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Inventor(s)	Honda; Masaaki

Vehicle driving support device

Abstract

A vehicle driving support device issues an alert to notify a driver of a vehicle in advance that the vehicle is approaching a road having a large curvature. The vehicle driving support device includes a forward information providing device that provides forward information that is information forward of the vehicle, acquires, from the forward information, a curvature of a point that is a first distance forward from the vehicle and a curvature of a point that is a second distance forward from the vehicle, as a near point curvature and a distant point curvature, respectively, the second distance being longer than the first distance, and the curvatures being curvatures of a road on which the vehicle is traveling, and issues the alert when an alert condition is satisfied that the distant point curvature is larger than the near point curvature by a predetermined value or more.

Inventors: **Honda; Masaaki (Okazaki, JP)**

Applicant: **TOYOTA JIDOSHA KABUSHIKI KAISHA** (Toyota, JP)

Family ID: **1000008748673**

Assignee: **TOYOTA JIDOSHA KABUSHIKI KAISHA (Toyota, JP)**

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Primary Examiner: Tran; Khoi H

Assistant Examiner: Cullen; Tanner L

Attorney, Agent or Firm: Sughrue Mion, PLLC

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

(1) This application claims priority to Japanese Patent No. 2020-192328 filed on Nov. 19, 2020, incorporated herein by reference in its entirety.

BACKGROUND

1. Technical Field

(2) The present disclosure relates to a vehicle driving support device.

2. Description of Related Art

(3) A vehicle driving support device is known that issues an alert to notify a driver of a vehicle that the vehicle cannot travel along the lane. As the vehicle driving support device mentioned above, a vehicle driving support device is also known (see Japanese Unexamined Patent Application Publication No. 2002-79895 (JP 2002-79895 A), for example). The vehicle driving support device acquires by calculation the yaw rate of the vehicle required to be generated (required yaw rate) at that moment in order for the vehicle to reach the center point of the lane that is a predetermined distance forward of the vehicle. When a deviation of the current actual yaw rate from the required yaw rate is large, the vehicle driving support device determines that the vehicle cannot travel along the lane and issues an alert.

SUMMARY

(4) The related-art vehicle driving support device mentioned above uses information on a point that is located a predetermined distance forward of the vehicle (required yaw rate) to determine whether to issue an alert. Therefore, for example, in order to notify the driver that the vehicle is approaching a sharp curved road in a case where there is the sharp curved road (road with a large curvature) ahead of a straight road, the predetermined distance may be set to a relatively long distance so that the information on the point of the sharp curved road (required yaw rate) is used for determining whether to issue an alert while the vehicle is traveling on the straight road.

(5) However, if the predetermined distance is set to a too long distance, the following inconveniences may occur. The related-art vehicle driving support device uses the current actual yaw rate to determine whether to issue an alert. Accordingly, the alert issued by the related-art vehicle driving support device is an alert for the driver's current steering wheel operation in anticipation of the yaw rate that will be required in the future. Thus, for the driver, the alert issued by the related-art vehicle driving support device is an alert only for the driver's current steering wheel operation. Therefore, if the predetermined distance is set to a too long distance, an alert is issued for the driver's current steering wheel operation based on the steering wheel operation that will be required in the distant future. In other words, even though the vehicle is long away from reaching the sharp curved road, an alert is issued for the driver's current steering wheel operation. This can give the driver a sense of discomfort. Of course, by setting the predetermined distance to a short distance, such a situation can be suppressed, but in that case, the alert is issued only when the vehicle approaches a sharp curved road, and it may be too late as an alert to the driver.

(6) An object of the present disclosure is to provide a vehicle driving support device capable of notifying a driver in advance and without discomfort that a vehicle is approaching a road having a large curvature.

(7) A vehicle driving support device includes a control unit that issues an alert to notify a driver of a vehicle in advance that the vehicle is approaching a road having a large curvature. Further, the vehicle driving support device according to the present disclosure includes a forward information providing device that provides forward information that is information forward of the vehicle. The control unit is configured to: acquire, from the forward information, a curvature of a point that is a first distance forward from the vehicle and a curvature of a point that is a second distance forward from the vehicle, as a near point curvature and a distant point curvature, respectively, the second distance being longer than the first distance, and the curvatures being curvatures of a road on which the vehicle is traveling; and issue the alert when an alert condition is satisfied that the distant point

