DETAILED DESCRIPTION OF THE INVENTION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001]

The present international application claims priority based on Japanese Patent Application No. 2014 -201407 filed to the Japanese Patent Office on September 30, 2014, and the entire contents of Japanese Patent Application No. 2014 -201407 are incorporated herein by reference.

[Technical Field]

[0002]

The present disclosure relates to an automatic driving control device capable of allowing some or all of various driving operations of a driver necessary for causing a vehicle to travel, such as various determinations and operations by the driver, to be automatically performed without requiring the operation of the driver, or the like.

Description of the Related Art

[0003]

Various techniques for realizing automatic driving of a vehicle have been proposed and some have been put into practical use. Patent Literature 1 below discloses an automatic driving vehicle capable of automatic driving travel according to a preset travel plan.

PRIOR ART DOCUMENT

Patent Literature

[0004]

Patent Literature 1: Japanese Laid-Open Patent Publication No. 2012-59274

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005]

One of the final goals of automatic driving technology is to merely set a destination, and thereafter allow the occupant to reach the destination without any involvement in traveling. However, in the present situation, the level of reliability high enough to realize the above has not yet been reached.

[0006]

Until the automatic driving technology is established and the reliability thereof reaches a high level, it is desirable to make some or all of the controls being automatically executed invalid and entrust it to the driver’s operation as necessary while adopting the automatic driving technology.

[0007]

In one aspect of the present disclosure, in a vehicle capable of automatically executing some or all of various driving controls necessary for traveling without requiring an operation of a driver, it is desirable to be able to stop some or all of the controls being automatically executed at an appropriate timing.

[Means for Solving the Problem]

[0008]

One aspect of the present disclosure is an automatic driving control device mounted on a vehicle, the automatic driving control device including a surrounding information acquisition unit, a driving mode setting unit, and an automatic control unit. The surrounding information acquisition unit acquires surrounding information of the vehicle. The surrounding information is information indicating a state of the surrounding of the vehicle, and is information necessary for automatically executing at least one of the plurality of types of driving operations mentioned above without requiring an operation by the driver. The driving mode setting unit sets the driving mode of the vehicle to either an advanced automation mode or a basic mode. The advanced automation mode is a driving mode in which some or all of a plurality of types of driving operations necessary for traveling of the vehicle are automatically executed based on the surrounding information. The basic mode is a driving mode in which the type of driving operations to be automatically executed is less than that in the advanced automation mode or is zero. The automatic control unit executes a driving operation set to be automatically executed in the driving mode based on the driving mode set by the driving mode setting unit. Then, when the driving mode is set to the advanced automation mode, the driving mode setting unit switches the driving mode to the basic mode when a preset basic mode switching condition is satisfied.

[0009]

In the automatic driving control device configured as described above, the advanced automation mode and the basic mode are provided as the driving modes, and the driving mode is switched to the basic mode when the basic mode switching condition is satisfied during the advanced automation mode. The basic mode switching condition is a specific condition that it is necessary or desirable to switch the driving mode from the advanced automation mode to the basic mode. The number and contents of the basic mode switching conditions may be appropriately determined. In addition, in a case where a plurality of basic mode switching conditions are set, the mode may be switched to the basic mode when at least one of the plurality of basic mode switching conditions is satisfied, or the mode may be switched to the basic mode when a specific number or more of two or more or all of the set basic mode switching conditions are satisfied.

[0010]

The switch from the advanced automation mode to the basic mode can be performed at an appropriate timing by appropriately setting the basic mode switching condition. Therefore, according to the automatic driving control device having the above configuration, it is possible to stop some or all of the driving operations being automatically executed in the advanced automation mode at an appropriate timing.

[0011]

When the vehicle is driven in the basic mode, it may be preferable to switch to the advanced automation mode and leave it to the automatic driving process depending on the situation. Therefore, when the driving mode is set to the basic mode, the driving mode setting unit may switch the driving mode to the advanced automation mode when a preset advanced automation switching condition is satisfied.

[0012]

The advanced automation switching condition is a specific condition that is necessary to switch or desirable to switch the driving mode from the basic mode to the advanced automation mode. The number and contents of the advanced automation switching conditions may be appropriately determined. In addition, in a case where a plurality of advanced automation switching conditions are set, the mode may be switched to the advanced automation mode when at least one of the plurality of advanced automation switching conditions is satisfied, or the mode may be switched to the advanced automation mode when a specific number or more of two or more or all of the set advanced automation switching conditions are satisfied.

