered earlier than the base timing. Thereby, the driving assistance desired by the driver is not provided. With the present disclosure, when the positive assistance function and the assistance delay function are both requested to be performed, the assistance delay function is not performed. As a result, the positive assistance function is performed. Thus, the driving assistance desired by the driver is provided.

According to a teaching of the present disclosure, the assistance delay function may be a function to change the predetermined execution condition such that the timing of starting to execute the driving assistance control is later than the base timing when a predetermined driving operation is detected. In this teaching, the predetermined driving operation may be a driving operation to the own vehicle which is carried out by the driver and leads to a probability of rendering the driving assistance by the driving assistance control unnecessary.

If the driving assistance control starts to be executed when the driver carries out the driving operation to the own vehicle which renders the driving assistance by the driving assistance control unnecessary, the driver may feel inconvenience. With this teaching of the present disclosure, when the predetermined driving operation carried out by the driver which renders the driving assistance by the driving assistance control unnecessary, is detected, the timing of starting to execute the driving assistance control is rendered later than the base timing. Thus, the driver does not feel inconvenience.

According to another teaching of the present disclosure, the driving assistance control may be a deceleration-to-stop control which autonomously decelerates the own vehicle to stop to avoid a collision of the own vehicle with an object ahead of the own vehicle. In this teaching, the predetermined driving operation may be a driving operation to the own vehicle carried out by the driver to avoid the collision of the own vehicle with the object.

When the driving assistance control is the deceleration-to-stop control to autonomously decelerate the own vehicle to stop to avoid the collision of the own vehicle with the object ahead thereof, and the driver requests to perform the positive assistance function, if the assistance delay function is performed, the timing of starting to execute the deceleration-to-stop control is rendered earlier than the base timing. Thus, the driving assistance desired by the driver is not provided. With this teaching of the present disclosure, when the positive assistance function and the assistance delay function are requested to be performed, the assistance delay function is not performed. As a result, the positive assistance function is performed. Thus, the driving assistance desired by the driver is provided.

According to another teaching of the present disclosure, the electronic control unit may be configured to determine that the positive assistance function is requested to be

performed when the electronic control unit receives a predetermined signal from the driver. In this teaching, the predetermined signal may be a signal which represents that the driver needs performing the positive assistance function.

With this teaching of the present disclosure, the driver can request to perform the positive assistance function by transmitting the signal which represents that the positive assistance function needs to be performed.

Elements of the present disclosure are not limited to elements of embodiments and modified examples of the present disclosure described with reference to the drawings. The other objects, features and accompanied advantages of the present disclosure can be easily understood from the embodiments and the modified examples of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view which shows a vehicle driving assistance apparatus according to an embodiment of the present disclosure and a vehicle or an own vehicle installed with the vehicle driving assistance apparatus.

FIG. **2** is a view which shows a distance between the own vehicle and an object or a vehicle in front of the own vehicle.

FIG. **3**A is a view which shows a predicted moving area of the own vehicle.

FIG. **3**B is a view which shows a scene that there is an object or a vehicle in the predicted moving area of the own vehicle.

FIG. **4**A is a view which shows a scene that the own vehicle approaches the object or the vehicle in the predicted moving area of the own vehicle, and an alert condition becomes satisfied.

FIG. **4**B is a view which shows a scene that the own vehicle moves close to the object or the vehicle in the predicted moving area of the own vehicle, and a deceleration-to-stop condition becomes satisfied.

FIG. **5**A is a view which shows a scene that a deceleration-to-stop control starts to be executed.

FIG. **5**B is a view which shows a scene that the own vehicle is stopped by the deceleration-to-stop control.

FIG. **6** is a view which shows a flowchart of a routine executed by the vehicle driving assistance apparatus according to the embodiment of the present disclosure.

FIG. **7** is a view which shows a flowchart of a routine executed by the vehicle driving assistance apparatus according to the embodiment of the present disclosure.

DESCRIPTION OF THE EMBODIMENTS

Below, a vehicle driving assistance apparatus as one of autonomous driving apparatuses or automatic driving apparatuses according to an embodiment of the present disclosure will be described with reference to the drawings. As shown in FIG. **1**, the vehicle driving assistance apparatus **10** according to the embodiment of the present disclosure is installed on an own vehicle **100**. In the following description, a term "driver" is a driver of the own vehicle **100**.

<ECU>

The vehicle driving assistance apparatus **10** includes an ECU **90** as a control device. ECU stands for electronic control unit. The ECU **90** includes a microcomputer as a main component. The microcomputer includes a CPU, a ROM, a RAM, a non-volatile memory, and an interface. The CPU is configured or programmed to realize various functions by executing instructions, programs, or routines stored in the ROM.

<Vehicle Moving Apparatus>

The own vehicle **100** is installed with a vehicle moving apparatus **20**. The vehicle moving apparatus **20** includes a driving apparatus **21**, a braking apparatus **22**, and a steering apparatus **23**.

<Driving Apparatus>

The driving apparatus **21** is an apparatus which outputs a driving torque or a driving force to be applied to the own vehicle **100** to move the same. The driving apparatus **21** may include an internal combustion engine and at least one electric motor. The driving apparatus **21** is electrically connected to the ECU **90**. The ECU **90** controls the driving torque output from the driving apparatus **21** by controlling operations of the driving apparatus **21**.

<Braking Apparatus>

The braking apparatus **22** is an apparatus which outputs a braking torque or a braking force to be applied to the own vehicle **100** to brake the same. The braking apparatus **22** may be a brake apparatus. The braking apparatus **22** is electrically connected to the ECU **90**. The ECU **90** controls the braking torque output from the braking apparatus **22** by controlling operations of the braking apparatus **22**.

<Steering Apparatus>

The steering apparatus **23** is an apparatus which outputs a steering torque or a steering force to be applied to the own vehicle **100** to steer the same. The steering apparatus **23** may be a power steering apparatus. The steering apparatus **23** is electrically connected to the ECU **90**. The ECU **90** controls the steering torque output from the steering apparatus **23** by controlling operations of the steering apparatus **23**.

<Sensors, Etc.>

Further, the own vehicle **100** is installed with an accelerator pedal **31**, an accelerator pedal operation amount sensor **32**, a brake pedal **33**, a brake pedal operation amount sensor **34**, a steering wheel **35**, a steering shaft **36**, a steering angle sensor **37**, a steering torque sensor **38**, a vehicle moving speed detection device **40**, an assistance delay request device **50**, a receiving-and-transmitting device **60**, an alert apparatus **70**, and a surrounding information detection apparatus **80**.