curvature is larger than the near point curvature by a predetermined value or more.
(8) The vehicle driving support device according to the present disclosure uses the curvature of the road at the point that is the first distance ahead of the point where the vehicle is currently traveling (near point curvature) and the curvature of the road at the point that is the second distance ahead of the point where the vehicle is currently traveling (distant point curvature), rather than the curvature of the road at the point where the vehicle is currently traveling, in order to determine whether to issue an alert. Therefore, for the driver, the alert is not for the driver's current steering wheel operation, but for the steering wheel operation required in the future. Thus, it is possible to notify the driver in advance and without discomfort that the vehicle is approaching a road having a large curvature.
(9) In the vehicle driving support device according to the present disclosure, the control unit may be configured to set a level of the alert to be lower when a steering wheel operation by the driver is detected than when the steering wheel operation by the driver is not detected.
(10) For example, when the driver is operating the steering wheel by themselves when the alert condition is satisfied, the driver must steer the vehicle by themselves such that the vehicle travels along the lane when the vehicle approaches a sharp curved road. In this case, issuing an alert may make the driver feel annoyed. In contrast, if the driver is not operating the steering wheel while looking aside, taking a nap, or taking their hands off the steering wheel, the alert is useful to the driver.
(11) The vehicle driving support device according to the present disclosure sets the alert level to be lower when the steering wheel operation by the driver is detected than when the steering wheel operation by the driver is not detected. Thus, when the alert may make the driver feel annoyed, a low level alert is issued, and when issuing the alert is useful for the driver, a high level alert is issued. Therefore, it is possible to issue a useful alert while suppressing making the driver feel annoyed.
(12) The alert condition may include a condition that a steering wheel operation by the driver is not detected. With this, when the steering wheel operation by the driver is detected, the alert is not issued. Thus, it is possible to issue an alert while suppressing making the driver feel annoyed.
(13) Also, the alert condition may include a condition that the distant point curvature is equal to or larger than a predetermined distant point curvature. With this, the alert can be issued only when the distant point curvature is large and the need for the alert is high.
(14) Also, the alert condition may include a condition that the near point curvature is equal to or larger than a predetermined near point curvature. With this, the alert can be issued only when the near point curvature is large and the need for the alert is high.
(15) The constituent elements of the present disclosure are not limited to the embodiment of the present disclosure described later with reference to the drawings. Other objects, other features and accompanying advantages of the present disclosure will be readily understood from the description of the embodiment of the present disclosure.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:
(2) FIG. **1** is a diagram showing a vehicle driving support device according to an embodiment of the present disclosure and a vehicle equipped with the vehicle driving support device;
(3) FIG. **2** is a diagram showing a road on which the vehicle equipped with the vehicle driving support device according to the embodiment of the present disclosure travels, and the like;

(4) FIG. **3** is a time chart showing a near point curvature, a distant point curvature, and the like when the vehicle equipped with the vehicle driving support device according to the embodiment of the present disclosure travels on the road shown in FIG. **2**;
(5) FIG. **4** is a flowchart showing a routine executed by the vehicle driving support device according to the embodiment of the present disclosure; and
(6) FIG. **5** is a flowchart showing a routine executed by the vehicle driving support device according to a modification of the embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