[0013]

According to the automatic driving control device configured as described above, the switch between the advanced automation mode and the basic mode can be performed at an appropriate timing by appropriately setting the advanced automation switching condition.

[0014]

Even if the advanced automation switching condition is satisfied when the driving mode is set to the basic mode, the driving mode setting unit may maintain the basic mode if the basic mode switching condition continues to be satisfied.

[0015]

When the basic mode switching condition is satisfied, it is presumed that it is preferable to increase the specific weight of the driving operation by the driver's own operation by reducing the types of driving operations to be automated. Therefore, in a case where both the advanced automation switching condition and the basic mode switching condition are satisfied, an appropriate vehicle control in which the driving operation of the driver is respected can be realized by prioritizing the basic mode and not switching to the advanced automation mode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

FIG. 1A is a side view of a vehicle according to an embodiment, and FIG. 1B is a top view of the vehicle according to the embodiment.

FIG. 2 is a block diagram illustrating an electrical configuration of the vehicle according to the embodiment.

FIG. 3A is an explanatory diagram illustrating an automatic driving level of each driving mode, and FIG. 3B is an explanatory diagram illustrating that control contents at each automatic driving level may be arbitrarily set.

FIG. 4 is an explanatory diagram for describing an outline of automatic driving.

FIG. 5 is a flowchart of main processing.

FIG. 6 is a flowchart of an automatic driving control process in the main processing of FIG. 5.

FIG. 7 is a flowchart of an initial automatic switching confirmation process in the automatic driving control process of FIG. 6.

FIG. 8 is a flowchart of a normal-time automatic switching confirmation process in the automatic driving control process of FIG. 6.

FIG. 9 is an explanatory diagram for explaining a case where an advanced automation mode should be switched to a basic mode.

FIG. 10 is a flowchart of a basic mode switching confirmation process in the automatic driving control process of FIG. 6.

FIG. 11 is a flowchart illustrating another example of the basic mode switching confirmation process.

FIG. 12 is a flowchart illustrating another example of the basic mode switching confirmation process.

FIG. 13 is a flowchart of a basic mode preparation confirmation process.

FIG. 14 is a flowchart of a control parameter setting process.

[Description of Reference Numerals]

[0017]

1, 61 to 66 vehicle

2 first front camera

3 indoor camera

4 first rear camera

5 second front camera

6 second rear camera

7 left-side camera

8 right-side camera

11 front radar device

12 rear radar device

13 left radar device

14 right radar device

16 automatic driving operation lamp

20 steering wheel

21 biological sensor

22 solar sensor

23 rainfall sensor

24 vehicle speed sensor

25 seating sensor

26 belt sensor

27 travel driving control unit

28 brake control unit

29 steering control unit

30 automatic driving control unit

30a arithmetic unit

30b memory

31 GPS communication unit

32 vehicle-to-vehicle communication unit

33 road-to-vehicle communication unit

34 pedestrian-to-vehicle communication unit

35 LTE communication unit

36 TV/radio reception unit

37 display

38 HUD

39 microphone

40 speaker

41 blinker operation unit

42 automatic driving start switch

43 automatic driving stop switch

44 emergency stop switch

45 level setting operation unit

71, 72 traffic light

73 temporary stop sign

76, 77 pedestrian

81 on-road communication device

82 camera

90 road

91, 92 signboard

95 accident site

DESCRIPTION OF EMBODIMENTS

[0018]

Exemplary embodiments of the present disclosure will be described below with reference to the drawings.

(1) Configuration of vehicle 1

FIG. 1A is a side view of a vehicle 1 according to the present embodiment, and FIG. 1B is a top view of the vehicle 1. However, FIGS. 1A and 1B simply illustrate arrangement states of various cameras, radars, sensors, and the like mainly in the vehicle 1 for the purpose of clearly indicating the arrangement states thereof.

