US 20230249549A1

(19) **United States**
(12) **Patent Application Publication**
KUMAZAKI
(10) **Pub. No.: US 2023/0249549 A1**
(43) **Pub. Date: Aug. 10, 2023**

(54) **VEHICLE CONTROL DEVICE, STORAGE MEDIUM FOR STORING COMPUTER PROGRAM FOR VEHICLE CONTROL, AND METHOD FOR CONTROLLING VEHICLE**

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(21) Appl. No.: **18/084,874**

(22) Filed: **Dec. 20, 2022**

(30) **Foreign Application Priority Data**

Feb. 7, 2022 (JP) 2022-017382

Publication Classification

(51) **Int. Cl.**
B60K 31/00 (2006.01)

(52) **U.S. Cl.**
CPC ***B60K 31/0066*** (2013.01)

(57) **ABSTRACT**

A vehicle control device has a processor configured to set a reference curve speed when a vehicle is traveling on a curved road based on the speed of the vehicle and the curvature radius of the road, determine a target curve speed based on the reference curve speed and a current correction value, count the number of changes the speed of the vehicle has been changed from the target curve speed by driver operation and calculate a new correction value for the reference curve speed based on a correction coefficient determined each time the number of changes has been counted and the amount of change in the speed of the vehicle that has changed from the target curve speed by driver operation, wherein the subsequent target curve speed is determined based on the reference curve speed and the new correction value.

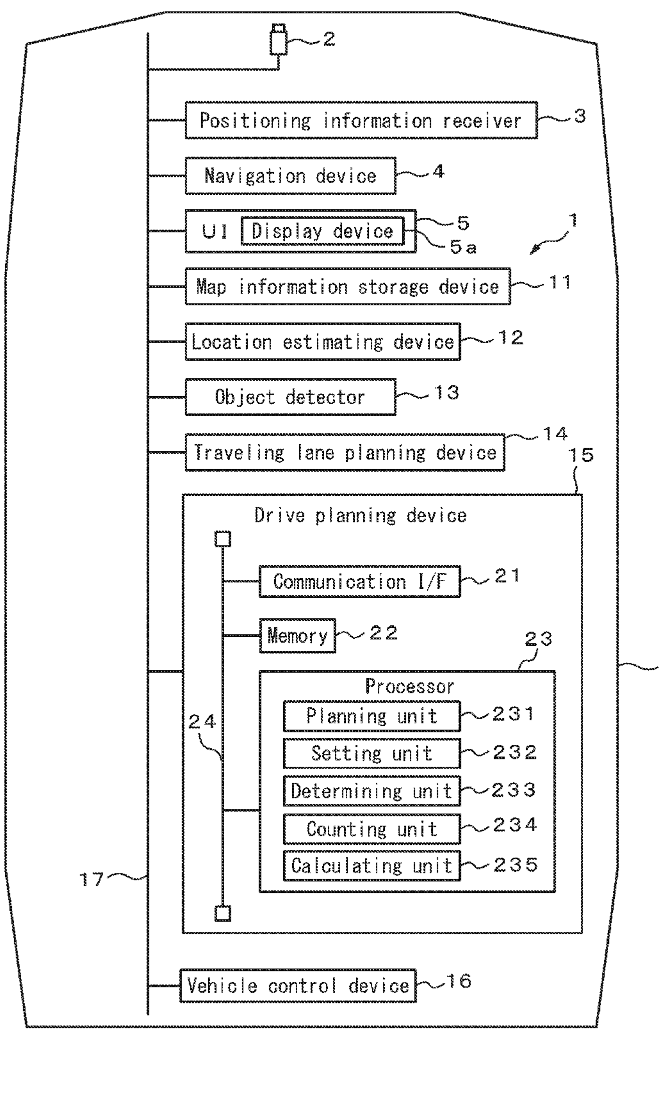


FIG. 1A

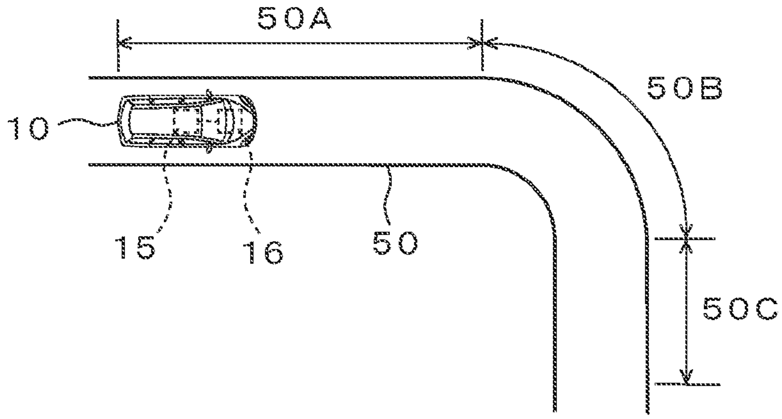


FIG. 1B

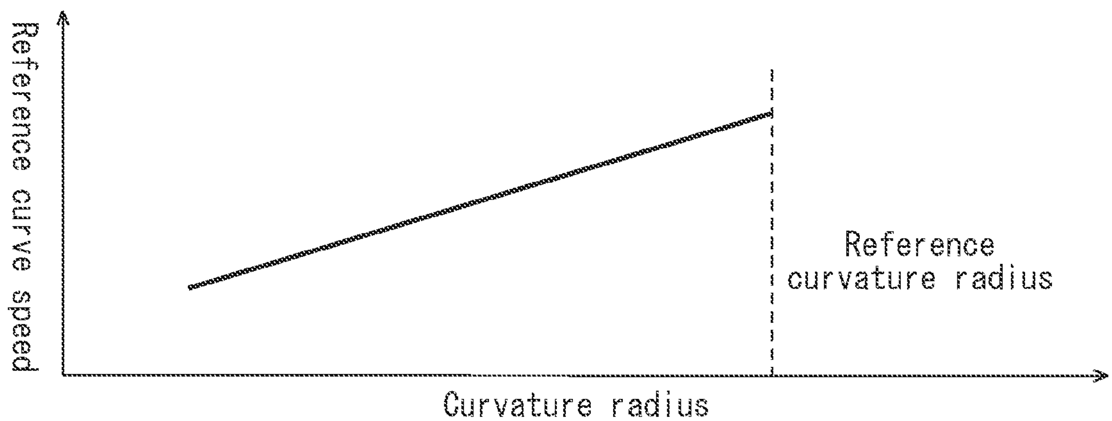


FIG. 1C

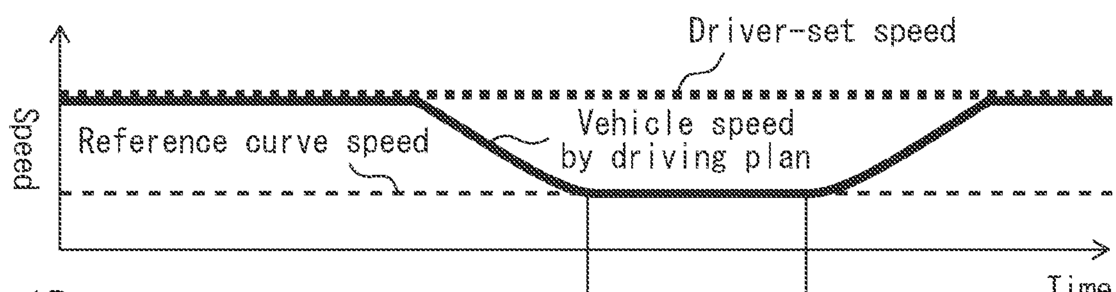


FIG. 1D

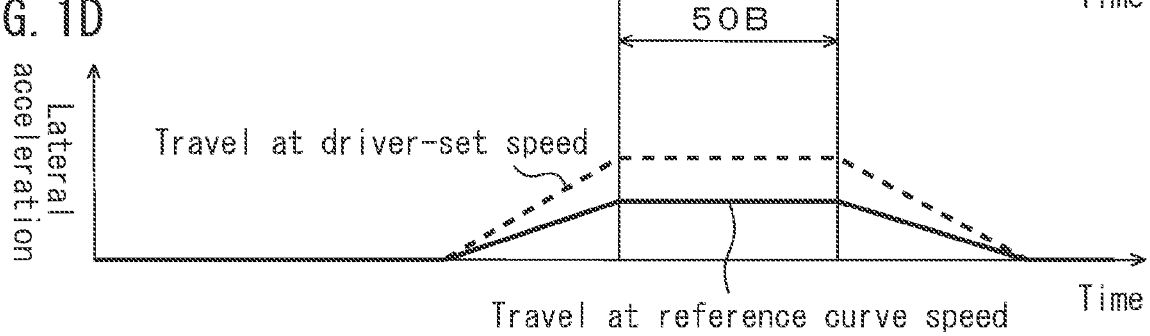


FIG. 2A

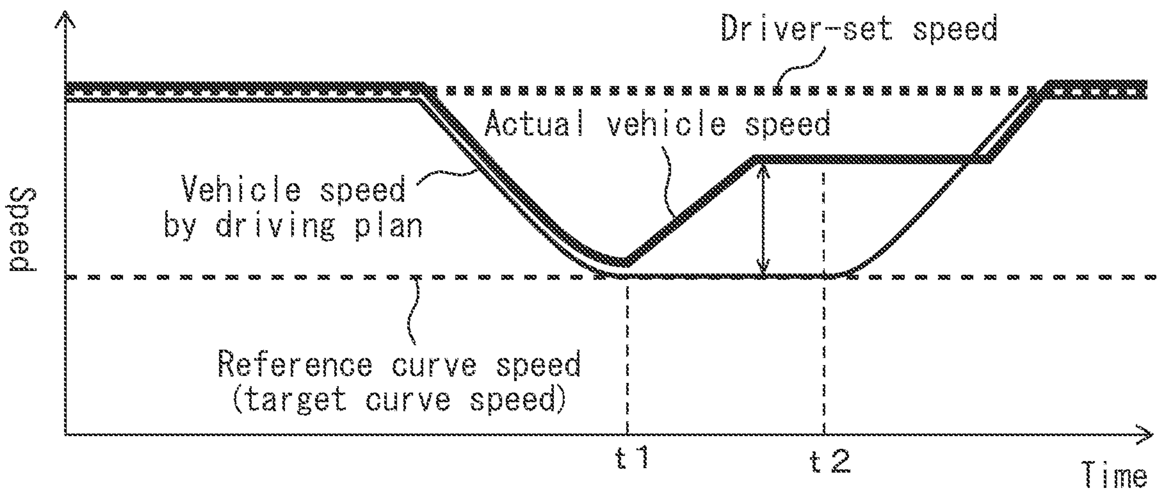

Driver-set speed
Actual vehicle speed
Vehicle speed by driving plan
Speed
Reference curve speed (target curve speed)
t1
t2
Time