(7) Hereinafter, a vehicle driving support device according to an embodiment of the present disclosure will be described with reference to the drawings. FIG. **1** shows a vehicle driving support device **10** according to the embodiment of the present disclosure and a vehicle **100** equipped with the vehicle driving support device **10**.
(8) ECU
(9) The vehicle driving support device **10** includes an electronic control unit (ECU) **90**. The ECU is an abbreviation for electronic control unit. The ECU **90** includes a microcomputer as a main component. The microcomputer includes a central processing unit (CPU), a read only memory (ROM), a random access memory (RAM), a non-volatile memory, an interface, and the like. The CPU realizes various functions by executing instructions, programs, or routines stored in the ROM.
(10) Forward Information Providing Device, etc.
(11) The vehicle **100** is equipped with a steering device **11**, a steering angle sensor **21**, a steering torque sensor **22**, a lane keeping support operation unit **23**, a forward information providing device **24**, a Global Positioning System (GPS) device **25**, and an alert device **26**.
(12) Steering Device
(13) The steering device **11** is a device that outputs a steering force (steering torque) applied to the vehicle **100** to steer the vehicle **100**, and is, for example, a power steering device. The steering device **11** is electrically connected to the ECU **90**. The ECU **90** can control the steering force output from the steering device **11** by controlling the operation of the steering device **11**.
(14) Steering Angle Sensor and Steering Torque Sensor
(15) The steering angle sensor **21** is a sensor that detects a rotation angle of a steering wheel **31** (or a steering shaft **32**) with respect to the neutral position. The steering angle sensor **21** is electrically connected to the ECU **90**. The steering angle sensor **21** transmits information on the detected rotation angle of the steering wheel **31** to the ECU **90**. The ECU **90** acquires the rotation angle of the steering wheel **31** as a steering angle θ based on the information.
(16) The steering torque sensor **22** is a sensor that detects the torque input to the steering shaft **32** via the steering wheel **31**. The steering torque sensor **22** is electrically connected to the ECU **90**. The steering torque sensor **22** transmits information of the detected torque to the ECU **90**. Based on the information, the ECU **90** acquires the torque input to the steering shaft **32** via the steering wheel **31** as a steering torque TQ.
(17) The ECU **90** acquires by calculation a required steering force (required steering torque) from the steering angle θ and the steering torque TQ. Alternatively, the ECU **90** corrects the calculated required steering force as necessary to acquire a corrected required steering force while a lane keeping support control described later is being executed. The required steering force and the corrected required steering force are steering forces for which output is required of the steering device **11**. The ECU **90** controls the operation of the steering device **11** so that the required steering force or the corrected required steering force is output. Further, the ECU **90** can determine whether the operation of the steering wheel **31** by the driver is being performed, from the steering angle θ, the steering torque TQ, and the like.
(18) Lane Keeping Support Operation Unit
(19) The lane keeping support operation unit **23** is a device operated by the driver of the vehicle **100** in order to request the execution of the lane keeping support control described later as the

vehicle driving support control, and has at least one of a button, a switch, and the like, for example. The lane keeping support operation unit **23** is electrically connected to the ECU **90**. When a predetermined operation requesting execution of the lane keeping support control is performed, the lane keeping support operation unit **23** transmits a signal corresponding to the predetermined operation to the ECU **90**. When the ECU **90** receives the signal, the ECU **90** determines that the execution of the lane keeping support control is requested.

(20) Forward Information Providing Device

(21) The forward information providing device **24** is a device that provides information forward of the vehicle **100**, and has at least one of a sensor such as a camera, a radar sensor (millimeter wave radar, and the like), an ultrasonic sensor (clearance sonar), and a laser radar (light detection and ranging (LiDAR)), and a road shape database such as a map database, for example.

(22) The forward information providing device **24** is electrically connected to the ECU **90**. The forward information providing device **24** provides information forward of the vehicle **100** (forward information) to the ECU **90**. From the forward information, the ECU **90** acquires the curvature of the road on which the vehicle **100** is traveling, more specifically, the curvature of the road forward of the vehicle **100** (forward road curvature R). In particular, the ECU **90** acquires the curvature of a lane LN (see FIG. **2**) in which the vehicle **100** is traveling, more specifically, the curvature of the lane LN forward of the vehicle **100**, as the forward road curvature R.

(23) For example, when the forward information providing device **24** has a camera, the forward information is information of an image in front of the vehicle **100** captured by the camera. In this case, the ECU **90** detects “a lane marking LM such as a white line provided on the road forward of the vehicle **100** (see FIG. **2**)” from the information of the image, and acquires the forward road curvature R from the detected lane marking LM. Further, the ECU **90** detects, from the information of the image, at least one of objects that take a shape along the road shape, such as “the trajectory of another vehicle (preceding vehicle and/or vehicle alongside) traveling in front of the vehicle **100** on the same road as the road on which the vehicle **100** is traveling”, “a guard rail GR installed on the road forward of the vehicle **100** (see FIG. **2**)”, and “an outer wall or a fence of a building BD on the side of the road forward of the vehicle **100** (see FIG. **2**)”, and acquires the forward road curvature R from the detected shape of the object.

(24) When the forward information providing device **24** has a sensor, the forward information is object information such as “time from the time the sensor emits an electromagnetic wave or a sound wave to the time the sensor receives the reflected wave of the electromagnetic wave or the sound wave from the object” and “the direction in which the sensor receives the reflected wave of the electromagnetic wave or the sound wave”. From the object information, the ECU **90** detects at least one of the objects that take a shape along the road shape, such as “the guard rail GR installed on the road forward of the vehicle **100** (see FIG. **2**)”, and “the outer wall or the fence of the building BD on the side of the road forward of the vehicle **100** (see FIG. **2**)”, and acquires the forward road curvature R from the detected shape of the object.

