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(54) **VEHICLE DRIVING ASSISTANCE APPARATUS**

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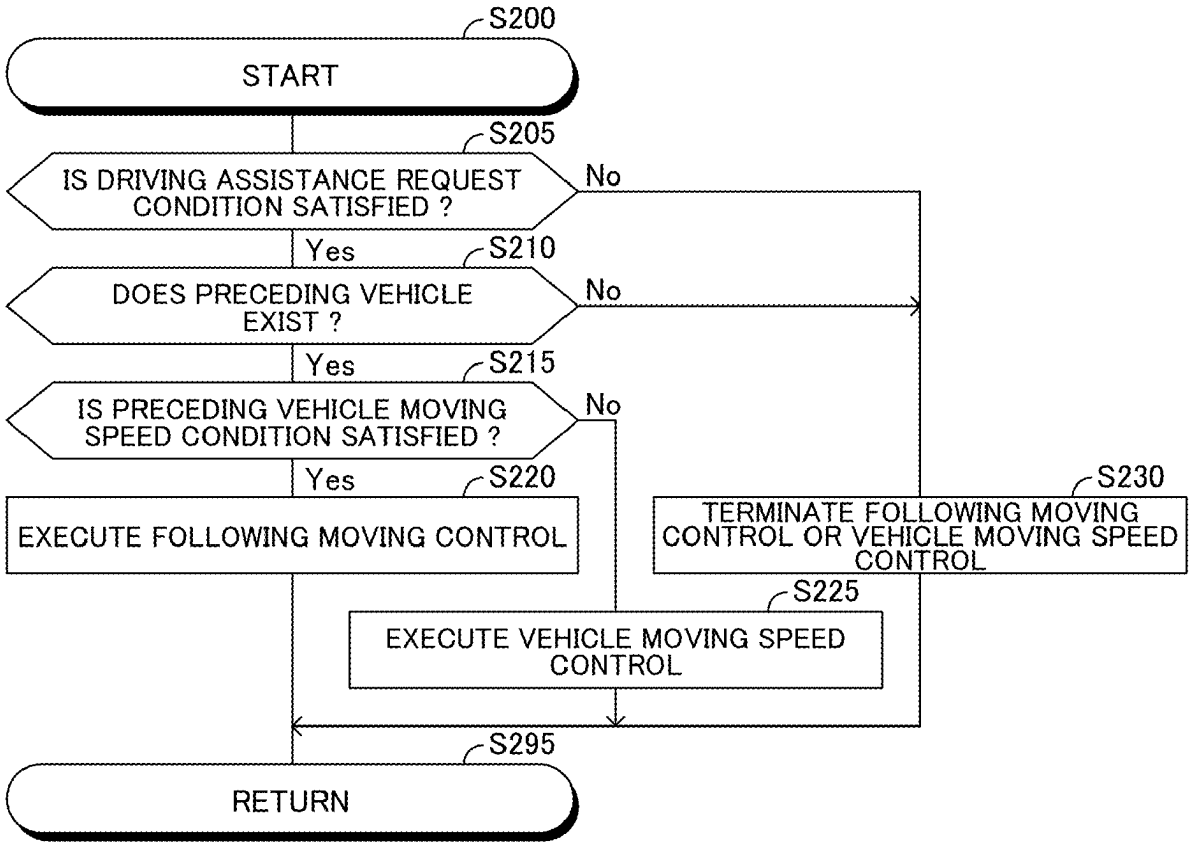
(57) **ABSTRACT**

A vehicle driving assistance apparatus executes a following moving control of moving an own vehicle, autonomously executing a powering control of powering the own vehicle and a coasting control of causing the own vehicle to coast alternately, maintaining an inter-vehicle distance between the own vehicle and a preceding vehicle in front of the own vehicle within a predetermined inter-vehicle distance range, and a vehicle moving speed control of moving the own vehicle, autonomously executing the powering control and the coasting control alternately, maintaining a moving speed of the own vehicle within a predetermined vehicle moving speed range. The apparatus executes the following moving control when a moving speed of the preceding vehicle is equal to or smaller than a predetermined vehicle moving speed. The apparatus executes the vehicle moving speed control when the moving speed of the preceding vehicle is greater than the predetermined vehicle moving speed.