FIG. 2B

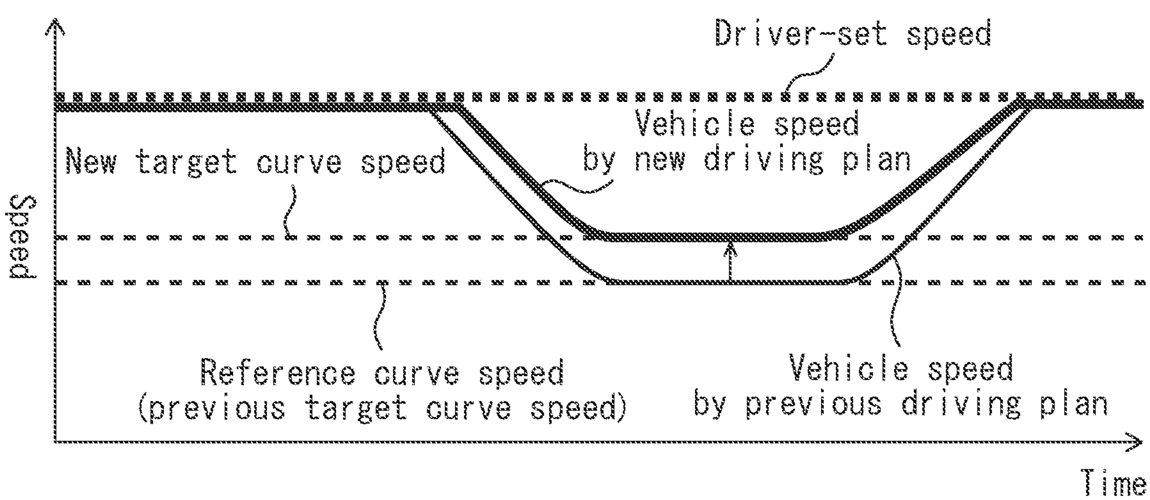

Driver-set speed
Vehicle speed by new driving plan
New target curve speed
Speed
Reference curve speed (previous target curve speed)
Vehicle speed by previous driving plan
Time

FIG. 3

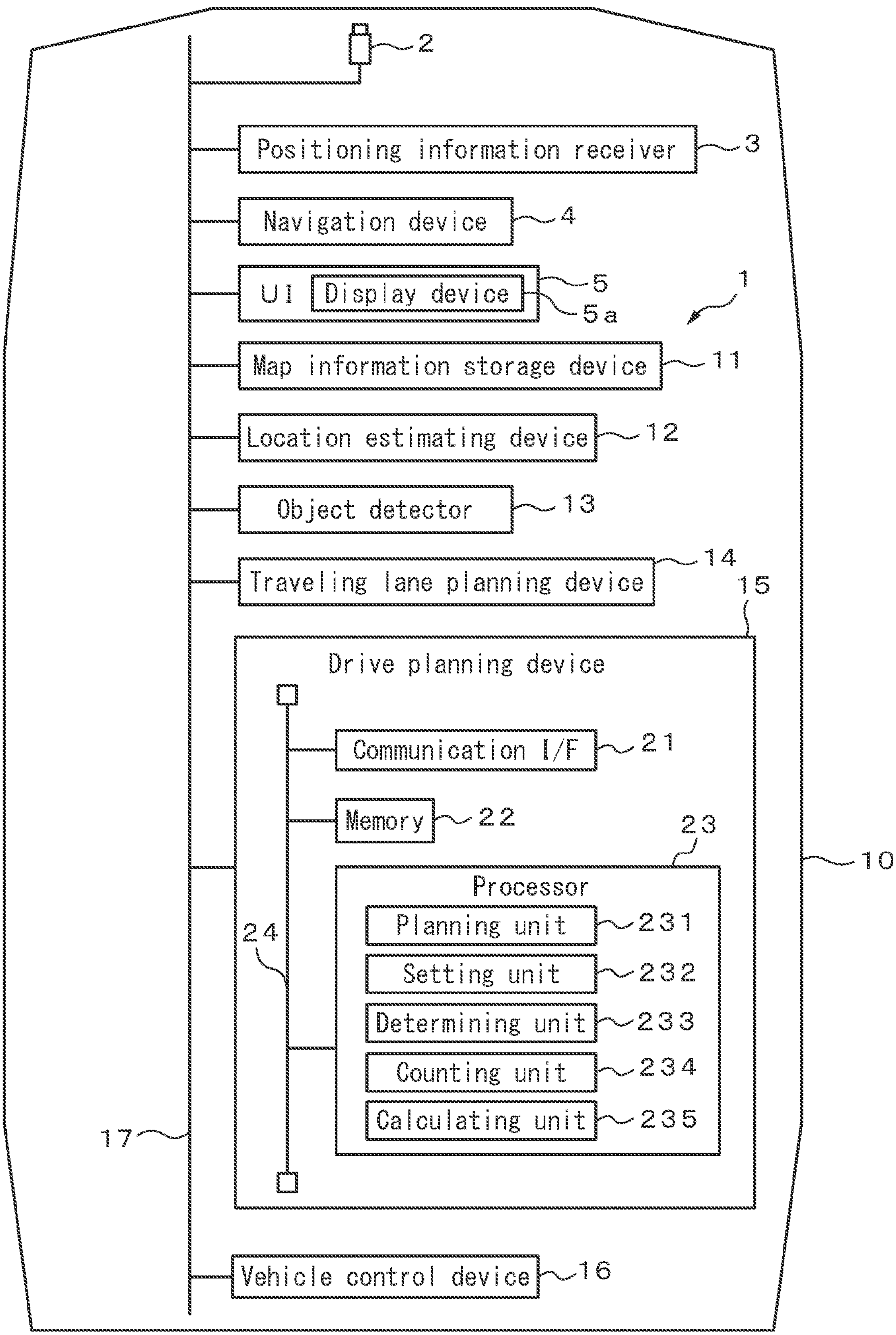

2
Positioning information receiver
3
Navigation device
4
UI
Display device
5
5a
1
Map information storage device
11
Location estimating device
12
Object detector
13
Traveling lane planning device
14
15
Drive planning device
Communication I/F
21
Memory
22
23
Processor
Planning unit
231
Setting unit
232
Determining unit
233
Counting unit
234
Calculating unit
235
24
10
17
Vehicle control device
16

FIG. 4

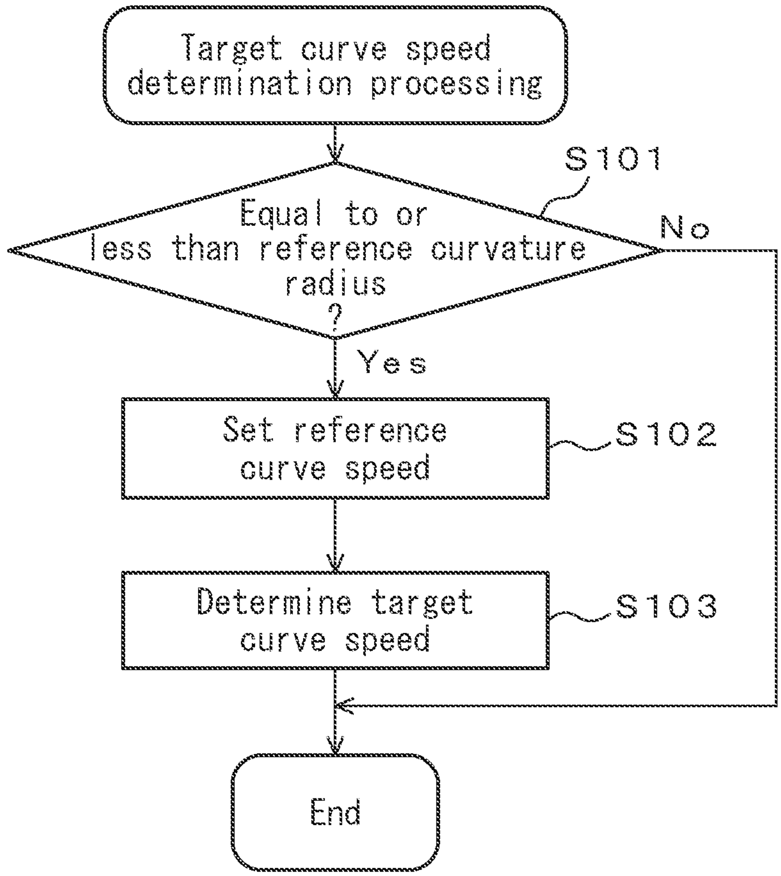

Target curve speed determination processing
Equal to or less than reference curvature radius ?
S101
No
Yes
Set reference curve speed
S102
Determine target curve speed
S103
End