(25) When the forward information providing device **24** has a road information database, the forward information is road information stored in the road information database. The ECU **90** acquires the shape of the road forward of the vehicle **100** from the road information and the current position of the vehicle **100**, and acquires the forward road curvature R from the shape of the road.

(26) GPS Device

(27) The GPS device **25** is a device that receives so-called GPS signals. The GPS device **25** is electrically connected to the ECU **90**. The GPS device **25** transmits the received GPS signal to the ECU **90**. The ECU **90** acquires the current position of the vehicle **100** based on the GPS signal.

(28) Alert Device

(29) The alert device **26** is a device that issues an alert to the driver of the vehicle **100**, and has, for example, at least one of a buzzer, a speaker, a lamp, a display, a vibration device, and the like. The alert device **26** is electrically connected to the ECU **90**. When an alert condition Calert, which will

be described later, is satisfied, the ECU **90** issues an alert to the driver by operating the alert device **26**.
(30) When the alert device **26** has a buzzer, the alert is an output of an alert sound from the buzzer. When the alert device **26** has a speaker, the alert is an output of voice (announcement) from the speaker. When the alert device **26** is a lamp, the alert is lighting of the lamp. When the alert device **26** is a display, the alert is an indication of an announcement image on the display. When the alert device **26** is a vibration device, the alert is the vibration of the steering wheel **31** or the driver's seat by the vibration device.
(31) Outline of Operations of Vehicle Driving Support Device
(32) Next, the outline of the operations of the vehicle driving support device **10** will be described. The vehicle driving support device **10** issues an alert to notify the driver of the vehicle **100** that the vehicle **100** is approaching a sharp curved road when the predetermined alert condition Calert is satisfied.
(33) The vehicle driving support device **10** may issue an alert when the alert condition Calert is satisfied, in the case where the driver of the vehicle **100** requests issuance of an alert, or regardless of whether the driver of the vehicle **100** requests issuance of an alert, or regardless of whether the lane keeping support control is being executed. However, in this example, an alert is issued when the alert condition Calert is satisfied during the execution of the lane keeping support control.
(34) Lane Keeping Support Control
(35) The lane keeping support control is a control of acquiring a centerline LC of the lane LN in which the vehicle **100** is traveling (see FIG. **2**) from the forward information, correcting the required steering force as necessary so that the vehicle **100** travels along the centerline LC, and providing the corrected required steering force to the vehicle **100**, to cause the vehicle **100** to travel along the centerline LC of the lane LN. In other words, the lane keeping support control is a control for causing the vehicle **100** to travel along the lane LN.
(36) When determining that the execution of the lane keeping support control is requested, the vehicle driving support device **10** starts the lane keeping support control, and when determining that the execution of the lane keeping support control is no longer requested, the vehicle driving support device **10** ends (stops) the lane keeping support control.
(37) Alert
(38) During execution of the lane keeping support control, the vehicle driving support device **10** acquires a forward road curvature R at a point that is a first distance D**1** forward from the vehicle **100** (near point curvature Rn) and a forward road curvature R at a point that is a second distance D**2** forward from the vehicle **100** (distant point curvature Rf). The second distance D**2** is longer than the first distance D**1**.
(39) The first distance D**1** may be a predetermined fixed distance, but in this example, the first distance D**1** is a distance that the vehicle **100** is predicted to travel from the present time to a time after a predetermined first time. Therefore, the first distance D**1** becomes longer as the vehicle speed Vown of the vehicle **100** increases. The second distance D**2** may be a predetermined fixed distance, but in this example, the second distance D**2** is a distance that the vehicle **100** is predicted to travel from the present time to a time after a predetermined second time that is longer than the first time. Therefore, the second distance D**2** also becomes longer as the vehicle speed Vown of the vehicle **100** increases.
(40) Further, in this example, the near point curvature Rn is a curvature acquired from the forward information. That is, the near point curvature Rn is the forward road curvature R at the point that is the first distance D**1** ahead of the vehicle **100**. The distant point curvature Rf may also be a curvature acquired from the forward information, that is, the forward road curvature R at the point that is the second distance D**2** ahead of the vehicle **100**. However, in this example, the distant point curvature Rf is a curvature calculated by the following equation (1) using “a curvature Rnow of the lane LN at the point where the vehicle **100** is currently traveling”, “a change rate Rrn of the near

point curvature Rn per distance”, and “the second distance D**2**”.