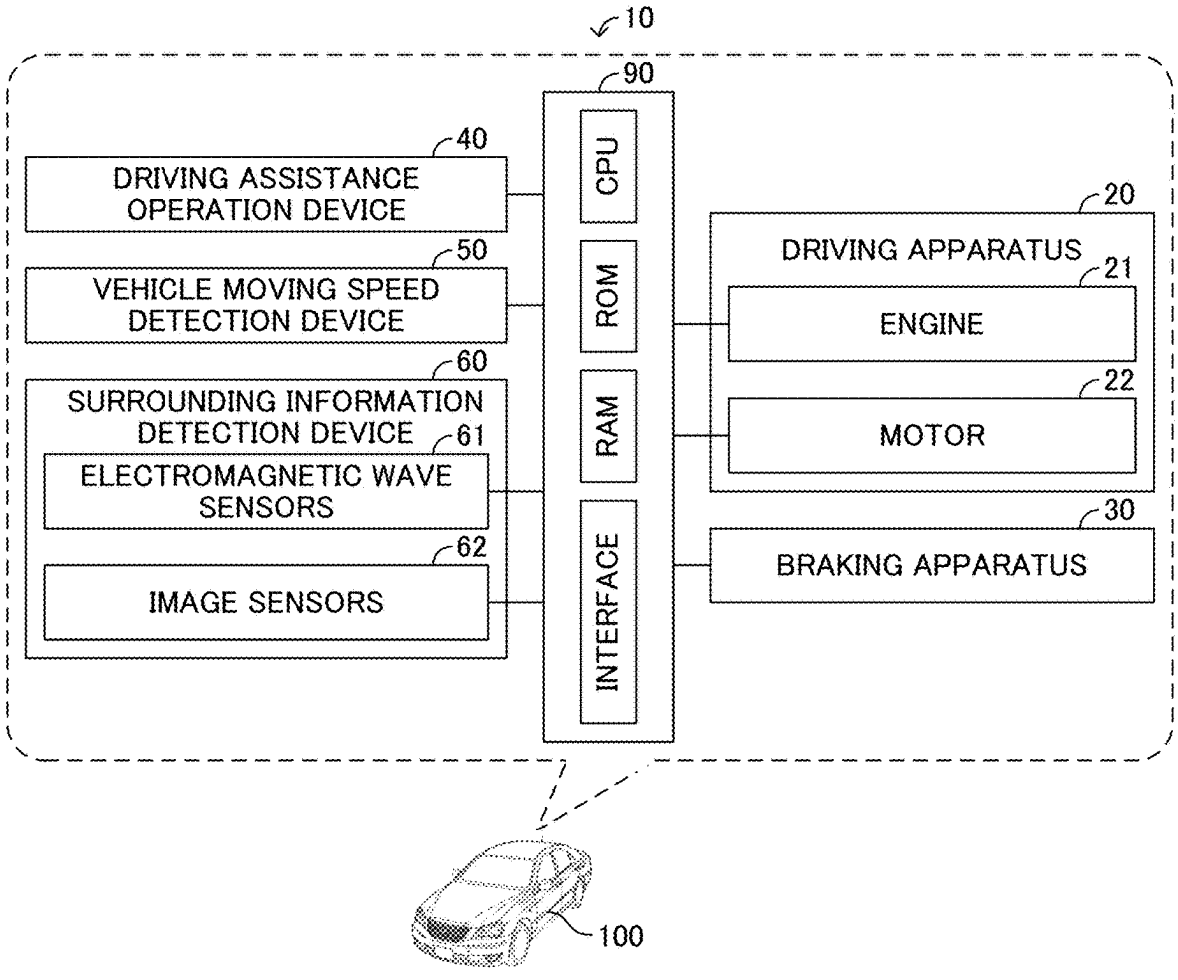

10
90
CPU
ROM
RAM
INTERFACE
40
DRIVING ASSISTANCE OPERATION DEVICE
50
VEHICLE MOVING SPEED DETECTION DEVICE
60
SURROUNDING INFORMATION DETECTION DEVICE
61
ELECTROMAGNETIC WAVE SENSORS
62
IMAGE SENSORS
20
DRIVING APPARATUS
21
ENGINE
22
MOTOR
30
BRAKING APPARATUS
100