FIG. 5

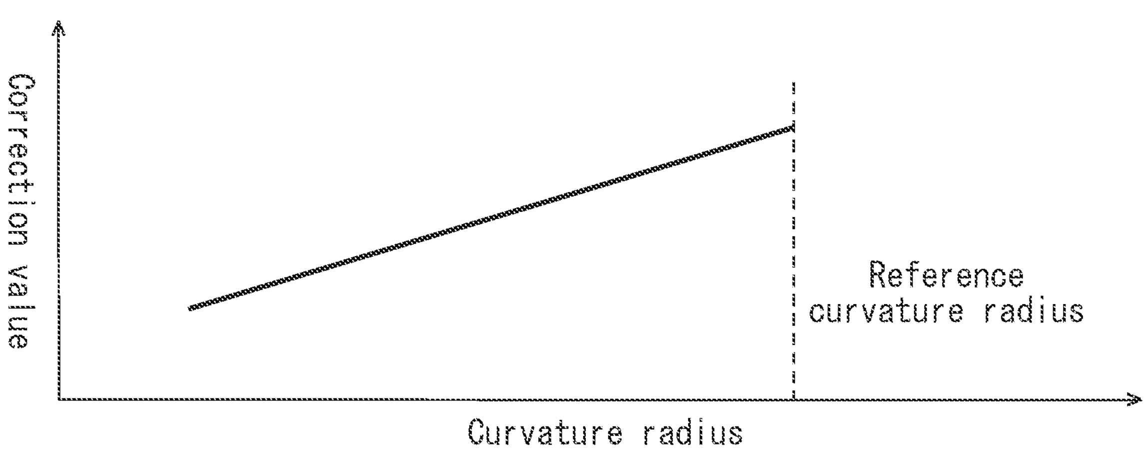

Correction value
Reference curvature radius
Curvature radius

FIG. 6

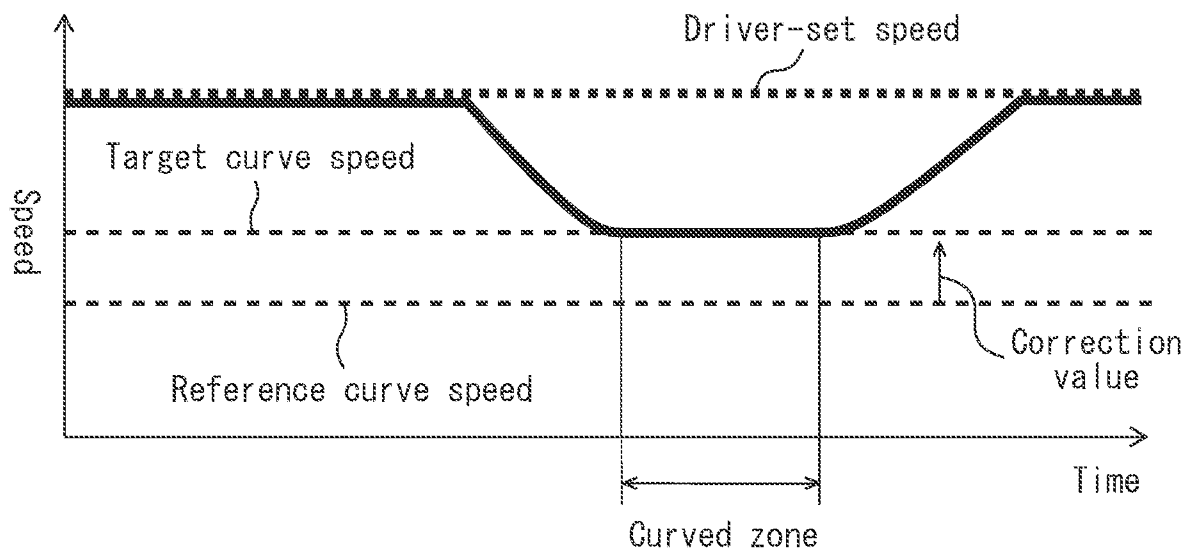

Driver-set speed
Target curve speed
Speed
Correction value
Reference curve speed
Time
Curved zone

FIG. 7

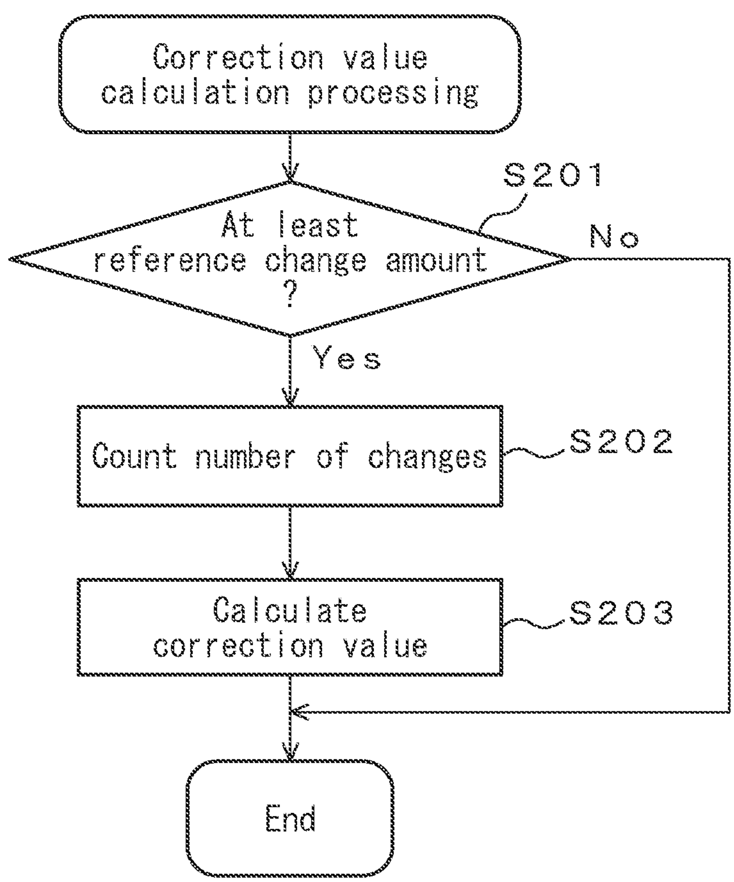

Correction value calculation processing
S201
At least reference change amount ?
No
Yes
Count number of changes
S202
Calculate correction value
S203
End

FIG. 8

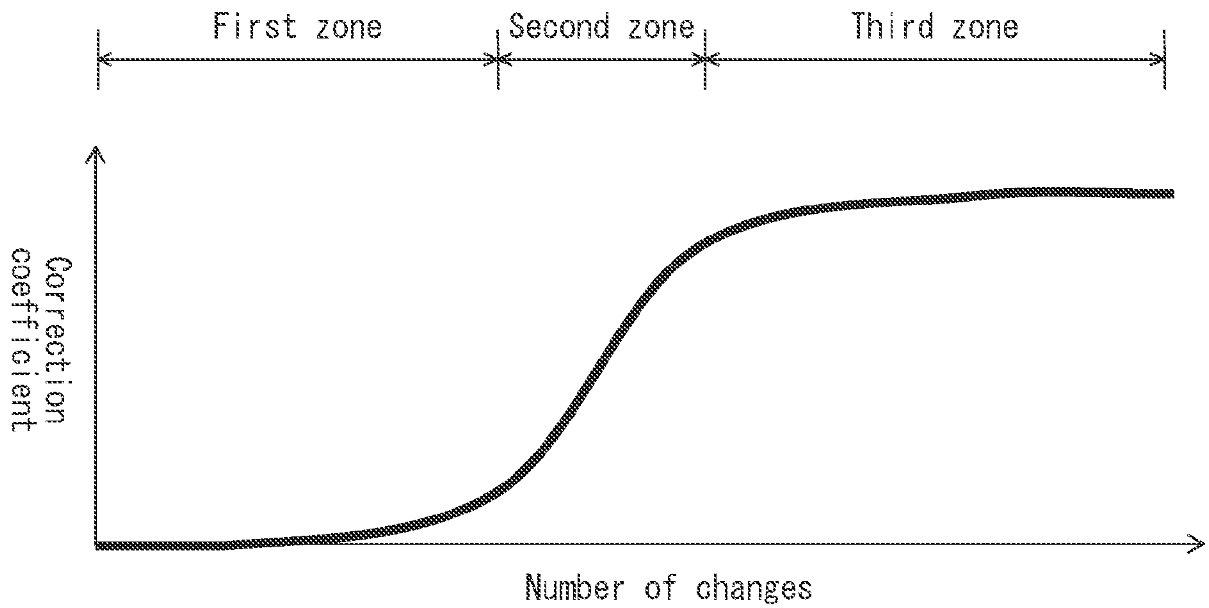

First zone
Second zone
Third zone
Correction coefficient
Number of changes

FIG. 9A

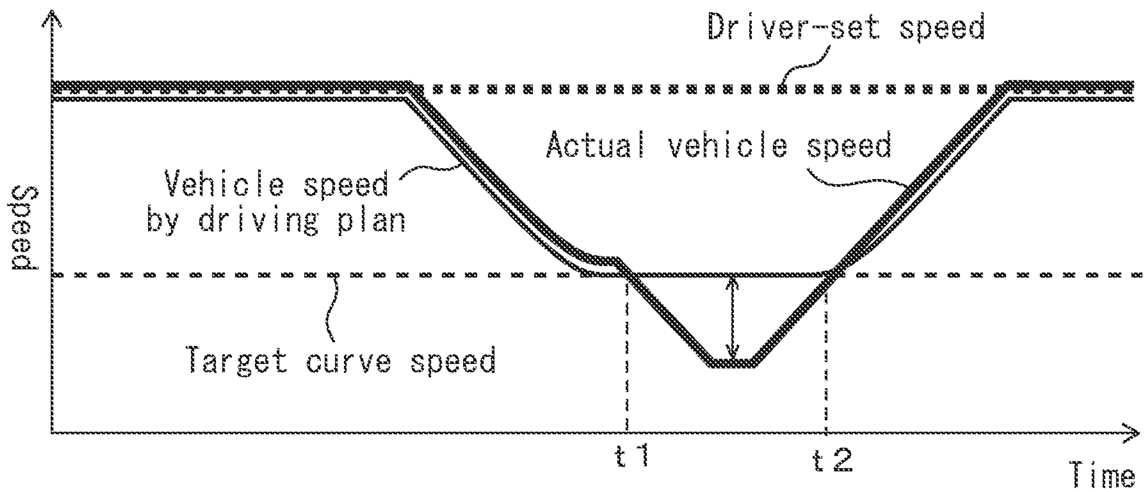

Driver-set speed
Actual vehicle speed
Vehicle speed
by driving plan
Speed
Target curve speed
t1
t2
Time