$$Rf=Rnow+Rrn\times D2 \qquad (1)$$

(41) When the distant point curvature Rf is larger than the near point curvature Rn and a difference between the curvatures (curvature difference ΔR) is equal to or larger than a predetermined value ΔRth, the vehicle driving support device **10** determines that the alert condition Calert is satisfied. In other words, the vehicle driving support device **10** determines that the alert condition Calert is satisfied when the distant point curvature Rf becomes larger than the near point curvature Rn by the predetermined value ΔRth or more.

(42) In this example, the vehicle driving support device **10** determines that the alert condition Calert is satisfied when the distant point curvature Rf becomes larger than the near point curvature Rn by the predetermined value ΔRth or more regardless of whether the driver of the vehicle **100** is operating the steering wheel **31**. However, the vehicle driving support device **10** may determine that the alert condition Calert is satisfied when the distant point curvature Rf becomes larger than the near point curvature Rn by the predetermined value ΔRth or more while the driver of the vehicle **100** is not operating the steering wheel **31**.

(43) When the vehicle driving support device **10** determines that the alert condition Calert is satisfied, the vehicle driving support device **10** issues an alert. That is, the vehicle driving support device **10** issues an alert, when the alert condition Calert that the distant point curvature Rf is larger than the near point curvature Rn by the predetermined value ΔRth or more is satisfied.

(44) Further, the vehicle driving support device **10** may stop the alert when the alert condition Calert is no longer satisfied, but in this example, the alert is stopped when the alert condition Calert is no longer satisfied and an alert end condition Cend that an elapsed time T from the start of the alert has reached a predetermined time Tth is satisfied.

(45) The operations of the vehicle driving support device **10** will be described with reference to FIGS. **2** and **3**. In the example shown in FIG. **2**, the road on which the vehicle **100** travels is a straight road SR with a curvature of the lane LN in which the vehicle **100** travels being zero up to a point P**22**. The road on which the vehicle **100** travels becomes a curved road CR**1** with the curvature of the lane LN in which the vehicle **100** travels being a first curvature R**1** at the point P**22**. Then, at a point P**25**, the road on which the vehicle **100** travels becomes a curved road CR**2** with the curvature of the lane LN in which the vehicle **100** travels being a second curvature R**2** that is larger than the first curvature R**1**.

(46) As shown in FIG. **3**, the near point curvature Rn acquired by the vehicle driving support device **10** is zero before the vehicle **100** reaches the point P**21** that is the first distance D**1** before the point P**22** (the point where the straight road SR shifts to the curved road CR**1**). When the vehicle **100** reaches the point P**21**, the near point curvature Rn becomes the first curvature R**1**. Then, when the vehicle **100** reaches the point P**23** that is the first distance D**1** before the point P**25** (the point where the curved road CR**1** shifts to the curved road CR**2**), the near point curvature Rn becomes the second curvature R**2**.

(47) Also, the distant point curvature Rf acquired by the vehicle driving support device **10** is zero before the vehicle **100** reaches the point P**20** that is the second distance D**2** before the point P**22** (the point where the straight road SR shifts to the curved road CR**1**). When the vehicle **100** reaches the point P**20**, the distant point curvature Rf becomes the first curvature R**1**. Then, when the vehicle **100** reaches the point P**22** that is the second distance D**2** before the point P**25** (the point where the curved road CR**1** shifts to the curved road CR**2**), the distant point curvature Rf becomes the second curvature R**2**.

(48) When the vehicle **100** travels as described above and the near point curvature Rn and the distant point curvature Rf are acquired, the curvature difference ΔR is zero until the vehicle **100** reaches the point P**20**, but once the vehicle **100** passes through the point P**20**, the curvature difference ΔR becomes the first curvature difference ΔR**1**. At this time, since the first curvature difference ΔR**1** is smaller than the predetermined value ΔRth, no alert is issued.