FIG.1

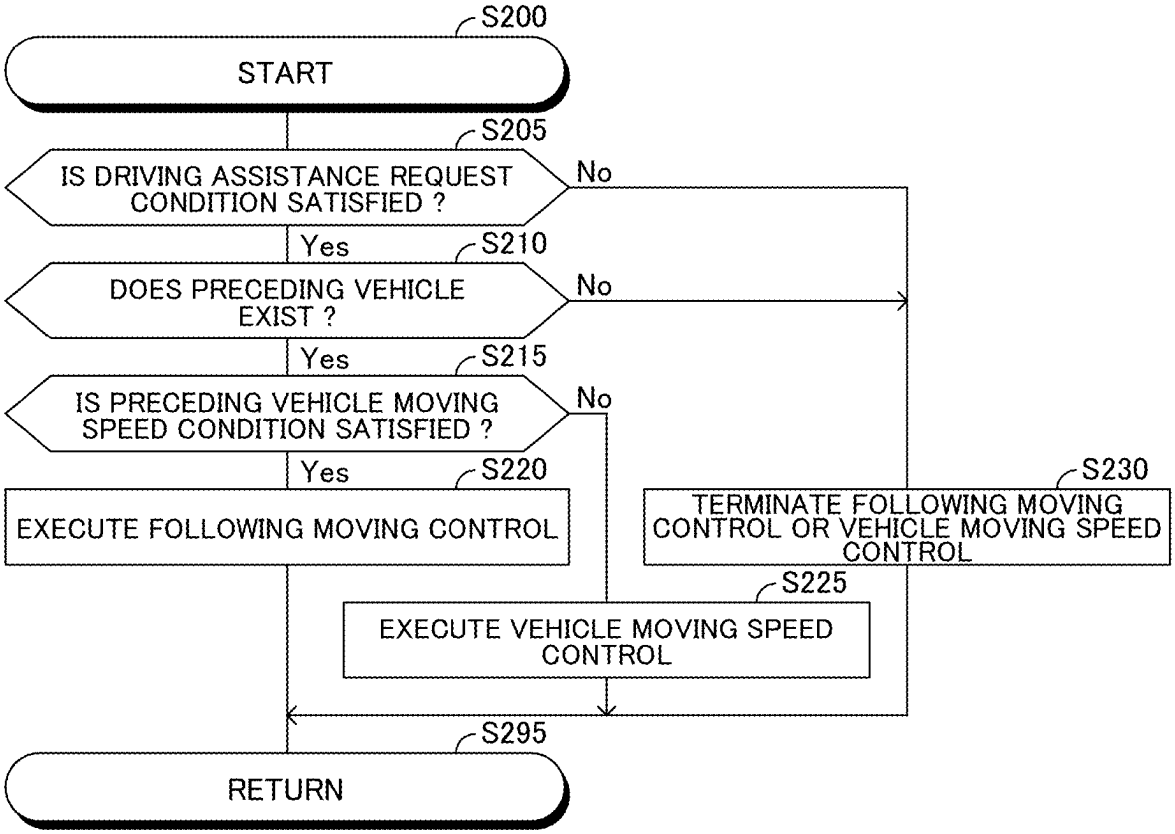

S200
START
S205
IS DRIVING ASSISTANCE REQUEST CONDITION SATISFIED ?
No
Yes
S210
DOES PRECEDING VEHICLE EXIST ?
No
Yes
S215
IS PRECEDING VEHICLE MOVING SPEED CONDITION SATISFIED ?
No
Yes
S220
EXECUTE FOLLOWING MOVING CONTROL
S230
TERMINATE FOLLOWING MOVING CONTROL OR VEHICLE MOVING SPEED CONTROL
S225
EXECUTE VEHICLE MOVING SPEED CONTROL
S295
RETURN