<Accelerator Pedal Operation Amount Sensor>

The accelerator pedal operation amount sensor **32** is a sensor which detects an operation amount of the accelerator pedal **31**. The accelerator pedal operation amount sensor **32** is electrically connected to the ECU **90**. The accelerator pedal operation amount sensor **32** sends information on the detected operation amount of the accelerator pedal **31** to the ECU **90**. The ECU **90** acquires the operation amount of the accelerator pedal **31** as an accelerator pedal operation amount AP, based on the information sent from the accelerator pedal operation amount sensor **32**. The ECU **90** calculates and acquires a driver requested driving torque or a driver requested driving force, based on the accelerator pedal operation amount AP and a vehicle moving speed V**100** of the own vehicle **100**. The driver requested driving torque is the driving torque which the driver requests the driving apparatus **21** to output. The ECU **90** controls the operations of the driving apparatus **21** so as to output the driving torque corresponding to the driver requested driving torque. It should be noted that while the ECU **90** executes an alerting deceleration control or a deceleration-to-stop control described later in detail, the ECU **90** determines a system requested driving torque (i.e., the driving torque to be output from the driving apparatus **21**), independently of the accelerator pedal operation amount AP and controls the

operations of the driving apparatus **21** so as to output the driving torque corresponding to the system requested driving torque.

<Brake Pedal Operation Amount Sensor>

The brake pedal operation amount sensor **34** is a sensor which detects an operation amount of the brake pedal **33**. The brake pedal operation amount sensor **34** is electrically connected to the ECU **90**. The brake pedal operation amount sensor **34** sends information on the detected operation amount of the brake pedal **33** to the ECU **90**. The ECU **90** acquires the operation amount of the brake pedal **33** as a brake pedal operation amount BP, based on the information sent from the brake pedal operation amount sensor **34**. The ECU **90** calculates and acquires a driver requested braking torque or a driver requested braking force, based on the brake pedal operation amount BP. The driver requested braking torque is the braking torque which the driver requests the braking apparatus **22** to output. The ECU **90** controls the operations of the braking apparatus **22** so as to apply the braking torque corresponding to the driver requested braking torque to the own vehicle **100**. It should be noted that while the ECU **90** executes the alerting deceleration control or the deceleration-to-stop control described later in detail, the ECU **90** determines a system requested braking torque (i.e., the braking torque to be applied to the own vehicle **100** by the braking apparatus **22**), independently of the brake pedal operation amount BP and controls the operations of the braking apparatus **22** so as to apply the braking torque corresponding to the system requested braking torque to the own vehicle **100**.

<Steering Angle Sensor>

The steering angle sensor **37** is a sensor which detects a rotation angle of the steering shaft **36** with respect to its neutral position. The steering angle sensor **37** is electrically connected to the ECU **90**. The steering angle sensor **37** sends information on the detected rotation angle of the steering shaft **36** to the ECU **90**. The ECU **90** acquires the rotation angle of the steering shaft **36** as a steering angle θ, based on the information sent from the steering angle sensor **37**.

<Steering Torque Sensor>

The steering torque sensor **38** is a sensor which detects a torque which the driver inputs to the steering shaft **36** via the steering wheel **35**. The steering torque sensor **38** is electrically connected to the ECU **90**. The steering torque sensor **38** sends information on the detected torque to the ECU **90**. The ECU **90** acquires the torque which the driver inputs to the steering shaft **36** via the steering wheel **35** as a driver input torque TQ_D, based on the information sent from the steering torque sensor **38**.

<Vehicle Moving Speed Detection Device>

The vehicle moving speed detection device **40** is a device which detects a moving speed of the own vehicle **100**. The vehicle moving speed detection device **40** may include vehicle wheel rotation speed sensors. The vehicle moving speed detection device **40** is electrically connected to the ECU **90**. The vehicle moving speed detection device **40** sends information on the detected moving speed of the own vehicle **100** to the ECU **90**. The ECU **90** acquires the moving speed of the own vehicle **100** as the vehicle moving speed V**100**, based on the information sent from the vehicle moving speed detection device **40**.

The ECU **90** acquires a driver requested steering torque, based on the steering angle θ, the driver input torque TCLD, and the vehicle moving speed V**100**. The driver requested steering torque is the steering torque which the driver requests the steering apparatus **23** to output. The ECU **90** controls the operations of the steering apparatus **23** so as to output the steering torque corresponding to the driver requested steering torque.

<Assistance Delay Request Device>

The assistance delay request device **50** is a device which is operated by the driver to request the vehicle driving assistance apparatus **10** to perform an assistance delay to change a start timing of starting to execute a driving assistance control described later in detail such that the start timing of starting to execute the driving assistance control is later than an ordinary start timing of starting to execute the driving assistance control and to request the vehicle driving assistance apparatus **10** to terminate performing the assistance delay. In this embodiment, the assistance delay request device **50** is an assistance delay button **51** provided near a driver's seat of the own vehicle **100**. The assistance delay button **51** is electrically connected to the ECU **90**.

The ECU **90** recognizes that the assistance delay is requested to be performed when the assistance delay button **51** is turned into an ON state (i.e., a state of requesting performing the assistance delay) by the driver. On the other hand, the ECU **90** recognizes that the assistance delay is not requested to be performed when the assistance delay button **51** is turned into an OFF state (i.e., a state of not requesting performing the assistance delay) by the driver.

<Receiving-And-Transmitting Device>

The receiving-and-transmitting device **60** is electrically connected to the ECU **90**. The ECU **90** receives wireless signals via the receiving-and-transmitting device **60**. The wireless signals are transmitted from a portable device **300** which the driver carries. In addition, the ECU **90** transmits wireless signals via the receiving-and-transmitting device **60**. In this embodiment, the portable device **300** is a smart key **301** which has the receiving-and-transmitting device.

The ECU **90** transmits a particular wireless signal via the receiving-and-transmitting device **60** when the ECU **90** detects the driver getting in the own vehicle **100**. When the smart key **301** receives the particular wireless signal which the ECU **90** transmits, the smart key **301** transmits another particular wireless signal. The wireless signal transmitted from the smart key **301** includes an identification signal which is used to identify the smart key **301** and a positive assistance request signal which requests performing a positive assistance. As described later in detail, the positive assistance is a driving assistance to change the start timing of starting to execute the driving assistance control of providing the driver with the driving assistance such that the start timing is later than the ordinary start timing.