(49) After that, the curvature difference ΔR becomes zero when the vehicle **100** reaches the point P**21**. Thereafter, the curvature difference ΔR becomes the second curvature difference ΔR**2** when the vehicle **100** reaches the point P**22**. At this time, since the second curvature difference ΔR**2** is equal to or larger than the predetermined value ΔRth, the alert is started. After that, the alert is continued as long as the curvature difference ΔR is equal to or larger than the second curvature difference ΔR**2**.
(50) In this example, the curvature difference ΔR becomes zero when the vehicle **100** reaches the point P**23**. At this point, the alert condition Calert is no longer satisfied, but the alert is continued because the elapsed time T from the start of the alert is shorter than the predetermined time Tth. After that, when the vehicle **100** reaches a point P**24**, the elapsed time T from the start of the alert reaches the predetermined time Tth and the alert end condition Cend is satisfied, so that the alert is ended.
(51) Effects
(52) The vehicle driving support device **10** uses the curvature of the road at the point that is the first distance D**1** ahead of the point where the vehicle **100** is currently traveling (near point curvature Rn) and the curvature of the road at the point that is the second distance D**2** ahead of the point where the vehicle **100** is currently traveling (distant point curvature Rf), rather than the curvature of the road at the point where the vehicle **100** is currently traveling, in order to determine whether to issue an alert. Therefore, the driver recognizes the alert as an alert that is not for the driver's current operation on the steering wheel **31**, but for the operation on the steering wheel **31** that will be required in the future. Thus, it is possible to notify the driver in advance and without discomfort that the vehicle **100** is approaching a road having a large curvature.
(53) In the above example, the alert condition Calert is a condition that the distant point curvature Rf is larger than the near point curvature Rn by the predetermined value ΔRth or more. However, the alert condition Calert may be a condition that the distant point curvature Rf is larger than the near point curvature Rn by the predetermined value ΔRth or more and the distant point curvature Rf is equal to or larger than a predetermined distant point curvature Rf_th. Alternatively, the alert condition Calert may be a condition that the distant point curvature Rf is larger than the near point curvature Rn by the predetermined value ΔRth or more and the near point curvature Rn is equal to or larger than a predetermined near point curvature Rn_th. Alternatively, the alert condition Calert may be a condition that the distant point curvature Rf is larger than the near point curvature Rn by the predetermined value ΔRth or more, the distant point curvature Rf is equal to or larger than the predetermined distant point curvature Rf_th, and the near point curvature Rn is equal to or larger than the predetermined near point curvature Rn_th.
(54) Further, the vehicle driving support device **10** stops the alert when the alert condition Calert is no longer satisfied after the start of the alert and the alert end condition Cend that the elapsed time T from the start of the alert has reached the predetermined time Tth is satisfied. However, the vehicle driving support device **10** may be configured to continue the alert until the vehicle **100** approaches a road having the curvature difference ΔR of a predetermined value ΔRth or more (road that is the target for the alert) after the start of the alert.
(55) Specific Operations of Vehicle Driving Support Device
(56) Next, the specific operations of the vehicle driving support device **10** will be described. The CPU of the ECU **90** of the vehicle driving support device **10** executes the routine shown in FIG. **4** every time a predetermined calculation time has elapsed. Thus, at a predetermined timing, the CPU starts the process from step **400** in FIG. **4**, advances the process to step **405**, and determines whether the lane keeping support control is being executed.
(57) When the CPU determines “Yes” in step **405**, the CPU advances the process to step **410** and acquires the near point curvature Rn and the distant point curvature Rf. Next, the CPU advances the process to step **415** and acquires the difference between the near point curvature Rn and the distant point curvature Rf acquired in step **410** (curvature difference ΔR). Next, the CPU advances the

process to step **420** and determines whether the alert condition Calert is satisfied. Specifically, the CPU determines whether the curvature difference ΔR acquired in step **415** is equal to or larger than the predetermined value ΔRth and the distant point curvature Rf acquired in step **410** is larger than the near point curvature Rn acquired in step **410**.

(58) When the CPU determines “Yes” in step **420**, the CPU advances the process to step **425**. The CPU starts the alert when the alert is not being issued and continues the alert when the alert is being issued. Thereafter, the CPU advances the process to step **495** and temporarily ends the routine.

(59) When the CPU determines “No” in step **420**, the CPU advances the process to step **430** and determines whether the alert is being issued.

(60) When the CPU determines “Yes” in step **430**, the CPU advances the process to step **435** and determines whether the elapsed time T from the start of the alert is equal to or more than the predetermined time Tth.

(61) When the CPU determines “Yes” in step **435**, the CPU advances the process to step **440** and stops the alert. Thereafter, the CPU advances the process to step **495** and temporarily ends the routine.