FIG.2

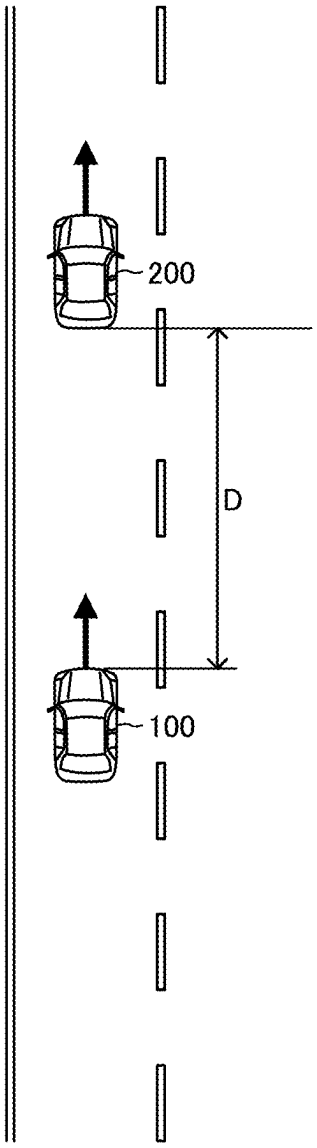


FIG.3

VEHICLE DRIVING ASSISTANCE APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Japanese patent application No. JP 2024-019355 filed on Feb. 13, 2024, the content of which is hereby incorporated by reference in its entirety.

BACKGROUND

Field

[0002] The present invention relates to a vehicle driving assistance apparatus. Description of the related art.

[0003] There is known a vehicle driving assistance apparatus which executes a following moving control of moving an own vehicle, autonomously executing a powering control of powering the own vehicle and a coasting control of causing the own vehicle to coast, maintaining an inter-vehicle distance, which is a distance between a preceding vehicle and the own vehicle, within a certain range (see, for example, JP 2022-95320 A). In the vehicle driving assistance apparatus, an energy consumption for moving the own vehicle is reduced by using the coasting control.

[0004] When a moving speed of the preceding vehicle is relatively great while the following moving control described above is executed, the inter-vehicle distance increases relatively quickly when the own vehicle coasts by the coasting control. Therefore, a control of moving the own vehicle is immediately switched from the coasting control to the powering control. Therefore, a switch from the coasting control to the powering control is frequently performed, and an amount of energy consumed to move the own vehicle increases.

SUMMARY

[0005] An object of the present invention is to provide a vehicle driving assistance apparatus which can suppress an increase in the amount of energy consumed to move the own vehicle while the following moving control is executed.

[0006] A vehicle driving assistance apparatus according to the present invention comprises an electronic control unit which executes (i) a following moving control of moving an own vehicle, autonomously executing a powering control of powering the own vehicle and a coasting control of causing the own vehicle to coast alternately, maintaining an inter-vehicle distance between the own vehicle and a preceding vehicle in front of the own vehicle within a predetermined inter-vehicle distance range, and (ii) a vehicle moving speed control of moving the own vehicle, autonomously executing the powering control and the coasting control alternately, maintaining a moving speed of the own vehicle within a predetermined vehicle moving speed range. The electronic control unit is configured to (i) execute the following moving control when a moving speed of the preceding vehicle is equal to or smaller than a predetermined vehicle moving speed, and (ii) execute the vehicle moving speed control when the moving speed of the preceding vehicle is greater than the predetermined vehicle moving speed.

[0007] As mentioned above, when the moving speed of the preceding vehicle is relatively great while the following moving control is executed, the inter-vehicle distance increases relatively quickly when the own vehicle is coasted by the coasting control. Therefore, a control of moving the own vehicle is immediately switched from the coasting control to the powering control. Therefore, a switching from the coasting control to the powering control is performed frequently, and the amount of energy consumed to move the own vehicle increases.

[0008] According to the vehicle driving assistance apparatus of the present invention, when the moving speed of the preceding vehicle is relatively great, the own vehicle is moved by the vehicle moving speed control. Therefore, a frequent switch from the coasting control to the powering control can be suppressed. As a result, the increase in the amount of energy consumed to move the own vehicle can be suppressed.

[0009] In the vehicle driving assistance apparatus according to an aspect of the present invention, the predetermined vehicle moving speed may be a speed obtained by subtracting a value depending on a width of the predetermined vehicle moving speed range from an upper limit value of the predetermined vehicle moving speed range.