When the ECU **90** receives the wireless signal which the smart key **301** transmits, the ECU **90** determines whether the smart key **301** which transmits the wireless signal is a registered smart key **301**R, based on the identification signal included in the wireless signal. The registered smart key **301**R is a smart key registered as a smart key dedicated to the own vehicle **100**. In this embodiment, the smart key **301** is the registered smart key **301**R. Thus, the ECU **90** determines that the smart key **301** is the registered smart key **301**R when the ECU **90** receives the wireless signal which the smart key **301** transmits. That is, the ECU **90** detects the registered smart key **301**R.

Further, in this embodiment, the smart key **301** is a device which requests the vehicle driving assistance apparatus **10** to provide the driver with the positive assistance, and the wireless signal transmitted from the smart key **301** includes the positive assistance request signal. Thus, when the ECU **90** receives the wireless signal transmitted from the smart key **301**, the ECU **90** determines that the positive assistance

is requested to be performed. That is, when the ECU **90** receives from the smart key **301**, the positive assistance request signal which represents that a positive assistance function of performing the positive assistance is needed to be performed, the ECU **90** determines that the positive assistance function is requested to be performed.

On the other hand, when the ECU **90** does not detect the registered smart key, or when the ECU **90** detects the registered smart key, but the wireless signal transmitted from the registered smart key does not include the positive assistance request signal, the ECU **90** determines that the positive assistance is not requested to be performed.

It should be noted that a positive assistance request device such as a button or a switch which the driver operates to request the vehicle driving assistance apparatus to perform the positive assistance and cancel a request to perform the positive assistance, may be provided near the driver's seat. The positive assistance is to render the start timing of starting to execute the driving assistance control earlier than the ordinary timing. In this case, the vehicle driving assistance apparatus **10** may be configured to determine whether the positive assistance is requested to be performed, based on a state of the positive assistance request device operated by the driver.

<Alert Apparatus>

Further, the own vehicle **100** is installed with an alert apparatus **70**. The alert apparatus **70** is an apparatus which performs various alerts to the driver. In this embodiment, the alert apparatus **70** includes a displaying device **71** and a sound device **72**.

<Displaying Device>

The displaying device **71** is a device which displays various images. The displaying device **71** may be a display provided as a part of a combination meter, a head-up display, or a display of a car navigation device. The displaying device **71** is electrically connected to the ECU **90**. The ECU **90** displays various images on the displaying device **71**.

<Sound Device>

The sound device **72** is a device which outputs various informing sounds, alert sounds, informing announcements, and alert announcements. The sound device **72** may be a buzzer or a speaker. The sound device **72** is electrically connected to the ECU **90**. The ECU **90** outputs various informing sounds, alert sounds, informing announcements, or alert announcements from the sound device **72**.

<Surrounding Information Detection Apparatus>

The surrounding information detection apparatus **80** is an apparatus which detects information on a situation around the own vehicle **100**. In this embodiment, the surrounding information detection apparatus **80** includes radio wave sensors **81** and image sensors **82**. The radio wave sensors **81** may be radar sensors such as millimeter-wave radars. The image sensors **82** may be cameras. It should be noted that the surrounding information detection apparatus **80** may include sonic wave sensors such as ultrasonic wave sensors such as clearance sonars and optical sensors such as laser radars such as LiDARs.

<Radio Wave Sensors>

The radio wave sensors **81** are electrically connected to the ECU **90**. Each radio wave sensor **81** transmits radio waves and receives reflected waves (i.e., the radio waves reflected by objects). The radio wave sensor **81** sends detection results or information on the transmitted radio waves and the received reflected waves to the ECU **90**. In other words, the radio wave sensor **81** detects objects around the own vehicle **100** and sends the detection results or information on the detected objects. The ECU **90** acquires surrounding detection information IS (i.e., information on the objects around the own vehicle **100**), based on radio wave information (i.e., the information sent from the radio wave sensors **81**). It should be noted that in this embodiment, the objects are vehicles, bikes, bicycles, and persons.

<Image Sensors>

The image sensors **82** are electrically connected to the ECU **90**. Each image sensor **82** takes images of a view around the own vehicle **100** and sends information on the taken images to the ECU **90**. The ECU **90** acquires the surrounding detection information IS (i.e., the information on the situation around the own vehicle **100**), based on image information (i.e., the information sent from the image sensors **82**).

As shown in FIG. **2**, when there is a forward object **200** ahead of the own vehicle **100**, the ECU **90** detects the forward object **200**, based on the surrounding detection information IS. It should be noted that the forward object **200** is the vehicle, the bike, the bicycle, or the person. In this embodiment, as shown in FIG. **2**, the forward object **200** is the vehicle. When the ECU **90** detects the forward object **200**, the ECU **90** acquires an object distance D**200** and a relative speed ΔV**200**, based on the surrounding detection information IS. The object distance D**200** is a distance between the forward object **200** and the own vehicle **100**. The relative speed ΔV**200** is a speed of the own vehicle **100** with respect to the forward object **200**.

Further, the ECU **90** recognizes a left lane marking LM_L and a right lane marking LM_R which define an own vehicle lane moving lane LN (i.e., a moving lane in which the own vehicle **100** moves), based on the surrounding detection information IS. The ECU **90** specifies an area of the own vehicle moving lane LN, based on the recognized left and right lane markings LM_L and LM_R.

<Summary of Operations of Vehicle Driving Assistance Apparatus>

Next, a summary of operations of the vehicle driving assistance apparatus **10** will be described.

The vehicle driving assistance apparatus **10** is configured to execute the driving assistance control to provide the driver of the own vehicle **100** with the driving assistance when a predetermined execution condition becomes satisfied. The vehicle driving assistance apparatus **10** described below is an apparatus which executes a collision avoidance control to avoid the collision of the own vehicle **100** with the object ahead thereof as the driving assistance control. In this regard, the concept of the present disclosure may be applied to the vehicle driving assistance apparatus which executes the driving assistance control other than the collision avoidance control described below as far as it provides the driver of the own vehicle with the driving assistance when the predetermined execution condition becomes satisfied.