(62) When the CPU determines “No” in step **435**, the CPU advances the process to step **445** and continues the alert. Thereafter, the CPU advances the process to step **495** and temporarily ends the routine.

(63) When the CPU determines “No” in step **430**, the CPU directly advances the process to step **495** and temporarily ends the routine.

(64) When the CPU determines “No” in step **405**, the CPU advances the process to step **450**. The CPU stops the alert when the alert is being issued, and when the alert is not being issued, the CPU maintains the state in which the alert is not being issued. Thereafter, the CPU advances the process to step **495** and temporarily ends the routine.

(65) The above is the specific operations of the vehicle driving support device **10**.

(66) Note that the present disclosure is not limited to the above embodiment, and various modifications can be adopted within the scope of the present disclosure.

(67) Modifications

(68) For example, when the driver is operating the steering wheel **31** by themselves when the alert condition Calert is satisfied, the driver must steer the vehicle **100** by themselves such that the vehicle **100** travels along the lane LN when the vehicle **100** approaches a sharp curved road. In this case, issuing an alert may make the driver feel annoyed. In contrast, if the driver is not operating the steering wheel **31** while looking aside, taking a nap, or taking their hands off the steering wheel **31**, the alert is useful to the driver.

(69) The vehicle driving support device **10** described above issues an alert regardless of whether the driver is operating the steering wheel **31** when the alert condition Calert is satisfied. However, the vehicle driving support device **10** may be configured to determine whether to issue an alert depending on whether the driver is operating the steering wheel **31** when the alert condition Calert is satisfied.

(70) Specifically, the vehicle driving support device **10** according to the modification of the embodiment of the present disclosure determines whether a steering wheel operation condition Csteer that the driver is operating the steering wheel **31** (namely, steering wheel operation condition Csteer that the steering wheel operation of the driver is detected) is satisfied, when the alert condition Calert is satisfied.

(71) The vehicle driving support device **10** issues an alert when the steering wheel operation condition Csteer is not satisfied. The vehicle driving support device **10** does not issue an alert when the steering wheel operation condition Csteer is satisfied. Therefore, the alert condition Calert according to the modification includes a condition that the distant point curvature Rf is larger than the near point curvature Rn by the predetermined value ΔRth or more and a condition that the

driver's steering wheel operation is not detected.
(72) Alternatively, when the steering wheel operation condition Csteer is not satisfied, the vehicle driving support device **10** issues an alert in a form with a high possibility of being noticed by the driver. In other words, the vehicle driving support device **10** issues an alert with a high alert level. For example, when the vehicle driving support device **10** issues an alert by outputting an alert sound from the buzzer, the vehicle driving support device **10** issues an alert with a high alert level by outputting the alert sound from the buzzer at a relatively high volume. When the steering wheel operation condition Csteer is satisfied, the vehicle driving support device **10** issues an alert in a form with a relatively low possibility of being noticed by the driver. In other words, the vehicle driving support device **10** issues an alert with a low alert level. For example, when the vehicle driving support device **10** issues an alert by outputting an alert sound from the buzzer, the vehicle driving support device **10** issues an alert with a low alert level by outputting the alert sound from the buzzer at a relatively low volume. As described above, the vehicle driving support device **10** may set the alert level to be lower when the steering wheel operation by the driver is detected than when the steering wheel operation by the driver is not detected.
(73) Next, the specific operations of the vehicle driving support device **10** according to the modification will be described. The CPU of the ECU **90** of the vehicle driving support device **10** according to the modification executes the routine shown in FIG. **5** every time a predetermined calculation time has elapsed. Thus, at a predetermined timing, the CPU starts the process from step **500** in FIG. **5**, advances the process to step **505**, and determines whether the lane keeping support control is being executed.
(74) When the CPU determines "Yes" in step **505**, the CPU advances the process to step **510** and acquires the near point curvature Rn and the distant point curvature Rf. Next, the CPU advances the process to step **515** and acquires the difference between the near point curvature Rn and the distant point curvature Rf acquired in step **510** (curvature difference ΔR). Next, the CPU advances the process to step **520** and determines whether the alert condition Calert is satisfied. Specifically, the CPU determines whether the curvature difference ΔR acquired in step **515** is equal to or larger than the predetermined value ΔRth and the distant point curvature Rf acquired in step **510** is larger than the near point curvature Rn acquired in step **510**.
(75) When the CPU determines "Yes" in step **520**, the CPU advances the process to step **525** and determines whether the steering wheel operation condition Csteer is satisfied.
(76) When the CPU determines "Yes" in step **525**, the CPU advances the process to step **530**. The CPU stops the alert when the alert is being issued, and when the alert is not being issued, the CPU maintains the state in which the alert is not being issued. Alternatively, the CPU starts the alert with a low alert level when the alert with a low alert level is not being issued, and continues the alert with a low alert level when the alert with a low alert level is being issued. Thereafter, the CPU advances the process to step **595** and temporarily ends the routine.
(77) When the CPU determines "No" in step **525**, the CPU advances the process to step **535**. The CPU starts the alert when the alert is not being issued and continues the alert when the alert is being issued. Thereafter, the CPU advances the process to step **595** and temporarily ends the routine.
(78) When the CPU determines "No" in step **520**, the CPU advances the process to step **540** and determines whether the alert is being issued.
(79) When the CPU determines "Yes" in step **540**, the CPU advances the process to step **545** and determines whether the elapsed time T from the start of the alert is equal to or more than the predetermined time Tth.
(80) When the CPU determines "Yes" in step **545**, the CPU advances the process to step **550** and stops the alert. Thereafter, the CPU advances the process to step **595** and temporarily ends the routine.
(81) When the CPU determines "No" in step **545**, the CPU advances the process to step **555** and