[0010] According to the vehicle driving assistance apparatus according to this aspect of the present invention, it is determined whether to execute the following moving control or the vehicle moving speed control according to the width of the predetermined vehicle moving speed range. Therefore, the vehicle moving speed control can be executed in more appropriate situations in order to suppress the increase in the amount of energy consumed to move the own vehicle.

[0011] In the vehicle driving assistance apparatus according to another aspect of the present invention, the predetermined vehicle moving speed may be a speed which is equal to or smaller than an average vehicle moving speed of the own vehicle realized when the own vehicle is moved by the vehicle moving speed control.

[0012] According to the vehicle driving assistance apparatus according to this aspect of the present invention, it is determined whether to execute the following moving control or to execute the vehicle moving speed control using the average vehicle moving speed of the own vehicle realized when the own vehicle is moved by the vehicle moving speed control. Therefore, the vehicle moving speed control can be executed in more appropriate situations, in order to suppress the increase in the amount of energy consumed to move the own vehicle.

[0013] The components of the present invention are not limited to the embodiments of the present invention described below with reference to the drawings. Other objects, other features, and incidental advantages of the present invention will be readily understood from the description of the embodiments of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is a diagram showing a vehicle driving assistance apparatus according to an embodiment of the present invention.

[0015] FIG. **2** is a flowchart showing a routine executed by the vehicle driving assistance apparatus according to the embodiment of the present invention.

[0016] FIG. **3** is a diagram showing a scene in which a preceding vehicle is in front of the own vehicle.

DETAILED DESCRIPTION

[0017] Below, a vehicle driving assistance apparatus according to an embodiment of the present invention will be described with reference to the drawings. FIG. **1** shows the vehicle driving assistance apparatus **10** according to the embodiment of the present invention. The vehicle driving assistance apparatus **10** is installed in an own vehicle **100**. The following description of the vehicle driving assistance apparatus **10** is based on the case where an operator of the own vehicle **100** is a person who rides in the own vehicle **100** and drives the own vehicle **100** (i.e., a driver of the own vehicle **100**). However, the operator of the own vehicle **100** may also be a person who operates the own vehicle **100** remotely without getting into the own vehicle **100** (i.e., a remote operator of the own vehicle **100**). The present invention is also applicable to vehicles which can be driven by an automatic driving control only, as well as vehicles which can be driven by a manual driving operation and the automatic driving control.

[0018] As shown in FIG. **1**, the vehicle driving assistance apparatus **10** is equipped with an ECU (electronic control unit) **90** as a control device. The ECU **90** is equipped with a microcomputer as a main part. The microcomputer includes a CPU, storage media such as ROM, RAM, and nonvolatile memory, etc., and interfaces, etc. The CPU is configured to execute instructions, programs, or routines stored in the storage medium to realize various functions. In particular, in this embodiment, the vehicle driving assistance apparatus **10** stores in the storage medium programs which realizes various controls executed by the vehicle driving assistance apparatus **10**.

[0019] It should be noted that, in this embodiment, the vehicle driving assistance apparatus **10** is equipped with only one ECU **90**, but it may be configured to be equipped with multiple ECUs and to have each ECU perform the functions of the vehicle driving assistance apparatus **10** described below. In addition, the vehicle driving assistance apparatus **10** may be configured such that the programs stored in the storage medium can be updated by wireless communication (e.g., Internet communication) with external devices.

[0020] As shown in FIG. **1**, the own vehicle **100** is equipped with a driving apparatus **20**, a braking apparatus **30**, a driving assistance operation device **40**, a vehicle moving speed detection device **50**, and a surrounding information detection device **60**.

[0021] The driving apparatus **20** is an apparatus which generates a driving force applied to the own vehicle **100** (in particular, driving wheels of the own vehicle **100**). In this embodiment, the driving apparatus **20** includes an internal combustion engine **21** and at least one motor **22**. The driving apparatus **20** is electrically connected to the ECU **90**. The vehicle driving assistance apparatus **10** controls the driving force provided to the own vehicle **100** by controlling an operation of the driving apparatus **20** (i.e., the internal combustion engine **21** and the motor **22**).

[0022] The braking apparatus **30** is an apparatus which applies a braking force to the own vehicle **100** (in particular, wheels of the own vehicle **100**). The braking apparatus **30** is, for example, a hydraulic brake device. The braking apparatus **30** is electrically connected to the ECU **90**. The vehicle driving assistance apparatus **10** controls the braking force applied to the own vehicle **100** by controlling an operation of the braking apparatus **30**.