FIG. 9B

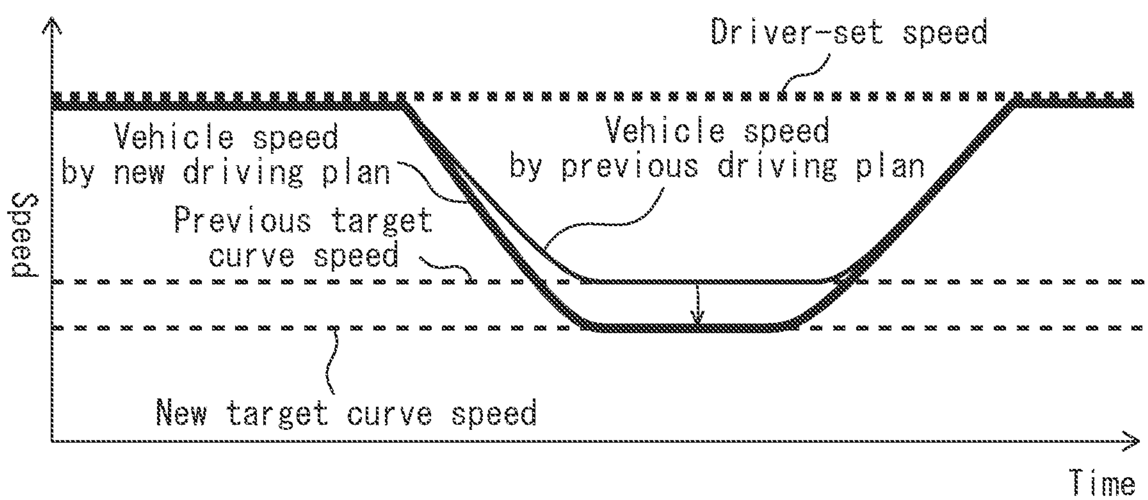
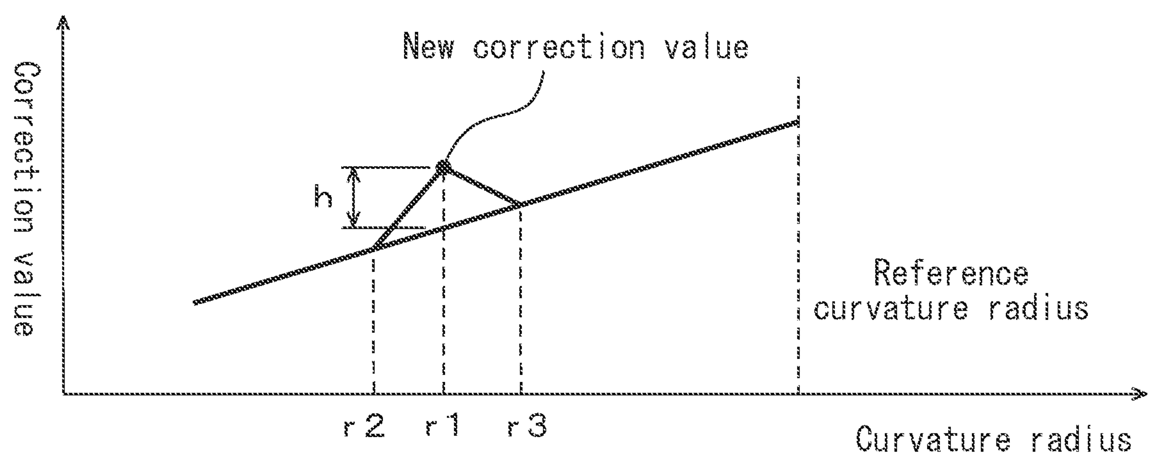

Driver-set speed
Vehicle speed
by new driving plan
Vehicle speed
by previous driving plan
Speed
Previous target
curve speed
New target curve speed
Time

FIG. 10



New correction value
Correction value
h
Reference
curvature radius
r2
r1
r3
Curvature radius

VEHICLE CONTROL DEVICE, STORAGE MEDIUM FOR STORING COMPUTER PROGRAM FOR VEHICLE CONTROL, AND METHOD FOR CONTROLLING VEHICLE

FIELD

[0001] The present disclosure relates to a vehicle control device, a storage medium storing a computer program for vehicle control, and a method for controlling a vehicle.

BACKGROUND

[0002] An autonomous control system mounted in a vehicle generates a navigation route for the vehicle based on the current location of the vehicle, the destination location of the vehicle, and a navigation map. The autonomous control system estimates the current location of the vehicle using the map information and controls the vehicle to travel along the navigation route.

[0003] The autonomous control system also controls the speed of the vehicle so that the vehicle travels at a driver-set speed which has been set by the driver. The driver-set speed is set by the driver based on the speed limit (legal speed limit) for the road on which the vehicle is traveling, for example. When the vehicle travels on a curved road, acceleration acts on the driver in the lateral direction.

[0004] Since the driver may feel discomfort if the lateral acceleration is strong while the vehicle is traveling, the autonomous control system sets a curve reference speed in response to the curvature radius of the road. The autonomous control system functions to prevent excessive lateral acceleration from being produced by traveling on the curved road at the curve reference speed. When the driver-set speed is faster than the curve reference speed, the autonomous control system decelerates the speed of the vehicle to the curve reference speed as the vehicle travels on the curved road.

[0005] For example, Japanese Unexamined Patent Publication No. 2020-192824 proposes a driving behavior control system that sets parameters establishing the driving behavior for an autonomous driven vehicle in response to a specific driving situation, detects passenger feedback for the driving behavior resulting from the parameters and, based on the parameters that have been changed in response to the feedback, establishes driving behavior for cases in which the autonomous driven vehicle subsequently encounters the specific driving situation or a driving situation similar to the specific driving situation.

SUMMARY

[0006] Since the response to lateral acceleration when a vehicle travels will differ depending on the driver, the allowable range for lateral acceleration will also differ depending on the driver. Some drivers may feel that the curve reference speed set by the autonomous control system is slow (a wide allowable range for lateral acceleration), while other drivers may feel that the curve reference speed is fast (a narrow allowable range for lateral acceleration).

[0007] There is potentially room for improvement in terms of controlling vehicle speed when a vehicle is traveling on a curved road, so that all drivers are satisfied.

[0008] It is an object of the present disclosure to provide a vehicle control device that can cause a vehicle to travel on a curved road at a lateral acceleration that is satisfactory for different drivers.

[0009] One embodiment of the invention provides a vehicle control device. The vehicle control device has a reference curve speed setting unit that sets a reference curve speed as a speed reference when a vehicle is traveling on a curved road, based on the speed of the vehicle and the curvature radius of the road on which the vehicle is traveling, a target curve speed determining unit that determines a target curve speed as a target speed at which the vehicle is to be controlled based on the reference curve speed and a current correction value corresponding to the curvature radius of the road when the vehicle is traveling on the curved road, a counting unit that counts the number of changes as the number of times the speed of the vehicle has been changed from the target curve speed by driver operation when the vehicle is traveling on the curved road, and a correction value calculating unit that calculates a new correction value for the reference curve speed corresponding to the curvature radius of the road based on a correction coefficient determined based on the number of changes, and the amount of change in the speed of the vehicle that has changed from the target curve speed by the driver operation each time the number of changes has been counted, in which the target curve speed determining unit determines the subsequent target curve speed based on the reference curve speed and the new correction value corresponding to the curvature radius of the road.

[0010] In this vehicle control device, the correction value calculating unit preferably calculates the new correction value as the sum of the products of the correction coefficients and the amount of change in the speed of the vehicle for each time the speed of the vehicle has been changed from the target curve speed by the driver operation.

[0011] In this vehicle control device, the relationship between the correction coefficient and number of changes preferably has a first zone in which the correction coefficient increases as the number of changes increases, a second zone in which the correction coefficient increases more than the first zone as the number of changes increases, and a third zone in which the correction coefficient increases less than the second zone as the number of changes increases.

[0012] In this vehicle control device, the correction value calculating unit preferably corrects the current correction value for the curvature radius of the road before and after the curvature radius of the road for which the new correction value was calculated so that difference between the new correction value and the current correction value for the curvature radius of the road before and after is at or below a predetermined reference value when the new correction value has been determined.

[0013] In this vehicle control device, it is preferable that the correction value calculating unit calculates the new correction value for the reference curve speed corresponding to the curvature radius of the road for each type of road, and the correction value calculating unit calculates the new correction value for the reference curve speed corresponding to the curvature radius of another road, based on the new correction value when the new correction value has been determined for one road on which the vehicle is traveling.

[0014] According to another embodiment, a non-transitory storage medium storing a computer program for vehicle control is provided. The computer program for vehicle control causes a processor execute a process, the process includes setting a reference curve speed as a speed reference when a vehicle is traveling on a curved road, based on a speed of the vehicle and the curvature radius of the road on which the vehicle is traveling, determining a target curve speed as a target speed at which the vehicle is to be controlled based on the reference curve speed and a current correction value corresponding to the curvature radius of the road when the vehicle is traveling on the curved road, counting number of changes as the number of times the speed of the vehicle has been changed from the target curve speed by driver operation when the vehicle is traveling on the curved road, and calculating a new correction value for the reference curve speed corresponding to the curvature radius of the road based on a correction coefficient determined based on the number of changes, and the amount of change in the speed of the vehicle that has changed from the target curve speed by the driver operation each time the number of changes has been counted, in which the subsequent target curve speed is determined based on the reference curve speed and the new correction value corresponding to the curvature radius of the road.

[0015] Yet another embodiment of the invention provides a method for controlling a vehicle carried out by a vehicle control device. The method for controlling a vehicle includes setting a reference curve speed as a speed reference when a vehicle is traveling on a curved road, based on the speed of the vehicle and the curvature radius of the road on which the vehicle is traveling, determining a target curve speed as a target speed at which the vehicle is to be controlled based on the reference curve speed and a current correction value corresponding to the curvature radius of the road when the vehicle is traveling on the curved road, counting number of changes as the number of times the speed of the vehicle has been changed from the target curve speed by driver operation when the vehicle is traveling on the curved road, and calculating a new correction value for the reference curve speed corresponding to the curvature radius of the road based on a correction coefficient determined based on the number of changes, and the amount of change in the speed of the vehicle that has changed from the target curve speed by the driver operation each time the number of changes has been counted, in which the subsequent target curve speed is determined based on the reference curve speed and the new correction value corresponding to the curvature radius of the road.

[0016] The vehicle control device of the present disclosure can cause a vehicle to travel on a curved road at a lateral acceleration that is satisfactory for different drivers.

[0017] The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF DRAWINGS

[0018] FIG. **1**A is a diagram illustrating operation of the drive planning device of the embodiment in overview, showing the state of a vehicle traveling on a road that includes a curve.

[0019] FIG. **1**B is a diagram illustrating operation of the drive planning device of the embodiment in overview, showing an example of the relationship between curvature radius and reference curve speed.

[0020] FIG. **1**C is a diagram illustrating operation of the drive planning device of the embodiment in overview, and a reference curve speed.

[0021] FIG. **1**D is a diagram illustrating operation of the drive planning device of the embodiment in overview, and lateral acceleration.