In this embodiment, the collision avoidance control includes an alert control, an alerting deceleration control, and a deceleration-to-stop control. The alert control is one of the driving assistance controls. The alert control is a control to alert the driver to inform the driver of a probability of the collision of the own vehicle **100** with the object ahead thereof. The alerting deceleration control is also one of the driving assistance controls. The alerting deceleration control is a control to decelerate the own vehicle **100** to inform the driver of the probability of the collision of the own vehicle **100** with the object ahead thereof. The deceleration-to-stop control is also one of the driving assistance controls. The deceleration-to-stop control is a control to stop the own vehicle **100** to avoid the collision of the own vehicle **100** with the object ahead thereof.

While the own vehicle **100** moves, the vehicle driving assistance apparatus **10** executes a process to detect the objects such as the vehicles ahead of the own vehicle **100** in a moving direction of the own vehicle **100**, based on the surrounding detection information IS. When the vehicle driving assistance apparatus **10** does not detects any objects ahead of the own vehicle **100** in the moving direction of the own vehicle **100**, the vehicle driving assistance apparatus **10** executes an ordinary moving control.

The ordinary moving control is a control to (i) output the driving torque corresponding to the driver requested driving torque from the driving apparatus **21** when the driver requested driving torque is greater than zero, (ii) apply the braking torque corresponding to the driver requested braking torque by the braking apparatus **22** when the driver requested braking torque is greater than zero, and (iii) output the steering torque corresponding to the driver requested steering torque from the steering apparatus **23** when the driver requested steering torque is greater than zero.

When the vehicle driving assistance apparatus **10** detects the forward object **200** (i.e., the object ahead of the own vehicle **100** in the moving direction of the own vehicle **100**), the vehicle driving assistance apparatus **10** determines whether the forward object **200** is in a predicted moving area A**100**, based on the surrounding detection information IS. As shown in FIG. **3**A, the predicted moving area A**100** is an area which has a center line along a predicted moving route R**100** of the own vehicle **100** and a width equal to a width of the own vehicle **100**. The predicted moving route R**100** is a moving route predicted for the own vehicle **100** to move assuming that the own vehicle **100** moves with the current steering angle θ. Thus, the predicted moving route R**100** shown in FIG. **3**A has a linear shape. However, the predicted moving route R**100** may have a curved shape, depending on situations.

When the detected forward object **200** is not in the predicted moving area A**100**, the vehicle driving assistance apparatus **10** continues to execute the ordinary moving control.

On the other hand, when the detected forward object **200** is in the predicted moving area A**100**, the vehicle driving assistance apparatus **10** determines whether an alert condition C**1** is satisfied. The alert condition C**1** is a predetermined condition for executing the alert control (i.e., the predetermined execution condition). In this embodiment, the alert condition C**1** is a condition that a collision index IC is equal to or smaller than a predetermined value or a first determination value IC**1**.

The collision index IC represents the probability of the collision of the own vehicle **100** with the forward object **200**. The collision index IC deceases as the probability of the collision of the own vehicle **100** with the forward object **200** increases. In this embodiment, the vehicle driving assistance apparatus **10** acquires a predicted reaching time TTC as the collision index IC. Then, the vehicle driving assistance apparatus **10** determines that the alert condition C**1** becomes satisfied when the predicted reaching time TTC decreases to a predetermined time or a first determination time TTC**1**. That is, in this embodiment, the alert condition C**1** is a condition that the predicted reaching time TTC is equal to or smaller than the first determination time TTC**1**.

The predicted reaching time TTC is a time predicted to be taken for the own vehicle **100** to reach the forward object **200**. The vehicle driving assistance apparatus **10** acquires the predicted reaching time TTC by dividing the object distance D**200** by the relative speed ΔV**200** (TTC=D**200**/ΔV**200**). Thus, when the relative speed ΔV**200** is the same, the predicted reaching time TTC decreases as the own vehicle **100** approaches the forward object **200**.

While the forward object **200** is in the predicted moving area A**100**, the vehicle driving assistance apparatus **10** (i) executes processes to acquire the object distance D**200** (i.e., the distance between the forward object **200** and the own vehicle **100**), the relative speed ΔV**200**, and the predicted reaching time TTC with a predetermined calculation cycle, and (ii) executes a process to determine whether the predicted reaching time TTC decreases to the first determination time TTC**1** each time the vehicle driving assistance apparatus **10** acquires the predicted reaching time TTC. It should be noted that the vehicle driving assistance apparatus **10** acquires the object distance D**200** and the relative speed DV**200**, based on the surrounding detection information IS.

While the predicted reaching time TTC is greater than the predicted reaching time TTC, the vehicle driving assistance apparatus **10** continues to execute the ordinary moving control. On the other hand, as shown in FIG. **4**A, when the own vehicle **100** comes near the forward object **200**, and the predicted reaching time TTC decreases to the first determination time TTC**1**, the vehicle driving assistance apparatus **10** determines that the alert condition C**1** becomes satisfied.

<Alert Control>

When the vehicle driving assistance apparatus **10** determines that the alert condition C**1** becomes satisfied, the vehicle driving assistance apparatus **10** starts executing the alert control. The alert control is a control to (i) output the informing sound (or the alert sound) or the informing announcement (or the alert announcement) from the alert apparatus **70** and/or (ii) display an informing image (or an alert image) on the alert apparatus **70**.

The informing sound and the alert sound output from the alert apparatus **70** by the alert control are to inform the driver of the forward object **200** (i.e., the object ahead of the own vehicle **100**) or the probability of the collision of the own vehicle **100** with the forward object **200**. The informing announcement and the alert announcement output from the alert apparatus **70** by the alert control are announcements to announce (i) the forward object **200** (i.e., the object ahead of the own vehicle **100**), (ii) the probability of the collision of the own vehicle **100** with the forward object **200**, or (iii) a driving operation necessary to avoid the collision of the own vehicle **100** with the forward object **200**.

The informing image and the alert image displayed by the alert apparatus **70** by the alert control are images to represent (i) the forward object **200** (i.e., the object ahead of the own vehicle **100**) by letters and/or graphics, (ii) the probability of the collision of the own vehicle **100** with the forward object **200** by the letters and/or the graphics, or (iii) the driving operation necessary to avoid the collision of the own vehicle **100** with the forward object **200** by the letters and/or the graphics.

It should be noted that the vehicle driving assistance apparatus **10** continues to execute the ordinary moving control while the vehicle driving assistance apparatus **10** executes the alert control.