[0023] The driving assistance operation device **40** is a device which is operated by the driver of the own vehicle **100** to request an execution of a following moving control described below or to request a stop of the execution of a following moving control. The driving assistance operation device **40** is electrically connected to the ECU **90**. In this embodiment, when the driving assistance operation device **40** is operated while the vehicle driving assistance apparatus **10** is not executing the following moving control, the vehicle driving assistance apparatus **10** determines that the execution of the following moving control is requested. On the other hand, when the driving assistance operation device **40** is operated while the vehicle driving assistance apparatus **10** is executing the following moving control, the vehicle driving assistance apparatus **10** determines that the stop of the execution of the following moving control is requested.

[0024] The vehicle moving speed detection device **50** is a device which detects a moving speed of the own vehicle **100**. The vehicle moving speed detection device **50** includes, for example, equipped wheel rotation speed sensors provided in each wheel of the own vehicle **100**. The vehicle moving speed detection device **50** is electrically connected to the ECU **90**. The vehicle driving assistance apparatus **10** acquires the moving speed of the own vehicle **100** as an own vehicle moving speed Vego using the vehicle moving speed detection device **50**.

[0025] The surrounding information detection device **60** is a device which detects information on surroundings of the own vehicle **100**. In this embodiment, the surrounding information detection device **60** includes electromagnetic wave sensors **61** and image sensors **62**. The electromagnetic wave sensors **61** and the image sensors **62** are electrically connected to the ECU **90**. The electromagnetic wave sensor **61** is, for example, a radar sensor such as a millimeter wave radar. The vehicle driving assistance apparatus **10** acquires information on objects in the vicinity of the own vehicle **100** using the electromagnetic wave sensors **61** as surrounding information IS. In addition, the image sensor **62** is, for example, a camera sensor. The vehicle driving assistance apparatus **10** acquires image information on the vicinity of the own vehicle **100** using the image sensors **62** as the surrounding information IS.

Operation of Vehicle Driving Assistance Apparatus

[0026] Next, an operation of the vehicle driving assistance apparatus **10** will be described. The vehicle driving assistance apparatus **10** is configured to execute a routine shown in FIG. **2** at predetermined time intervals, and when predetermined conditions are satisfied, to execute the following moving control or the vehicle moving speed control as an automatic driving control.

[0027] The following moving control is a control of moving the own vehicle **100**, autonomously or automatically executing a powering control and a coasting control alternately, maintaining an inter-vehicle distance D within a predetermined inter-vehicle distance range RD when a preceding vehicle **200** is present as shown in FIG. **3**.

[0028] The powering control is a control of powering the own vehicle **100** by providing the driving force to the own vehicle **100** from the driving apparatus **20**. In particular, the powering control is an optimal powering control of powering the own vehicle by providing the driving force to the own vehicle **100** from the driving apparatus **20**, operating the driving apparatus **20** with an optimal energy efficiency.

On the other hand, the coasting control is a control of causing the own vehicle **100** to coast by cutting a connection between the driving apparatus **20** and the driven wheels of the own vehicle **100**, thereby making the driving force provided from the driving apparatus **20** to the own vehicle **100** zero.

[0029] The preceding vehicle **200** is another vehicle which is moving in a traffic lane in which the own vehicle **100** is moving, and is within a predetermined distance ahead of the own vehicle **100**. In addition, the inter-vehicle distance D is a distance between the own vehicle **100** and the preceding vehicle **200**. The vehicle driving assistance apparatus **10** determines whether or not the preceding vehicle **200** exists based on the surrounding information IS. In addition, the vehicle driving assistance apparatus **10** acquires the inter-vehicle distance D based on the surrounding information IS.

[0030] In this embodiment, the predetermined inter-vehicle distance range RD is a range in which a lower limit value Dlower is a set inter-vehicle distance Dset and an upper limit value Dupper is a distance which is longer than the set inter-vehicle distance Dset by a predetermined width WD (or a predetermined value). The set inter-vehicle distance Dset is set by the driver. The predetermined width WD may be a constant value which is independent of the vehicle moving speed Vego, or it may be a value which varies depending on the vehicle moving speed Vego, specifically, a value which becomes greater as the vehicle moving speed Vego increases.