continues the alert. Thereafter, the CPU advances the process to step **595** and temporarily ends the routine.
(82) When the CPU determines "No" in step **540**, the CPU directly advances the process to step **595** and temporarily ends the routine.
(83) When the CPU determines "No" in step **505**, the CPU advances the process to step **560**. The CPU stops the alert when the alert is being issued, and when the alert is not being issued, the CPU maintains the state in which the alert is not being issued. Thereafter, the CPU advances the process to step **595** and temporarily ends the routine.
(84) The above is the specific operations of the vehicle driving support device **10** according to the modification.

Claims

1. A vehicle driving support device, comprising: an electronic control unit configured to issue an alert to notify a driver of a vehicle in advance that the vehicle is approaching a road having a large curvature; and a forward information providing device that provides, to the electronic control unit, forward information that includes information indicating a curvature of the road forward of the vehicle, wherein the forward information providing device is a camera installed in the vehicle that provides an image information as the forward information the image information obtained by the camera capturing images forward of the vehicle, wherein the electronic control unit is configured to: detect, from the image information, an outer wall or a fence of a building on a side of the road forward of the vehicle, and acquire a forward road curvature from the shape of the detected outer wall or fence as the forward information; determine, from the forward information, a near point curvature of a near point that is a first distance forward from the vehicle and a distant point curvature of a distant point that is a second distance forward from the vehicle, the second distance being longer than the first distance; detect a vehicle speed of the vehicle, wherein both the first distance and the second distance increase as the vehicle speed of the vehicle increases; issue the alert for turning of a steering wheel when an alert condition is satisfied that the distant point curvature is larger than the near point curvature by a predetermined value or more; and set a level of the alert to be lower when the turning of the steering wheel by the driver is detected than when the turning of the steering wheel by the driver is not detected.
2. The vehicle driving support device according to claim 1, wherein the alert condition includes a condition that a steering wheel operation by the driver is not detected.
3. The vehicle driving support device according to claim 1, wherein the alert condition includes a condition that the distant point curvature is equal to or larger than a predetermined distant point curvature.
4. The vehicle driving support device according to claim 1, wherein the alert condition includes a condition that the near point curvature is equal to or larger than a predetermined near point curvature.
5. The vehicle driving support device according to claim 1, wherein the vehicle driving support device acquires the near point curvature and the distant point curvature during execution of a lane keeping support control, and the lane keeping support control acquires a centerline of a lane in which the vehicle is travelling from the forward information, corrects a required steering force and provides the corrected required steering force so that the vehicle travels along the lane.
6. The vehicle driving support device according to claim 1, wherein the alert is stopped when the alert condition is no longer satisfied and an alert end condition that an elapsed time from a start of the alert has reached a predetermined time is satisfied.
7. The vehicle driving support device according to claim 1, wherein the driver is driving the vehicle when the alert condition is satisfied.
8. The vehicle driving support device according to claim 1, wherein the alert is issued when the

turning of the steering wheel by the driver is detected.

9. The vehicle driving support device according to claim 1, wherein the near point curvature and the distant point curvature are curvatures in a same curved road that curves in the same direction.