<Alerting Deceleration Control>

In addition, after the vehicle driving assistance apparatus **10** starts executing the alert control, the vehicle driving assistance apparatus **10** determines whether an alerting deceleration condition C**2** becomes satisfied. The alerting deceleration condition C**2** is a predetermined condition or a predetermined execution condition. In this embodiment, the alerting deceleration condition C**2** is a condition that the collision index IC is equal to or smaller than a predetermined value or a second determination value IC**2** which is smaller

than the first determination value IC1. In particular, in this embodiment, the alerting deceleration condition C2 is a condition that the predicted reaching time TTC is equal to or smaller than a predetermined time or a second determination time TTC2 which is smaller than the first determination time TTC1.

After the vehicle driving assistance apparatus **10** starts executing the alert control, the vehicle driving assistance apparatus **10** continues to execute the ordinary moving control as far as the alerting deceleration condition C2 is not satisfied. When the own vehicle **100** comes near the forward object **200**, and the collision index IC decreases to the second determination value IC2, the vehicle driving assistance apparatus **10** determines that the alerting deceleration condition C2 becomes satisfied. In particular, in this embodiment, when the predicted reaching time TTC decreases to the second determination time TTC2, the vehicle driving assistance apparatus **10** determines that the alerting deceleration condition C2 becomes satisfied.

When the alerting deceleration condition C2 becomes satisfied, the vehicle driving assistance apparatus **10** starts executing the alerting deceleration control. The alerting deceleration control is a control to decelerate the own vehicle **100** by (i) decreasing the driving force applied to the own vehicle **100**, independently of the operation applied to the accelerator pedal **31** by the driver or (ii) controlling the driving force applied to the own vehicle **100** to zero and applying the braking force to the own vehicle **100**.

Further, a deceleration of the own vehicle **100** realized by the alerting deceleration control is not the deceleration to stop the own vehicle **100** before the forward object **200**. The deceleration of the own vehicle **100** realized by the alerting deceleration control is controlled to the deceleration to cause the driver to know or recognize the forward object **200**. Thus, in this embodiment, decelerating the own vehicle **100** realized by the alerting deceleration control is one of the alert controls for the driver.

It should be noted that while the vehicle driving assistance apparatus **10** executes the alerting deceleration control, the vehicle driving assistance apparatus **10** continues to execute the alert control, but the vehicle driving assistance apparatus **10** may be configured to stop executing the alert control when the vehicle driving assistance apparatus **10** starts executing the alerting deceleration control.

<Deceleration-to-Stop Control>

Further, after the vehicle driving assistance apparatus **10** starts executing the alerting deceleration control, the vehicle driving assistance apparatus **10** determines whether a deceleration-to-stop condition C3 becomes satisfied. The deceleration-to-stop condition C3 is a predetermined condition or a predetermined execution condition. In this embodiment, the deceleration-to-stop condition C3 is a condition that the collision index IC is equal to or smaller than a predetermined value or a third determination value IC3 which is smaller than the second determination value IC2. In particular, in this embodiment, the deceleration-to-stop condition C3 is a condition that the predicted reaching time TTC is equal to or smaller than a predetermined time or a third determination time TTC3 which is smaller than the second determination time TTC2.

As shown in FIG. **4**B, when the own vehicle **100** comes close to the forward object **200**, and the collision index IC decreases to the third determination value IC3, the vehicle driving assistance apparatus **10** determines that the deceleration-to-stop condition C3 becomes satisfied. In particular, in this embodiment, when the predicted reaching time TTC decreases to the third determination time TTC3, the vehicle driving assistance apparatus **10** determines that the deceleration-to-stop condition C3 becomes satisfied.

When the deceleration-to-stop condition C3 becomes satisfied, the vehicle driving assistance apparatus **10** starts executing the deceleration-to-stop control. The deceleration-to-stop control is a control to stop the own vehicle **100** before the forward object **200** by (i) controlling the driving force applied to the own vehicle **100** to zero and (ii) forcibly applying the braking force to the own vehicle **100**, independently of the operations applied to the accelerator pedal **31** or the brake pedal **33** by the driver.

When the vehicle driving assistance apparatus **10** starts executing the deceleration-to-stop control, the vehicle driving assistance apparatus **10** (i) sets the deceleration of the own vehicle **100** necessary to stop the own vehicle **100** before the forward object **200** as a target deceleration and (ii) controls the braking force applied to the own vehicle **100** so as to decelerate the own vehicle **100** at the target deceleration. Thereby, as shown in FIG. **5**A, the driving force applied to the own vehicle **100** is controlled to zero, and the braking force is applied to the own vehicle **100**. Then, as shown in FIG. **5**B, the own vehicle **100** is stopped before the forward object **200**. Thereby, the collision of the own vehicle **100** with the forward object **200** is avoided.

When the vehicle driving assistance apparatus **10** stops the own vehicle **100** by the deceleration-to-stop control, the vehicle driving assistance apparatus **10** starts executing a stopped-state holding control to hold the own vehicle **100** stopped by continuing applying the braking force to the own vehicle **100**.

<Assistance Delay And Positive Assistance>

If the driving assistance control such as the alert control starts to be executed when the driver operates the brake pedal **33** to avoid the collision of the own vehicle **100** with the forward object **200**, the driver may feel inconvenience. Thus, the driver may desire the assistance delay to render the start timing of starting to execute the driving assistance control later than the ordinary timing when the driver starts a collision avoidance driving operation (i.e., a driving operation to avoid the collision of the own vehicle **100** with the forward object **200**). In this embodiment, the vehicle driving assistance apparatus **10** has an assistance delay function to perform the assistance delay. The driver desiring the assistance delay can request the vehicle driving assistance apparatus **10** to perform the assistance delay in response to the driver starting the collision avoidance driving operation by operating the assistance delay button **51** to the ON state. In other words, when the assistance delay button **51** is operated by the driver and is turned into the ON state, the vehicle driving assistance apparatus **10** is requested to perform the assistance delay in response to the vehicle driving assistance apparatus **10** determining that the driver starts the collision avoidance driving operation.

The driver may desire the positive assistance to render the start timing of starting to execute the driving assistance control earlier than the ordinary timing in order to enhance a moving safety of the own vehicle **100**. In this embodiment, the vehicle driving assistance apparatus **10** has a positive assistance function to perform the positive assistance. The driver desiring the positive assistance can request the vehicle driving assistance apparatus **10** to perform the positive assistance by getting in the own vehicle **100** with the registered smart key **301**R. In other words, when the driver gets in the own vehicle **100** with the registered smart key **301**R, the vehicle driving assistance apparatus **10** is requested to perform the positive assistance.