[0022] FIG. **2**A is a diagram illustrating operation of the drive planning device of the embodiment in overview, and correction value calculation processing when the vehicle has accelerated.

[0023] FIG. **2**B is a diagram illustrating operation of the drive planning device of the embodiment in overview, and a new target curve speed.

[0024] FIG. **3** is a general schematic drawing of a vehicle in which a vehicle control system of the embodiment is mounted.

[0025] FIG. **4** is an example of an operation flow chart for target curve speed determination processing by a drive planning device of the embodiment.

[0026] FIG. **5** is a diagram showing an example of the relationship between correction value and reference curvature radius.

[0027] FIG. **6** is a diagram illustrating target curve speed determination processing.

[0028] FIG. **7** is an example of an operation flow chart for correction value calculation processing by a drive planning device of the embodiment.

[0029] FIG. **8** is a diagram showing an example of the relationship between the correction coefficient and number of changes.

[0030] FIG. **9**A is a diagram illustrating correction value calculation processing when a vehicle has decelerated.

[0031] FIG. **9**B is a diagram illustrating a new target curve speed.

[0032] FIG. **10** is a diagram illustrating the relationship between correction value and reference curvature radius, for Modification Example 1.

DESCRIPTION OF EMBODIMENTS

[0033] FIG. **1**A to FIG. **1**D, FIG. **2**A and FIG. **2**B are diagrams showing operation of a drive planning device **15** according to an embodiment in overview. FIG. **1**A is a diagram showing the state of a vehicle **10** traveling on a road **50** that includes a curve. FIG. **1**B is a diagram showing an example of the relationship between curvature radius and reference curve speed. FIG. **1**C is a diagram illustrating reference curve speed. FIG. **1**D is a diagram illustrating lateral acceleration. FIG. **2**A is a diagram illustrating correction value calculation processing when the vehicle **10** has accelerated. FIG. **2**B is a diagram showing a new target curve speed.

[0034] Operation for vehicle control processing by the drive planning device **15** as disclosed herein will now be described in overview with reference to FIG. **1**A to FIG. **1**D, FIG. **2**A and FIG. **2**B.

[0035] As shown in FIG. **1**A, the vehicle **10** is traveling on the road **50**. The road **50** has a straight road zone **50**A, a curved road zone **50**B and a straight road zone **50**C in that order in the traveling direction of the vehicle **10**. The vehicle **10** is currently traveling in zone **50**A.

[0036] The vehicle **10** has a drive planning device **15** and a vehicle control device **16**. The drive planning device **15** generates a driving plan representing a scheduled traveling trajectory for the vehicle **10** until a predetermined time ahead. The driving plan is represented as a combination of the target location of the vehicle **10** and the target vehicle speed at the target location, at each time from the current time until the predetermined time. The vehicle **10** may be an autonomous vehicle.

[0037] The vehicle control device **16** controls each unit of the vehicle **10** based on a driving plan created by the drive planning device **15**, to drive the vehicle. The drive planning device **15** also sets a reference curve speed as a speed reference for when the vehicle **10** travels on a curved road, based on map information, the speed of the vehicle and the curvature radius of the road **50** on which the vehicle **10** is traveling.

[0038] The reference curve speed is a speed representing the upper limit for the vehicle **10** traveling on a road having a curvature radius that is equal to or less than the reference curvature radius. The reference curvature radius is determined based on the speed of the vehicle **10**. As shown in FIG. **1**B, the reference curve speed is lower with a lower curvature radius. When the curvature radius of the road is greater than the reference curvature radius, the drive planning device **15** does not set the reference curve speed. The speed of the vehicle **10** is determined based on the driver-set speed.

[0039] If the vehicle **10** travels on a curved road at a speed equal to or less than the reference curve speed, then lateral acceleration acting on the driver will be limited to no greater than a predetermined reference acceleration. The lateral acceleration is an acceleration acting in the direction perpendicular to the traveling direction of the vehicle **10**, as “centrifugal force”. This can minimize unpleasantness for the driver when the vehicle **10** travels on a curved road. Reducing the lateral acceleration to be at or below a predetermined reference acceleration also allows the vehicle **10** to stably travel on the scheduled traveling trajectory that has been planned.

[0040] In zone **50**A which is a straight line, the drive planning device **15** generates a driving plan for the vehicle **10** so that it travels at a driver-set speed, representing the speed of the vehicle **10** that has been set by the driver.

[0041] Since the curvature radius of zone **50**B which is a curved road is equal to or less than the reference curvature radius, the drive planning device **15** sets the reference curve speed for zone **50**B. In zone **50**B, the drive planning device **15** generates a driving plan for the vehicle **10** so that it travels at the reference curve speed.

[0042] FIG. **1**C shows an example of the relationship between speed of the vehicle **10** and time, based on a driving plan. In zone **50**A, the vehicle **10** travels at the driver-set speed, while in zone **50**B the vehicle **10** travels at the reference curve speed and in zone **50**C the vehicle **10** travels at the driver-set speed.

[0043] Since the reference curve speed is slower than the driver-set speed, the vehicle **10** decelerates to the reference curve speed just before zone **50**B which is a curved road, and after having passed through zone **50**B it accelerates to the driver-set speed in zone **50**C.

[0044] As shown in FIG. **1**D, lateral acceleration on the driver can be reduced if the vehicle **10** travels in zone **50**B at the reference curve speed, compared to if the vehicle **10** has traveled in zone **50**B at the driver-set speed.

[0045] As shown in FIG. **2**A, when the vehicle **10** travels in zone **50**B, a driver who feels that the speed of the vehicle **10** is slow may activate acceleration to increase the speed of the vehicle **10** above the reference curve speed.

[0046] This causes the actual speed of the vehicle **10** between time t1 and time t2, in zone **50**B, to increase above the speed of the driving plan. In part of zone **50**C as well, the actual speed of the vehicle **10** increases above the speed of the vehicle **10** according to the driving plan.

[0047] The drive planning device **15** counts the number of times that the speed of the vehicle **10** has changed from the speed of the driving plan by driver operation, while the vehicle **10** is traveling on the curved road. The drive planning device **15** may also count the number of times that the speed of the vehicle **10** has changed from the speed of the driving plan by driver operation while the vehicle **10** is traveling on a curved road, for each different curvature radius of the road.

[0048] Each time the number of changes has been counted, the drive planning device **15** calculates a correction value for the reference curve speed corresponding to the curvature radius of the road, based on a correction coefficient determined based on the number of changes, and the amount of change in the speed of the vehicle **10** that has changed from the speed of the driving plan by driver operation.

[0049] As shown in FIG. **2**A, when the vehicle **10** again travels on a road having the same curvature radius as zone **50**B, the drive planning device **15** determines the target curve speed to be a target speed at which the vehicle **10** is to be controlled when the vehicle **10** is traveling on the curved road, based on the reference curve speed and the current correction value corresponding to the curvature radius of the road.

[0050] As shown in FIG. **2**B, the new target curve speed is corrected so as to reflect the previous accelerating operation by the driver and to be increased above the previous reference curve speed.

[0051] When the vehicle **10** has again traveled on a road with the same curvature radius as zone **50**B, the drive planning device **15** determines a new correction value for the target curve speed corresponding to the curvature radius of the road, when a driver who feels that the speed of the vehicle **10** is slow has performed an accelerating operation so that the speed of the vehicle **10** has been increased above the speed of the driving plan.

[0052] As shown in FIG. **2**B, when the vehicle **10** once again travels on a road having the same curvature radius as zone **50**B, the drive planning device **15** again determines a new target curve speed based on the reference curve speed and the current correction value corresponding to the curvature radius of the road. The new target curve speed is corrected so as to reflect the previous accelerating operation by the driver and to be even further increased above the previous target curve speed.

[0053] As explained above, each time the number of changes has been counted, the drive planning device **15** determines the target curve speed using a correction value calculated based on the correction coefficient determined based on the number of changes, and the amount of change in the speed of the vehicle **10** that has changed from the target curve speed by driver operation. This allows the drive planning device **15** to cause the vehicle to travel on the curved road at a lateral acceleration that is satisfactory for different drivers.

[0054] FIG. **3** is a general schematic drawing of a vehicle **10** in which a vehicle control system **1** of the embodiment is mounted. The vehicle **10** has a camera **2**, a positioning information receiver **3**, a navigation device **4**, a user interface (UI) **5**, a map information storage device **11**, a location estimating device **12**, an object detector **13**, a traveling lane planning device **14**, a drive planning device **15** and a vehicle control device **16**. The vehicle **10** may also have a LiDAR sensor, as a distance sensor (not shown) for measurement of the distance of the vehicle **10** to surrounding objects. The vehicle control system **1** has at least vehicle control device **16**.

[0055] The camera **2**, positioning information receiver **3**, navigation device **4**, UI **5**, map information storage device **11**, location estimating device **12**, object detector **13**, traveling lane planning device **14**, drive planning device **15** and vehicle control device **16** are connected in a communicable manner through an in-vehicle network **17** that conforms to controller area network standards.

[0056] The camera **2** is an example of an imaging unit provided in the vehicle **10**. The camera **2** is mounted inside the vehicle **10** and directed toward the front of the vehicle **10**. The camera **2**, for example, takes a camera image in which the environment of a predetermined region ahead of the vehicle **10** is shown, at a predetermined cycle. The camera image can show the road in the predetermined region ahead of the vehicle **10**, and road features such as surface lane marking lines on the road. The camera **2** has a 2D detector composed of an array of photoelectric conversion elements with visible light sensitivity, such as a CCD or C-MOS, and an imaging optical system that forms an image of the photographed region on the 2D detector.

[0057] Each time a camera image is taken, the camera **2** outputs the camera image and the camera image photograph time at which the camera image was taken, through the in-vehicle network **17** to the location estimating device **12** and object detector **13**, etc. The camera image is also used for processing at the location estimating device **12** to estimate the location of the vehicle **10**. At the object detector **13**, the camera image is used for processing to detect other objects surrounding the vehicle **10**.

[0058] The positioning information receiver **3** outputs positioning information that represents the current location of the vehicle **10**. The positioning information receiver **3** may be a GNSS receiver, for example. The positioning information receiver **3** outputs positioning information and the positioning information acquisition time at which the positioning information has been acquired, to the navigation device **4** and map information storage device **11**, etc., each time positioning information is acquired at a predetermined receiving cycle.