[0031] When the inter-vehicle distance D becomes longer than the upper limit value Dupper of the predetermined inter-vehicle distance range RD while the following moving control is executed, the vehicle driving assistance apparatus **10** starts the powering control. On the other hand, when the inter-vehicle distance D becomes shorter than the lower limit value Dlower of the predetermined inter-vehicle distance range RD while the following moving control is executed, the vehicle driving assistance apparatus **10** starts the coasting control.

[0032] It should be noted that, in this embodiment, when the vehicle moving speed Vego rises to the set vehicle moving speed Vset while the vehicle driving assistance apparatus **10** executes the following moving control, the vehicle driving assistance apparatus **10** causes the own vehicle **100** to run, autonomously or automatically controlling the operations of the driving apparatus **20** and the braking apparatus **30**, maintaining the vehicle moving speed Vego at the set vehicle moving speed Vset. The predetermined vehicle moving speed Vset is set by the driver.

[0033] On the other hand, the vehicle moving speed control is a control of moving the own vehicle **100**, autonomously or automatically executing the powering control and the coast control alternately, maintaining the vehicle moving speed Vego within a predetermined vehicle moving speed range RV.

[0034] In this embodiment, the predetermined vehicle moving speed range RV is a range where an upper limit value Vupper is the set vehicle moving speed Vset, and a lower limit value Vlower is a vehicle moving speed which is slower than the set vehicle moving speed Vset by a predetermined width WV (or a predetermined value). As mentioned above, the set speed Vset is a vehicle moving speed set by the driver. The predetermined width WV may be a constant value which is independent of the vehicle moving speed Vego, or it may be a value which varies depending on the vehicle moving speed Vego, specifically, a value which becomes greater as the vehicle moving speed Vego becomes faster.

[0035] When the own vehicle moving speed Vego becomes faster than the upper limit value Vupper of the predetermined vehicle moving speed range RV while the vehicle moving speed control is executed, the vehicle driving assistance apparatus **10** starts the coasting control. On the other hand, when the own vehicle moving speed Vego becomes slower than the lower limit value Vlower of the predetermined vehicle moving speed range RV while the vehicle moving speed control is executed, the vehicle driving assistance apparatus **10** starts the powering control.

[0036] At a predetermined timing, the vehicle driving assistance apparatus **10** starts processing from a step S**200** of the routine shown in FIG. **2**, and proceeds with the processing to a step S**205** to determine whether a driving assistance request condition C1 is satisfied or not. The driving assistance request condition C1 is a condition in which the driver has requested that the following moving control be executed.

[0037] When the vehicle driving assistance apparatus **10** determines "Yes" at the step S**205**, the vehicle driving assistance apparatus **10** proceeds to a step S**210** and determines whether or not the preceding vehicle **200** exists.

[0038] When the vehicle driving assistance apparatus **10** determines "Yes" at the step S**210**, the vehicle driving assistance apparatus **10** proceeds to a step S**215** and determines whether or not a preceding vehicle moving speed condition C2 is satisfied. The preceding vehicle moving speed condition C2 is a condition in which it is possible to make the own vehicle **100** follow the preceding vehicle **200** by the following moving control. In this embodiment, the preceding vehicle moving speed condition C2 is a condition in which a preceding vehicle moving speed Vpre is less than or equal to a predetermined vehicle moving speed Vth. The preceding vehicle moving speed Vpre is the moving speed of the preceding vehicle **200**. The vehicle driving assistance apparatus **10** acquires the preceding vehicle moving speed Vpre based on the surrounding information IS and the own vehicle moving speed Vego.