In this regard, the driver getting in the own vehicle **100** with the registered smart key **301**R desires the positive assistance. Under the situation, if the assistance delay button **51** is at the ON state, the vehicle driving assistance apparatus **10** is requested to perform the assistance delay and the positive assistance. In this case, even when the start timing of starting to execute the driving assistance control is set to a timing earlier than the ordinary timing by the positive assistance, the start timing of starting to execute the driving assistance control is changed to a later timing by the assistance delay if the driver is determined to start the collision avoidance driving operation before the driving assistance control starts to be executed. Thereby, the driving assistance as desired by the driver cannot be provided.

Accordingly, the vehicle driving assistance apparatus **10** is configured to perform the assistance delay and the positive assistance as described below.

When (i) the assistance delay button **51** is at the ON state and thus, the assistance delay is requested to be performed, and (ii) the positive assistance is not requested to be performed, the vehicle driving assistance apparatus **10** performs the assistance delay in response to determining that the driver starts the collision avoidance driving operation. In other words, when (i) the assistance delay button **51** is at the ON state and thus, the assistance delay is requested to be performed, and (ii) the positive assistance is not requested to be performed, the vehicle driving assistance apparatus **10** performs the assistance delay in response to detecting a predetermined driving operation applied to the own vehicle **100** by the driver which renders the driving assistance by the collision avoidance driving operation unnecessary.

That is, the vehicle driving assistance apparatus **10** performs an assistance delay setting to decrease the first determination value IC**1**, the second determination value IC**2**, and the third determination value IC**3**. In particular, in this embodiment, the vehicle driving assistance apparatus **10** executes the assistance delay setting to decrease the first determination time TTC**1**, the second determination time TTC**2**, and the third determination time TTC**3**.

In particular, when (i) the assistance delay is requested to be performed but the positive assistance is not requested to be performed, and (ii) the vehicle driving assistance apparatus **10** does not determine that the driver starts the collision avoidance driving operation, the vehicle driving assistance apparatus **10** sets (i) the first determination value IC**1** to a base value (i.e., a first base determination value IC**1**_B), (ii) the second determination value IC**2** to a base value (i.e., a second base determination value IC**2**_B) smaller than the first base determination value IC**1**_B, and (iii) the third determination value IC**3** to a base value (i.e., a third base determination value IC**3**_B) smaller than the second base determination value IC**2**_B.

In particular, in this embodiment, when (i) the assistance delay is requested to be performed but the positive assistance is not requested to be performed, and (ii) the vehicle driving assistance apparatus **10** does not determine that the driver starts the collision avoidance driving operation, the vehicle driving assistance apparatus **10** sets (i) the first determination time TTC**1** to a base time (i.e., a first base determination time TTC**1**_B), (ii) the second determination time TTC**2** to a base time (i.e., a second base determination time TTC**2**_B) smaller than the first base determination time TTC**1**_B, and (iii) the third determination time TTC**3** to a base time (i.e., a third base determination time TTC**3**_B) smaller than the second base determination time TTC**2**_B.

In this case, the driving assistance control such as the alert control starts to be executed at the ordinary timing (i.e., the base timing).

On the other hand, when (i) the assistance delay is requested to be performed but the positive assistance is not requested to be performed, and (ii) the vehicle driving assistance apparatus **10** determines that the driver starts the collision avoidance driving operation, the vehicle driving assistance apparatus **10** sets (i) the first determination value IC**1** to a predetermined value (i.e., a first assistance delay determination value IC**1**_D) smaller than the first base determination value IC**1**_B, (ii) the second determination value IC**2** to a predetermined value (i.e., a second assistance delay determination value IC**2**_D) smaller than the second base determination value IC**2**_B and the first assistance delay determination value IC**1**_D, and (iii) the third determination value IC**3** to a predetermined value (i.e., a third assistance delay determination value IC**3**_D) smaller than the third base determination value IC**3**_B and the second assistance delay determination value IC**2**_D.

In particular, in this embodiment, when (i) the assistance delay is requested to be performed but the positive assistance is not requested to be performed, and (ii) the vehicle driving assistance apparatus **10** determines that the driver starts the collision avoidance driving operation, the vehicle driving assistance apparatus **10** sets (i) the first determination time TTC**1** to a predetermined time (i.e., a first assistance delay determination time TTC**1**_D) smaller than the first base determination time TTC**1**_B, (ii) the second determination time TTC**2** to a predetermined time (i.e., a second assistance delay determination time TTC**2**_D) smaller than the second base determination time TTC**2**_B and the first assistance delay determination time TTC**1**_D, and (iii) the third determination time TTC**3** to a predetermined time (i.e., a third assistance delay determination time TTC**3**_D) smaller than the third base determination time TTC**3**_B and the second assistance delay determination time TTC**2**_D.

Thereby, the driving assistance control such as the alert control starts to be executed at a timing later than the ordinary timing (i.e., the base timing).

Further, when (i) the assistance delay button **51** is at the ON state and thus, the assistance delay is requested to be performed, and (ii) the positive assistance is requested to be performed, the vehicle driving assistance apparatus **10** performs the positive assistance. In this case, the vehicle driving assistance apparatus **10** does not execute the assistance delay but continues performing the positive assistance in response to the driver being determined to start the collision avoidance driving operation.

That is, the vehicle driving assistance apparatus **10** performs a positive assistance setting to increase the first determination value IC**1**, the second determination value IC**2**, and the third determination value IC**3** when the positive assistance and the assistance delay are both requested to be performed. In this case, the vehicle driving assistance apparatus **10** does not perform the assistance delay setting and maintains the increased first determination value IC**1**, the increased second determination value IC**2**, and the increased third determination value IC**3** even when the driver is determined to start the collision avoidance driving operation. In particular, in this embodiment, the vehicle driving assistance apparatus **10** performs the positive assistance setting to increase the first determination time TTC**1**, the second determination time TTC**2**, and the third determination time TTC**3** even when the assistance delay is requested to be performed when the positive assistance is requested to be performed. In this case, the vehicle driving assistance

apparatus **10** does not perform the assistance delay setting and maintains the increased first determination time TTC**1**, the increased second determination time TTC**2**, and the increased third determination time TTC**3** even when the driver is determined to start the collision avoidance driving operation.