[0059] Based on the navigation map information, the destination location of the vehicle **10** input through the UI **5**, and positioning information representing the current location of the vehicle **10** input from the positioning information receiver **3**, the navigation device **4** generates a navigation route from the current location to the destination location of the vehicle **10**. The navigation route includes information relating to the locations of right turns, left turns, merging and branching. When the destination location has been newly set or the current location of the vehicle **10** has exited the navigation route, the navigation device **4** generates a new navigation route for the vehicle **10**. Every time a navigation route is created, the navigation device **4** outputs the navigation route to the location estimating device **12** and the traveling lane planning device **14**, etc., via the in-vehicle network **17**.

[0060] The UI **5** is an example of the notification unit. The UI **5**, controlled by the navigation device **4**, drive planning device **15** and vehicle control device **16**, notifies the driver of the vehicle **10** traveling information. The traveling information of the vehicle **10** includes information relating to the current location of the vehicle, the speed limit for the road and the current and future route of the vehicle, such as the navigation route. The UI **5** has a display device **5***a* such as a liquid crystal display or touch panel, for display of the traveling information. The UI **5** may also have an acoustic output device (not shown) to notify the driver of traveling information. The UI **5** also generates an operation signal in response to operation of the vehicle **10** by the driver. The operation information may be, for example, a destination location, transit points, vehicle speed (driver-set speed) or other vehicle control information. The UI **5** also has a touch panel or operating button, for example, as an input device for inputting operation information from the driver to the vehicle **10**. The driver sets the speed of the vehicle based on the speed limit for the road on which the vehicle **10** is traveling, for example. The UI **5** outputs the input operation information to the navigation device **4**, the drive planning device **15** and the vehicle control device **16**, etc., via the in-vehicle network **17**.

[0061] The map information storage device **11** stores wide-area map information for a relatively wide area (an area of 10 to 30 km^2, for example) that includes the current location of the vehicle **10**. The map information preferably has high precision map information including three-dimensional information for the road surface, the speed limit for the road, the curvature radius of the road, and information for the types and locations of structures and road features such as road lane marking lines.

[0062] The map information storage device **11** receives the wide-area map information from an external server via a base station, by wireless communication through a wireless communication device (not shown) mounted in the vehicle **10**, in relation to the current location of the vehicle **10**, and stores it in the storage device. Each time positioning information is input from the positioning information receiver **3**, the map information storage device **11** refers to the stored wide-area map information and outputs map information for a relatively narrow area including the current location represented by the positioning information (for example, an area of 100 m^2 to 10 km^2), through the in-vehicle network **17** to the location estimating device **12**, object detector **13**, traveling lane planning device **14**, drive planning device **15** and vehicle control device **16**, etc.

[0063] The location estimating device **12** estimates the location of the vehicle **10** at the camera image photograph time, based on the road features surrounding the vehicle **10** represented in the camera image. For example, the location estimating device **12** compares lane marking lines identified in the camera image with lane marking lines represented in the map information input from the map information storage device **11**, and determines the estimated location and estimated declination of the vehicle **10** at the camera image photograph time. The location estimating device **12** estimates the road traveling lane where the vehicle **10** is located, based on the lane marking lines represented in the map information and on the estimated location and estimated declination of the vehicle **10**. Each time the estimated location, estimated declination and traveling lane of the vehicle **10** are determined at the camera image photograph time, the location estimating device **12** outputs this information to the object detector **13**, traveling lane planning device **14**, drive planning device **15** and vehicle control device **16**, etc.

[0064] The object detector **13** detects other objects around the vehicle **10** and their types (for example, vehicles) based on the camera image, for example. Other objects also include other vehicles traveling around the vehicle **10**. The object detector **13** tracks other detected objects and determines the trajectories of the other objects. In addition, the object detector **13** identifies the traveling lanes in which the other objects are traveling, based on the lane marking lines represented in the map information and the locations of the objects. The object detector **13** outputs object detection information which includes information representing the types of other objects that were detected, information indicating their locations, and also information indicating their traveling lanes, to the traveling lane planning device **14** and drive planning device **15**, etc.

[0065] At a traveling lane-planning creation time set in a predetermined cycle, the traveling lane planning device **14** selects a traffic lane on the road on which the vehicle **10** is traveling, within the nearest driving zone (for example, 10 km) selected from the navigation route, based on the map information, the navigation route and surrounding environment information and the current location of the vehicle **10**, and generates a traveling lane plan representing the scheduled traveling lane for traveling of the vehicle **10**. For example, the traveling lane planning device **14** generates a traveling lane plan for the vehicle **10** to travel on a traffic lane other than a passing traffic lane. Each time a traveling lane plan is created, the traveling lane planning device **14** outputs the drive planning device **15** of the traveling lane plan.

[0066] The drive planning device **15** carries out plan processing, setting processing, assessment processing, count processing and calculation processing. The traveling lane planning device **14** comprises a communication interface (IF) **21**, a memory **22** and a processor **23** for this purpose. The communication interface **21**, memory **22** and processor **23** are connected via signal wires **24**. The communication interface **21** has an interface circuit to connect the traveling lane planning device **14** with the in-vehicle network **17**. The drive planning device **15** is an example of the vehicle control device.

[0067] The memory **22** is an example of a memory unit, and it has a volatile semiconductor memory and a non-volatile semiconductor memory, for example. The memory **22** stores an application computer program and various data to be used for information processing carried out by the processor **23**.

[0068] All or some of the functions of the drive planning device **15** are functional modules driven by a computer program operating on the processor **23**, for example. The processor **23** has a planning unit **231**, a setting unit **232**, a determining unit **233**, a counting unit **234** and a calculating unit **235**. Alternatively, the functional module of the processor **23** may be a specialized computing circuit in the processor **23**. The processor **23** comprises one or more CPUs (Central Processing Units) and their peripheral circuits. The processor **23** may also have other computing circuits such as a logical operation unit, numerical calculation unit or graphic processing unit.

[0069] At a driving plan creation time set with a predetermined cycle, the planning unit **231** carries out driving plan processing in which it generates a driving plan representing the scheduled traveling trajectory of the vehicle **10** up until a predetermined time (for example, 5 seconds), based on the traveling lane plan, the map information, the current location of the vehicle **10**, the surrounding environment information and the vehicle status information. The surrounding environment information includes the locations and speeds of other vehicles traveling around the vehicle **10**. The vehicle status information includes the current location of the vehicle **10**, and the vehicle speed, acceleration and traveling direction. The driving plan is represented as a combination of the target location of the vehicle **10** and the target vehicle speed at the target location, at each time from the current time until the predetermined time. The cycle in which the driving plan is created is preferably shorter than the cycle in which the traveling lane plan is created. The drive planning device **15** generates a driving plan to maintain a spacing of at least a predetermined distance between the vehicle **10** and other objects (such as vehicles). The drive planning device **15** outputs the driving plan to the vehicle control device **16** for each driving plan generated. Other operation by the drive planning device **15** will be described in detail below.

[0070] The vehicle control device **16** controls each unit of the vehicle **10** based on the current location of the vehicle **10** and the vehicle speed and yaw rate, as well as on the driving plan generated by the drive planning device **15**. For example, the vehicle control device **16** determines the steering angle, acceleration and angular acceleration of the vehicle **10** according to the driving plan and the speed and yaw rate of the vehicle **10**, and sets the amount of steering, and the accelerator or brake level so as to match that steering angle, accelerator level and angular acceleration. The vehicle control device **16** also outputs a control signal corresponding to a set steering amount, to an actuator (not shown) that controls the steering wheel for the vehicle **10**, via the in-vehicle network **17**. The vehicle control device **16** also outputs a control signal corresponding to the set accelerator level, to a drive unit (engine or motor) of the engine of the vehicle **10**, via the in-vehicle network **17**. Alternatively, the vehicle control device **16** may output a control signal corresponding to a set brake level to the brake (not shown) of the vehicle **10**, via the in-vehicle network **17**.

[0071] The map information storage device **11**, location estimating device **12**, object detector **13**, traveling lane planning device **14**, drive planning device **15** and vehicle control device **16** are electronic control units (ECU), for example. As for FIG. **3**, the map information storage device **11**, location estimating device **12**, object detector **13**, traveling lane planning device **14**, drive planning device **15** and vehicle control device **16** were explained as separate devices, but all or some of them may be constructed in a single device.

[0072] FIG. **4** is an example of an operation flow chart for target curve speed determination processing by a drive planning device **15** of the embodiment. Target curve speed determination processing by the drive planning device **15** will be described with reference to FIG. **4**. The drive planning device **15** carries out target curve speed determination processing according to the operation flow chart shown in FIG.

4, at a target curve speed assessment time having a predetermined cycle. The cycle at which the target curve speed determination processing is carried out is preferably no longer than the driving plan creation time.

[0073] First, the setting unit **232** refers to map information to determine whether or not the curvature radius of the road in the zone for which the next driving plan is to be created is equal to or less than a reference curvature radius (step S**101**). The setting unit **232** is an example of a reference curve speed setting unit. The setting unit **232** refers to map information to acquire the curvature radius of the road of the zone for which the next driving plan is to be created, for the road on which the vehicle **10** is traveling. The setting unit **232** may also calculate the zone for which the next driving plan is to be created based on the current location of the vehicle **10** and the most recent average speed of the vehicle **10**. The setting unit **232** also determines the reference curvature radius based on the speed of the vehicle **10**. For example, the setting unit **232** may refer to a table in which the relationship between speed and reference curvature radius is registered, stored in the memory **22**, and may determine the reference curvature radius based on the speed of the vehicle **10**. When the zone for which the next driving plan is to be created includes a road having a curvature radius that is equal to or less than the reference curvature radius, the setting unit **232** determines that the curvature radius of the road is equal to or less than the reference curvature radius (step S**101** - Yes). When the zone for which the next driving plan is to be created does not include a road having a curvature radius that is equal to or less than the reference curvature radius, on the other hand, it determines that the curvature radius of the road is not equal to or less than the reference curvature radius (step S**101** - No).