[0039] The predetermined vehicle moving speed Vth can be any vehicle moving speed which is set as appropriate to obtain effects described below. In this embodiment, the predetermined vehicle moving speed Vth is a value obtained by subtracting a value ΔV depending on the width WV of the predetermined vehicle moving speed range RV from the upper limit value Vupper of the predetermined vehicle moving speed range RV (Vth=Vupper−ΔV). In particular, in this embodiment, the value ΔV depending on the width WV of the predetermined vehicle moving speed range RV is a value obtained by multiplying the width WV of the predetermined vehicle moving speed range RV by a predetermined coefficient k (ΔV=WV·k). In this embodiment, the predetermined coefficient k is a value smaller than "1". The predetermined coefficient k is set such that the predetermined vehicle moving speed Vth is less than or equal to an average vehicle moving speed Vave of the own vehicle **100** realized when the own vehicle **100** is moved by the vehicle moving speed control (Vth≤Vave). Alternatively, the predetermined coefficient k is set such that the predetermined vehicle moving speed Vth is less than or equal to the vehicle moving speed Vcenter at the center of the predetermined vehicle moving speed range RV (Vth≤Vcenter).

[0040] When the vehicle driving assistance apparatus **10** determines "Yes" at the step S**215**, the vehicle driving assistance apparatus **10** proceeds to a step S**220** and executes the following moving control. The vehicle driving assistance apparatus **10** then proceeds to a step S**295** and terminates the processing of this routine.

[0041] On the other hand, when the vehicle driving assistance apparatus **10** determines "No" at the step S**215**, the vehicle driving assistance apparatus **10** proceeds to a step S**225** and executes the vehicle moving speed control. In other words, even when the preceding vehicle **200** exists and the execution of following moving control is requested, when the preceding vehicle moving speed Vpre is greater than the predetermined vehicle moving speed Vth, the vehicle driving assistance apparatus **10** executes the vehicle moving speed control. The vehicle driving assistance apparatus **10** then proceeds to the step S**295** and terminates the processing of this routine.

[0042] In addition, when the vehicle driving assistance apparatus **10** determines "No" at the step S**205** or the step S**210**, the vehicle driving assistance apparatus **10** proceeds to a step S**230** and, when the following moving control or the vehicle moving speed control is executed, terminates the execution of the following moving control or the vehicle moving speed control. The vehicle driving assistance apparatus **10** then proceeds to the step S**295** and terminates the processing of this routine.

[0043] The operation of the vehicle driving assistance apparatus **10** has been described.

[0044] When the preceding vehicle moving speed Vpre is relatively great while the following moving control is executed, the inter-vehicle distance D increases relatively quickly when the own vehicle **100** is coasted by the coasting control. Therefore, a control of moving the own vehicle **100** immediately switches from the coasting control to the powering control. Therefore, a switch from the coasting control to the powering control is performed frequently, and an amount of energy consumed to move the own vehicle **100** increases.

[0045] According to the vehicle driving assistance apparatus **10**, when the preceding vehicle moving speed Vpre is relatively great, the own vehicle **100** is moved by the vehicle moving speed control. Therefore, the frequent switch from the coasting control to the powering control can be suppressed, and as a result, an increase in the amount of energy consumed to move the own vehicle **100** can be suppressed.

[0046] It should be noted that the present invention is not limited to the above embodiments, and various modified examples can be adopted within the scope of the present invention.

What is claimed is:

1. A vehicle driving assistance apparatus comprising an electronic control unit which executes:

a following moving control of moving an own vehicle, autonomously executing a powering control of powering the own vehicle and a coasting control of causing the own vehicle to coast alternately, maintaining an inter-vehicle distance between the own vehicle and a preceding vehicle in front of the own vehicle within a predetermined inter-vehicle distance range; and

a vehicle moving speed control of moving the own vehicle, autonomously executing the powering control and the coasting control alternately, maintaining a moving speed of the own vehicle within a predetermined vehicle moving speed range,

wherein the electronic control unit is configured to:

execute the following moving control when a moving speed of the preceding vehicle is equal to or smaller than a predetermined vehicle moving speed; and

execute the vehicle moving speed control when the moving speed of the preceding vehicle is greater than the predetermined vehicle moving speed.

2. The vehicle driving assistance apparatus according to claim **1**, wherein the predetermined vehicle moving speed is a speed obtained by subtracting a value depending on a width of the predetermined vehicle moving speed range from an upper limit value of the predetermined vehicle moving speed range.

3. The vehicle driving assistance apparatus according to claim **1**, wherein the predetermined vehicle moving speed is a speed which is equal to or smaller than an average vehicle moving speed of the own vehicle realized when the own vehicle is moved by the vehicle moving speed control.

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