In particular, when the assistance delay and the positive assistance are both requested to be performed, the vehicle driving assistance apparatus **10** sets (i) the first determination value IC**1** to a predetermined value (i.e., a first positive assistance determination value IC**1**_A) greater than the first base determination value IC**1**_B, (ii) the second determination value IC**2** to a predetermined value (i.e., a second positive assistance determination value IC**2**_A) greater than the second base determination value IC**2**_B and smaller than the first positive assistance determination value IC**1**_A, and (iii) the third determination value IC**3** to a predetermined value (i.e., a third positive assistance determination value IC**3**_A) greater than the third base determination value IC**3**_B. and smaller than the second positive assistance determination value IC**2**_A. Then, even when the vehicle driving assistance apparatus **10** determines that the driver starts the collision avoidance driving operation, the vehicle driving assistance apparatus **10** maintains setting the first determination value IC**1**, the second determination value IC**2**, and the third determination value IC**3** to the first positive assistance determination value IC**1**_A, the second positive assistance determination value IC**2**_A, and the third positive assistance determination value IC**3**_A, respectively.

In particular, in this embodiment, when the assistance delay and the positive assistance are both requested to be performed, the vehicle driving assistance apparatus **10** sets (i) the first determination time TTC**1** to a predetermined time (i.e., a first positive assistance determination time TTC**1**_A) greater than the first base determination time TTC**1**_B, (ii) the second determination time TTC**2** to a predetermined time (i.e., a second positive assistance determination time TTC**2**_A) greater than the second base determination time TTC**2**_B. and smaller than the first positive assistance determination time TTC**1**_A, and (iii) the third determination time TTC**3** to a predetermined time (i.e., a third positive assistance determination time TTC**3**_A) greater than the third base determination time TTC**3**_B. and smaller than the second positive assistance determination time TTC**2**_A. Then, even when the vehicle driving assistance apparatus **10** determines that the driver starts the collision avoidance driving operation, the vehicle driving assistance apparatus **10** maintains setting the first determination time TTC**1**, the second determination time TTC**2**, and the third determination time TTC**3** to the first positive assistance determination time TTC**1**_A, the second positive assistance determination time TTC**2**_A, and the third positive assistance determination time TTC**3**_A, respectively.

Thereby, when the driver desires that the driving assistance such as the alert starts to be performed at an earlier timing, the driving assistance control such as the alert control starts to be executed at the earlier timing.

It should be noted that the vehicle driving assistance apparatus **10** performs the positive assistance or the positive assistance setting when the positive assistance is requested to be performed, and the assistance delay is not requested to be performed.

It should be noted that the vehicle driving assistance apparatus **10** may be configured to determine that the collision avoidance driving operation starts when the brake pedal operation amount BP becomes equal to or greater than a predetermined value, or when the steering angle θ becomes equal to or greater than a predetermined value, or when a shift lever is operated to increase a transmission gear ratio, or when the own vehicle **100** is determined to change lanes due to a blinker lever being operated.

Further, in an example described above, the vehicle driving assistance apparatus **10** performs the assistance delay setting when (i) the assistance delay is requested to be performed but the positive assistance is not requested to be performed, and (ii) the vehicle driving assistance apparatus **10** determines that the collision avoidance driving operation starts. In this regard, the vehicle driving assistance apparatus **10** may be configured to perform the assistance delay setting, independently of whether the vehicle driving assistance apparatus **10** determines that the collision avoidance driving operation starts.

The summary of the operations of the vehicle driving assistance apparatus **10** has been described.

As described above, the concept of the present disclosure can be applied to the vehicle driving assistance apparatus which executes the driving assistance control other than the collision avoidance control described above. In this regard, the driving assistance control other than the collision avoidance control may be (i) a collision avoidance control or a steering collision avoidance control to execute an alert control and an autonomous steering control to avoid the collision of the own vehicle with the object ahead of the own vehicle or (ii) a lane departure prevention control to execute an alert control or an autonomous steering control to prevent the own vehicle from departing from the moving lane.

The alert control of the steering collision avoidance control is one of the driving assistance controls. The alert control of the steering collision avoidance control is a control to alert the driver to inform the driver of the probability of the collision of the own vehicle with the object ahead thereof. The autonomous steering control of the steering collision avoidance control is also one of the driving assistance controls. The autonomous steering control of the steering collision avoidance control is a control to steer the own vehicle to avoid the collision of the own vehicle with the object ahead thereof.

The alert control of the lane departure prevention control is also one of the driving assistance controls. The alert control of the lane departure prevention control is a control to alert the driver to inform the driver of a probability of the own vehicle departing from the moving lane. The autonomous steering control of the lane departure prevention control is also one of the driving assistance controls. The autonomous steering control of the lane departure prevention control is a control to steer the own vehicle to return to a center of the moving lane.

<Specific Operations of Vehicle Driving Assistance Apparatus>

Next, specific operations of the vehicle driving assistance apparatus **10** will be described. The CPU of the ECU **90** of the vehicle driving assistance apparatus **10** according to the embodiment of the present disclosure is configured or programmed to execute a routine shown in FIG. **6** with a predetermined calculation cycle. Thus, at a predetermined timing, the CPU starts a process from a step **600** of the routine shown in FIG. **6** and proceeds with the process to a step **605** to determine whether a driving assistance termination condition C**4** is satisfied.

The driving assistance termination condition C**4** is a condition for terminating executing the driving assistance control. For example, when the driving assistance control is the collision avoidance control described above, the driving assistance termination condition C**4** is a condition that the

own vehicle **100** is stopped by the driver operating the brake pedal **33** and a condition that the driver operates the steering wheel **35**, and the forward object **200** is not in the predicted moving area A**100**.

When the CPU determines "Yes" at the step **605**, the CPU proceeds with the process to a step **650** to terminate executing the driving assistance control and then, terminate executing this routine once. In this case, when the CPU executes the alert control, the CPU terminates executing the alert control. When the CPU executes the alerting deceleration control, the CPU terminates executing the alerting deceleration control. When the CPU executes the deceleration-to-stop control, the CPU terminates executing the deceleration-to-stop control.

On the other hand, when the CPU determines "No" at the step **605**, the CPU proceeds with the process to a step **610** to determine whether the alert condition C**1** is satisfied. When the CPU determines "Yes" at the step **610**, the CPU proceeds with the process to a step **615** to execute the alert control. Next, the CPU proceeds with the process to a step **620** to determine whether the alerting deceleration condition C**2** is satisfied. When the CPU determines "Yes" at the step **620**, the CPU proceeds with the process to a step **625** to execute the alerting deceleration control. Then, the CPU proceeds with the process to a step **630**. On the other hand, when the CPU determines "No" at the step **620**, the CPU proceeds with the process directly to the step **630**.