[0074] When it has been determined that the curvature radius of the road is equal to or less than the reference curvature radius (step S**101** - Yes), the setting unit **232** sets the reference curve speed to be the speed reference for traveling of the vehicle **10** on a curved road (step S**102**). The reference curve speed is a speed representing the upper limit for the vehicle **10** traveling on a road having a curvature radius that is equal to or less than the reference curvature radius. The setting unit **232** calculates the reference curve speed based on the curvature radius of the road, the reference acceleration allowed as lateral acceleration, and the mass of the vehicle **10**. The reference acceleration preferably represents the upper limit for the size of lateral acceleration that does not cause discomfort for an ordinary adult driver. The reference acceleration may also be determined according to the driver-set speed. The mass of the vehicle **10** may be its mass when the vehicle **10** is carrying a typical number of passengers and a typical amount of luggage. As shown in FIG. 1B, the reference curve speed decreases with a lower curvature radius.

[0075] The determining unit **233** then determines a target curve speed as the target speed to which the vehicle **10** is to be controlled when the vehicle **10** is traveling on a curved road, based on the reference curve speed and the current correction value corresponding to the curvature radius of the road (step S**103**), thus completing the series of processing steps. The determining unit **233** is an example of a target curve speed determining unit. The planning unit **231** uses the target curve speed to create a driving plan for traveling on the curved road. Calculation processing of the correction value will be described below.

[0076] When it has been determined that the curvature radius of the road is not equal to or less than the reference curvature radius (step S**101** - No), the series of processing steps is complete. The planning unit **231** uses the driver-set speed to create the driving plan.

[0077] Processing by which the determining unit **233** determines the target curve speed in step S**103** will now be described with reference to FIG. **5** and FIG. **6**.

[0078] The determining unit **233** determines a target curve speed Va as the target speed to which the vehicle **10** is to be controlled when the vehicle **10** is traveling on a curved road, based on the reference curve speed and the current correction value corresponding to the curvature radius of the road. Specifically, the determining unit **233** calculates the target curve speed Va to be the sum of the reference curve speed Vb and the current correction value M corresponding to the curvature radius of the road, according to the following formula (1).

$$Va = Vb + M \quad (1)$$

[0079] FIG. **5** is a diagram showing an example of the relationship between correction value and reference curvature radius. For this embodiment, the correction value is calculated according to the curvature radius of the road. For example, the calculating unit **235** may calculate the correction value for each demarcation, where a demarcation is every 10 m of curvature radius. The correction value for the curvature radius is the same within a single demarcation. The initial value for the correction value may be zero. In this case, the target curve speed matches the reference curve speed. For the example shown in FIG. **5**, the correction value is a positive value, but the correction value may also be a negative value. An upper limit is preferably set for the absolute value of the correction value. The upper limit of the correction value is determined by design and experimentation, for example. The upper limit for the correction value may also be determined according to the curvature radius of the road.

[0080] FIG. **6** is a diagram illustrating target curve speed determination processing. The setting unit **232** also determines the reference curvature radius based on the driver-set speed, which is the speed of the vehicle **10**. Since the curvature radius of the road in the zone for which the next driving plan is to be created is equal to or less than the reference curvature radius, the setting unit **232** sets the reference curve speed to be the speed reference for traveling of the vehicle **10** on a curved road. The setting unit **232** also calculates the target curve speed to be the sum of the reference curve speed and the current correction value corresponding to the curvature radius of the road. Since the target curve speed is slower than the driver-set speed in the example shown in FIG. **6**, the planning unit **231** generates a driving plan so as to decelerate to the target curve speed until entering the zone where the curvature radius of the road is equal to or less than the reference curvature radius (curved road zone), and after having passed through the curved road zone, to accelerate to the driver-set speed.

[0081] Correction value calculation processing will now be explained with reference to FIG. **7**. FIG. **7** is an example of an operation flow chart for correction value calculation processing by a drive planning device **15** of the embodiment. The drive planning device **15** carries out correction value calculation processing according to the operation flow chart shown in FIG. **7** each time the vehicle **10** passes through a curved zone with a target curve speed determined by the target curve speed determination processing.

[0082] The counting unit **234** first determines whether or not the absolute value of the amount of change in the speed of the vehicle **10** that has changed from the target curve speed by driver operation is at least a reference change amount, when the vehicle **10** has passed through a curved zone (step S**201**).

[0083] FIG. **2**A shows an example where the speed of the vehicle **10** has changed from the target curve speed by accelerating operation by the driver when the vehicle **10** is in a curved road zone. In the curved road zone, the amount of change in speed S, such that the difference between the actual speed of the vehicle **10** and the target curve speed deviates by at least a predetermined reference speed difference, is calculated by formula (2) below. In the formula, t1 represents the time at which the speed of the vehicle **10** begins to diverge from the speed of the driving plan by at least a reference divergence. The variable t2 represents the time at which the vehicle **10** reaches the end point of the curved road zone when the speed of the vehicle **10** has diverged from the speed of the driving plan by at least the reference divergence, and v_{acc} represents the difference between the speed of the vehicle **10** and the target curve speed.

$$S = \int_{t1}^{t2} v_{acc}\, dt \tag{2}$$

[0084] When the speed of the vehicle **10** has changed from the target curve speed due to an accelerating operation by the driver, the amount of change in speed S is positive. When the speed of the vehicle **10** has changed from the target curve speed due to a decelerating operation by the driver, on the other hand (see FIG. **9**A), the amount of change in speed S is negative.

[0085] The reference change amount may be established in consideration of variation in the speed of the vehicle **10** while it travels at a constant speed. The reference divergence may likewise be established in consideration of variation in the speed of the vehicle **10** while it travels at a constant speed.

[0086] If the amount of change in the speed of the vehicle **10** is at least a reference change amount (step S**201** - Yes), the counting unit **234** increments by one the number of times that the speed of the vehicle **10** has been changed from the target curve speed by driver operation (step S**202**). The initial value for the number of changes may be zero.

[0087] Each time the number of changes has been counted, the calculating unit **235** calculates a new correction value for the reference curve speed corresponding to the curvature radius of the road based on the correction coefficient determined based on the number of changes, and the amount of change in the speed of the vehicle **10** that has changed from the target curve speed by driver operation (step S**203**), thus completing the series of processing steps. The calculating unit **235** is an example of the correction value calculating unit.

[0088] When the amount of change in the speed of the vehicle **10** is not at least the reference change amount (step S**201** - No), the series of processing steps is complete.

[0089] Processing in which the calculating unit **235** calculates a new correction value will now be explained with reference to FIG. **8**. FIG. **8** is a diagram showing an example of the relationship between the correction coefficient and number of changes. The relationship between the correction coefficient and number of changes has a first zone in which the correction coefficient increases as the number of changes increases, a second zone in which the correction coefficient increases more than the first zone as the number of changes increases, and a third zone in which the correction coefficient increases less than the second zone as the number of changes increases. It is possible that accelerating or decelerating operation by the driver may be coincidental at the early stage during the course of learning the correction values, and therefore the correction coefficient is low (first zone). When it has been determined that there is a tendency for the driver to perform acceleration or deceleration operation, the correction coefficient is high (second zone). There is essentially an upper limit to the correction coefficient, however (third zone). The correction coefficient used may be a sigmoid function, for example. For this embodiment, the correction coefficient is positive.

[0090] The calculating unit **235** calculates the new correction value to be the sum of the products of the correction coefficients and amounts of change in vehicle speed for each time the speed of the vehicle **10** has been changed from the target curve speed by driver operation.

[0091] Each product L_i of the correction coefficient and amount of change in vehicle speed each time the speed of the vehicle **10** has been changed from the target curve speed by driver operation is calculated by the following formula (3). The variable "i" is the change number, "α_i" is the correction coefficient for the "i"th change, and S_i is the amount of change in speed for the "i"th change. The initial value α_0 of the correction coefficient may be zero.

$$L_i = a_i S_i \tag{3}$$

[0092] When the driver has performed an accelerating operation, the amount of change in speed S_i is positive and the correction coefficient α_i is zero or a positive value, and therefore the product L_i is zero or positive. When the driver has performed a decelerating operation, on the other hand, the amount of change in speed S_i is negative and the correction coefficient α_i is zero or a positive value, and therefore the product L_i is zero or negative.

[0093] The new correction value M is calculated by the following formula (4). Here, "m" is the current number of changes.

$$M = \sum_{i=0}^{m} L_i \tag{4}$$

[0094] An example of operation of the drive planning device **15**, in which the speed of the vehicle **10** has been changed from the target curve speed due to accelerating operation by the driver when the vehicle **10** is in a curved road zone, will now be explained with reference to FIG. **2**A and FIG. **2**B.

[0095] As shown in FIG. **2**A, when the vehicle **10** travels on a curved road having a curvature radius that is equal to or less than the reference curvature radius, the drive planning device **15** determines the target curve speed to be a target speed at which the vehicle **10** is to be controlled when the vehicle **10** is traveling on the curved road, based on the reference curve speed and the current correction value corresponding to the curvature radius of the road.

[0096] The drive planning device **15** determines a new correction value for the target curve speed corresponding to the curvature radius of the road, when a driver who feels that the speed of the vehicle **10** is slow has performed an accelerating operation so that the speed of the vehicle **10** has been increased above the target curve speed when the vehicle **10** is traveling on a curved road.

[0097] The vehicle **10** in a curved road zone may sometimes travel based on multiple driving plans. In this case, the new correction value is determined based on the amount of change in speed across multiple driving zones in the curved road zone, between time t1, at which divergence of speed has begun, and time t2.

[0098] As shown in FIG. **2**B, when the vehicle **10** travels on a subsequent curved road having the same curvature radius as the current one, the drive planning device **15** determines a new target curve speed based on the reference curve speed and the current correction value corresponding to the curvature radius of the road. The new target curve speed is corrected so as to reflect the previous accelerating operation by the driver and to be increased above the previous target curve speed.

[0099] In the driving plan that includes the new target curve speed, the speed at which the vehicle **10** travels on the curved road is faster than the previous target curve speed, and therefore the timing at which the speed of the vehicle **10** begins to decrease from the driver-set speed may be slower than before in some cases.

[0100] An example of operation of the drive planning device **15**, wherein the speed of the vehicle **10** has been changed from the target curve speed due to decelerating operation by the driver when the vehicle **10** is in a curved road zone, will now be explained with reference to FIG. **9**A and FIG. **9**B.

[0101] FIG. **9**A is a diagram illustrating correction value calculation processing when the vehicle **10** has decelerated, and FIG. **9**B is a diagram illustrating a new target curve speed.