When the CPU proceeds with the process to the step **630**, the CPU determines whether the deceleration-to-stop condition C**3** is satisfied. When the CPU determines "Yes" at the step **630**, the CPU proceeds with the process to a step **635** to stop executing the alerting deceleration control and execute the deceleration-to-stop control. Next, the CPU proceeds with the process to a step **640** to determine whether the own vehicle **100** is stopped.

When the CPU determines "Yes" at the stpe **640**, the CPU proceeds with the process to a step **645** to stop executing the alert control and the deceleration-to-stop control and execute the stopped-state holding control. Then, the CPU terminates executing this routine once. On the other hand, when the CPU determines "No" at the step **640**, the CPU terminates executing this routine once.

When the CPU determines "No" at the step **610** or **630**, the CPU proceeds with the process to the step **650** to terminate executing the collision avoidance control. Then, the CPU terminates executing this routine once.

In addition, the CPU is configured or programmed to execute a routine shown in FIG. **7** with the predetermined calculation cycle. Thus, at a predetermined timing, the CPU starts a process from a step **700** of the routine shown in FIG. **7** and proceeds with the process to a step **705** to determine whether the predicted reaching time TTC is greater than zero. That is, the CPU determines whether the forward object **200** is detected, and the predicted reaching time TTC has been calculated.

When the CPU determines "Yes" at the step **705**, the CPU proceeds with the process to a step **710** to determine whether the assistance delay is requested to be performed. When the CPU determines "Yes" at the step **710**, the CPU proceeds with the process to a step **715** to determine whether the positive assistance is requested to be performed. When the CPU determines "Yes" at the step **715**, the CPU proceeds with the process to a step **720** to perform the positive assistance setting. In this case, in this embodiment, the first determination time TTC**1** to the third determination time TTC**3** are set to the first positive assistance determination time TTC**1**_A to the third positive assistance determination time TTC**3**_A, respectively. Thereby, the start timing of starting to execute the driving assistance control is rendered earlier than the ordinary timing or the base timing. Then, the CPU terminates executing this routine once.

On the other hand, when the CPU determines "No" at the step **715**, the CPU proceeds with the process to a step **725** to determine whether the collision avoidance driving operation predictively starts. When the CPU determines "Yes" at the step **725**, the CPU proceeds with the process to a step **730** to perform the assistance delay setting. In this case, in this embodiment, the first determination time TTC**1** to the third determination time TTC**3** are set to the first assistance delay determination time TTC**1**_D to the third assistance delay determination time TTC**3**_D, respectively. Thereby, the start timing of starting to execute the driving assistance control becomes later than the ordinary timing or the base timing. Then, the CPU terminates executing this routine once.

On the other hand, when the CPU determines "No" at the step **725**, the CPU proceeds with the process to a step **735** to perform the ordinary assistance setting. In this case, in this embodiment, the first determination time TTC**1** to the third determination time TTC**3** are set to the first base determination time TTC**1**_B to the third base determination time TTC**3**_B, respectively. Thereby, the start timing of starting to execute the driving assistance control is set to the ordinary timing or the base timing. Then, the CPU terminates executing this routine once.

When the CPU determines "No" at the step **710**, the CPU proceeds with the process to a step **740** to determine whether the positive assistance is requested to be performed. When the CPU determines "Yes" at the step **740**, the CPU proceeds with the process to a step **745** to perform the positive assistance setting. In this case, in this embodiment, the first determination time TTC**1** to the third determination time TTC**3** are set to the first positive assistance determination time TTC**1**_A to the third positive assistance determination time TTC**3**_A, respectively. Thereby, the start timing of starting to execute the driving assistance control is rendered earlier than the ordinary timing or the base timing. Then, the CPU terminates executing this routine once.

On the other hand, when the CPU determines "No" at the step **740**, the CPU proceeds with the process to a step **750** to perform the ordinary assistance setting. In this case, in this embodiment, the first determination time TTC**1** to the third determination time TTC**3** are set to the first base determination time TTC**1**_B to the third base determination time TTC**3**_B, respectively. Thereby, the start timing of the driving assistance control is set to the ordinary timing or the base timing. Then, the CPU terminates executing this routine once.

When the CPU determines "No" at the step **705**, the CPU terminates executing this routine once.

The specific operations of the vehicle driving assistance apparatus **10** have been described.

It should be noted that the present disclosure is not limited to the aforementioned embodiments, and various modifications can be employed within the scope of the present disclosure.

What is claimed is:

1. A vehicle driving assistance apparatus comprising:

an electronic control unit configured to:

execute a driving assistance control which provides a driver of an own vehicle with a driving assistance when a predetermined execution condition becomes satisfied,

perform an assistance delay function and a positive assistance function, and

determine an ordinary timing, the ordinary timing being a time of detection of a collision before the predetermined execution condition becomes satisfied,

the assistance delay function being a function to change the predetermined execution condition such that a timing of starting to execute the driving assistance control is later than the ordinary timing, and

the positive assistance function being a function to change the predetermined execution condition such that the timing of starting to execute the driving assistance control is earlier than the ordinary timing,

wherein the electronic control unit is configured not to perform the assistance delay function even when the assistance delay function is requested to be performed while the positive assistance function is requested to be performed.

2. The vehicle driving assistance apparatus as set forth in claim **1**,

wherein the assistance delay function is a function to change the predetermined execution condition such that the timing of starting to execute the driving assistance control is later than the ordinary timing when a predetermined driving operation is detected, and

wherein the predetermined driving operation is a driving operation to the own vehicle which is carried out by the driver and leads to a probability of rendering the driving assistance by the driving assistance control unnecessary.

3. The vehicle driving assistance apparatus as set forth in claim **2**,

wherein the driving assistance control is a deceleration-to-stop control which autonomously decelerates the own vehicle to stop to avoid a collision of the own vehicle with an object ahead of the own vehicle, and

wherein the predetermined driving operation is a driving operation to the own vehicle carried out by the driver to avoid the collision of the own vehicle with the object.

4. The vehicle driving assistance apparatus as set forth in claim **1**,

wherein the electronic control unit is configured to determine that the positive assistance function is requested to be performed when the electronic control unit receives a predetermined signal from the driver, and

wherein the predetermined signal is a signal which represents that the driver needs performing the positive assistance function.

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