[0102] As shown in FIG. **9**A, when the vehicle **10** travels on a curved road having a curvature radius that is equal to or less than the reference curvature radius, the drive planning device **15** determines the target curve speed to be a target speed at which the vehicle **10** is to be controlled when the vehicle **10** is traveling on the curved road, based on the reference curve speed and the current correction value corresponding to the curvature radius of the road.

[0103] The correction value when the vehicle **10** has decelerated is calculated in the same manner as described above for when the vehicle **10** has accelerated. In the example shown in FIG. **9**A, tl represents the time at which the speed of the vehicle **10** begins to diverge from the speed of the driving plan by at least a reference divergence. The variable t2 is the time at which the speed of the vehicle **10** has stopped diverging by at least the reference divergence from the speed of the driving plan, or the time at which the vehicle **10** has reached the end point of the curved road zone while the speed of the vehicle **10** is diverged from the speed of the driving plan by at least the reference divergence.

[0104] The drive planning device **15** determines a new correction value for the target curve speed corresponding to the curvature radius of the road, when a driver who feels that the speed of the vehicle **10** is fast has performed a decelerating operation so that the speed of the vehicle **10** has been decreased below the target curve speed when the vehicle **10** is traveling on a curved road,. As mentioned above, the new correction value is determined based on the amount of change in speed between time tl at which divergence of speed has begun, and time t2 at which divergence of speed has stopped.

[0105] As shown in FIG. **9**B, when the vehicle **10** travels on a subsequent curved road having the same curvature radius as the current one, the drive planning device **15** determines a new target curve speed based on the reference curve speed and the current correction value corresponding to the curvature radius of the road. The new target curve speed is corrected so as to reflect the previous decelerating operation by the driver and to be decreased below the previous target curve speed.

[0106] In the driving plan that includes the new target curve speed, the speed at which the vehicle **10** travels on the curved road is slower than the previous target curve speed, and therefore the timing at which the speed of the vehicle **10** begins to decrease from the driver-set speed may be earlier than before in some cases.

[0107] As explained above, each time the number of changes has been counted, the drive planning device of this embodiment determines the target curve speed using a correction value calculated based on the correction coefficient determined based on the number of changes, and the amount of change in the speed of the vehicle that has changed from the target curve speed by driver operation. This allows the drive planning device to cause the vehicle to travel on the curved road at a lateral acceleration that is satisfactory for different drivers.

[0108] Modification Example 1 and Modification Example 2 of the drive planning device of this embodiment will now be described.

[0109] FIG. **10** is a diagram illustrating the relationship between correction value and reference curvature radius, for Modification Example 1. For this modification example, when the new correction value has been determined, the calculating unit **235** corrects the current correction value for the curvature radius of the road before and after so that the difference h between new correction value and the current correction value for the curvature radius of the road before and after the curvature radius of the road for which the new correction value was calculated, is at or below a predetermined reference value.

[0110] As shown in FIG. **10**, the new correction value is calculated with respect to the curvature radius r1. The difference between the current correction value for the curvature radius of the road before and after the curvature radius r1, and the new correction value, is larger than the predetermined reference value. The new correction value is in a discontinuous relationship with the current correction value for the curvature radius of the road before and after the curvature radius r1.

[0111] The calculating unit **235** therefore connects the correction value at locations r2, r3 with predetermined curvature radii differing before and after the curvature radius r1 with the new correction value for the curvature radius r1 by a straight line (or curved line), and uses the correction value represented by the straight line (or curved line) as the current correction value for the curvature radius of the road before and after the curvature radius r1. Since the new correction value is thus in a continuous relationship with the correction value for the curvature radius of the road for the road before and after the curvature radius r1, the target curve speed while the vehicle **10** is traveling on a curved road with a different curvature radius is set to the continuous value.

[0112] In the example shown in FIG. **10**, the difference h between the current correction value for the curvature radius and the new correction value is positive, but the aforementioned explanation also applies when the difference h is a negative value.

[0113] Modification Example 2 of the drive planning device **15** of the embodiment will now be described. In this modification example, the calculating unit **235** calculates a new correction value for the reference curve speed corresponding to the curvature radius of the road, for each type of road. When the new correction value has been determined for one road on which the vehicle **10** is traveling, the calculating unit **235** calculates a new correction value for the reference curve speed corresponding to the curvature radius of another road, based on the new correction value.

[0114] The type of road, may be, for example, the main lane of a high-speed road, a junction road connecting together two different high-speed roads, or an interchange road connecting a high-speed road with a general road. Such roads can potentially have curved zones.

[0115] The calculating unit **235** may also calculate the correction value for a road with few changes by multiplying the correction value for a road with many changes by a predetermined coefficient. This can yield an appropriate new correction value for different types of roads that are curved roads with the same curvature radius.

[0116] For example, when calculating a correction value Mi for an interchange road based on a correction value Mj for a junction road, the formula $Mi = Mj \times \beta$ may be used. The value of β used here may be $\beta = 0.7$, for example.

[0117] When calculating a correction value Mh for a main road based on a correction value Mj for a junction road, the formula $Mh = Mj \times \beta$ may be used. The value of β used here may be $\beta = 0.8$, for example.

[0118] When calculating a correction value Mj for a junction road based on a correction value Mi for an interchange road, the formula $Mj = Mi \times \beta$ may be used. The value of β used here may be $\beta = 0.5$, for example.

[0119] When calculating a correction value Mh for a main road based on a correction value Mi for an interchange road, the formula $Mh = Mi \times \beta$ may be used. The value of β used here may be $\beta = 0.4$, for example.

[0120] When calculating a correction value Mj for a junction road based on a correction value Mh for a main road, the formula $Mj = Mh \times \beta$ may be used. The value of β used here may be $\beta = 0$, for example.

[0121] When calculating a correction value Mi for an interchange road based on a correction value Mh for a main road, the formula $Mi = Mh \times \beta$ may be used. The value of β used here may be $\beta = 0$, for example.

[0122] The vehicle control device, the computer program for vehicle control and the method for controlling a vehicle according to the embodiment described above may incorporate appropriate modifications that are still within the gist of the disclosure. Moreover, the technical scope of the disclosure is not limited to these embodiments, and includes the invention and its equivalents as laid out in the Claims.

[0123] For example, when the location where the vehicle is located is in bad weather with rain or snow, the correction coefficient may be zero or smaller, compared to when it is in a favorable weather location with sunny weather, for example. Since the road surface is wetted in bad weather, the vehicle driving conditions will differ from a weather situation with a dry road surface. This can lower the effect that correction in bad weather may have over the correction value in good weather. The correction value may also be determined separately for good weather and for bad weather.

1. A vehicle control device comprising:

a processor configured to

set a reference curve speed as a speed reference when a vehicle is traveling on a curved road, based on a speed of the vehicle and a curvature radius of the road on which the vehicle is traveling,

determine a target curve speed as a target speed at which the vehicle is to be controlled based on the reference curve speed and a current correction value corresponding to the curvature radius of the road when the vehicle is traveling on the curved road,

count a number of changes as the number of times the speed of the vehicle has been changed from the target curve speed by driver operation when the vehicle is traveling on the curved road, and

calculate a new correction value for the reference curve speed corresponding to the curvature radius of the road based on a correction coefficient determined based on the number of changes, and the amount of change in the speed of the vehicle that has changed from the target curve speed by the driver operation each time the number of changes has been counted,

wherein the subsequent target curve speed is determined based on the reference curve speed and the new correction value corresponding to the curvature radius of the road.

2. The vehicle control device according to claim **1**, wherein the processor is further configured to calculate the new correction value as the sum of the products of the correction coefficients and the amounts of change in the speed of the vehicle for each time the speed of the vehicle has been changed from the target curve speed by the driver operation.

3. The vehicle control device according to claim **1**, wherein relationship between the correction coefficient and number of changes has a first zone in which the correction coefficient increases as the number of changes increases, a second zone in which the correction coefficient increases more than the first zone as the number of changes increases, and a third zone in which the correction coefficient increases less than the second zone as the number of changes increases.

4. The vehicle control device according to claim **1**, wherein the processor is further configured to correct the current correction value for the curvature radius of the road before and after the curvature radius of the road for which the new correction value was calculated so that difference between the new correction value and the current correction value for the curvature radius of the road before and after is at or below a predetermined reference value when the new correction value has been determined.

5. The vehicle control device according to claim **1**, wherein the processor is further configured to

calculate the new correction value for the reference curve speed corresponding to the curvature radius of the road for each type of road, and calculate the new correction value for the reference curve speed corresponding to the curvature radius of another road, based on the new correction value when the new correction value has been determined for one road on which the vehicle is traveling.

6. A computer-readable, non-transitory storage medium storing a computer program for vehicle control, which causes a processor execute a process, the process comprising:

setting a reference curve speed as a speed reference when a vehicle is traveling on a curved road, based on a speed of the vehicle and the curvature radius of the road on which the vehicle is traveling;

determining a target curve speed as a target speed at which the vehicle is to be controlled based on the reference curve speed and a current correction value corresponding to the curvature radius of the road when the vehicle is traveling on the curved road;

counting a number of changes as the number of times the speed of the vehicle has been changed from the target curve speed by driver operation when the vehicle is traveling on the curved road; and

calculating a new correction value for the reference curve speed corresponding to the curvature radius of the road based on a correction coefficient determined based on the number of changes, and the amount of change in the speed of the vehicle that has changed from the target curve speed by the driver operation each time the number of changes has been counted,

wherein the subsequent target curve speed is determined based on the reference curve speed and the new correction value corresponding to the curvature radius of the road.

7. A method for controlling a vehicle which is carried out by a vehicle control device and the method comprising:

setting a reference curve speed as a speed reference when a vehicle is traveling on a curved road, based on a speed of the vehicle and the curvature radius of the road on which the vehicle is traveling;

determining a target curve speed as a target speed at which the vehicle is to be controlled based on the reference curve speed and a current correction value corresponding to the curvature radius of the road when the vehicle is traveling on the curved road;

counting a number of changes as the number of times the speed of the vehicle has been changed from the target curve speed by driver operation when the vehicle is traveling on the curved road; and

calculating a new correction value for the reference curve speed corresponding to the curvature radius of the road based on a correction coefficient determined based on the number of changes, and the amount of change in the speed of the vehicle that has changed from the target curve speed by the driver operation each time the number of changes has been counted,

wherein the subsequent target curve speed is determined based on the reference curve speed and the new correction value corresponding to the curvature radius of the road.

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