[0019]

As illustrated in FIGS. 1A and 1B, the vehicle 1 includes at least a first front camera 2, an indoor camera 3, a first rear camera 4, a second front camera 5, a second rear camera 6, a left-side camera 7, and a right-side camera 8 as cameras for photographing the inside and outside of the vehicle 1. Each of the cameras 2 to 8 is a camera capable of photographing color images and moving images. Each camera 2 to 8 may be a monocular camera, or may be a stereo camera including a plurality of lenses so as to be able to acquire information in the depth direction as well.

[0020]

The first front camera 2 is provided so as to face the front side on the front end side of the ceiling in the vehicle interior. The first front camera 2 can photograph the front side of the vehicle 1 in a wide range. The indoor camera 3 is provided so as to face the rear side (vehicle interior) on the front end side of the ceiling in the vehicle interior. The indoor camera 3 can photograph at least the upper body of the driver (driver) in the vehicle interior. The first rear camera 4 is provided so as to face the rear side on the rear end side of the ceiling in the vehicle interior. The first rear camera 4 can photograph the rear side of the vehicle 1 in a wide range.

[0021]

The second front camera 5 is provided so as to face the front side at the front end of the vehicle 1. The second front camera 5 can photograph the front side of the vehicle 1 in a wide range. The second rear camera 6 is provided so as to face the rear side at the rear end of the vehicle 1. The second rear camera 6 can photograph the rear side of the vehicle 1 in a wide range. The left-side camera 7 is provided so as to face the left side at the left side surface of the vehicle 1. The left-side camera 7 can photograph the left side of the vehicle 1 in a wide range. The right-side camera 8 is provided so as to face the right side at the right side surface of the vehicle 1. The right-side camera 8 can photograph the right side of the vehicle 1 in a wide range.

[0022]

As illustrated in FIGS. 1A and 1B, the vehicle 1 includes a front radar device 11, a rear radar device 12, a left radar device 13, and a right radar device 14. In the present embodiment, each radar device 11 to 14 is a millimeter-wave radar. As is well known, a millimeter-wave radar is a radar that transmits a millimeter-wave radio wave and receives its reflected wave by a plurality of receiving antennas, thereby detecting target information on a target around the vehicle 1 based on a relationship between a transmitting wave and each of the receiving waves and a relationship between the respective receiving waves. Target information detectable by each radar device 11 to 14 includes presence or absence of a target in a detecting direction, distance to the target, direction of the target with respect to the vehicle 1, moving speed of the target (relative speed with respect to the vehicle 1), and the like.

[0023]

Specifically, the front radar device 11 is provided at the front end of the vehicle 1, and transmits and receives a millimeter-wave having a predetermined frequency with respect to the front side of the vehicle 1. The front radar device 11 can acquire target information on a target on the front side of the vehicle 1. The rear radar device 12 is provided at the rear end of the vehicle 1, and transmits and receives a millimeter-wave having a predetermined frequency with respect to the rear side of the vehicle 1. The rear radar device 12 can acquire target information on a target on the rear side of the vehicle 1.

The left radar device 13 is provided on the left side surface of the vehicle 1, and transmits and receives a millimeter-wave having a predetermined frequency with respect to the left side of the vehicle 1. The left radar device 13 can acquire target information on a target on the left side of the vehicle 1. The right radar device 14 is provided on the right side surface of the vehicle 1, and transmits and receives a millimeter-wave having a predetermined frequency with respect to the right side of the vehicle 1. The right radar device 14 can acquire target information on a target on the right side of the vehicle 1.

[0024]

As illustrated in FIGS. 1A and 1B, the vehicle 1 includes a biological sensor 21, a solar sensor 22, and a rainfall sensor 23. A plurality of (two in the present embodiment) biological sensors 21 are provided on the steering wheel 20 operated by the driver for steering. The biological sensor 21 can detect whether or not the driver is touching the steering wheel 20, and can detect various types of biological information such as a pulse and a perspiration state of the driver while the driver is touching the steering wheel 20. The solar sensor 22 is installed at a lower portion of a front window 10 on the front side of the vehicle interior. The solar sensor 22 can detect a solar radiation amount with respect to the vehicle 1, and thus the brightness around the vehicle 1. The rainfall sensor 23 is installed at an upper portion of the inner side of the vehicle interior in the front window 10. The rainfall sensor 23 can detect the presence or absence of rainfall and the amount of rainfall.

[0025]

In addition, as illustrated in FIGS. 1A and 1B, the vehicle 1 includes four automatic driving operation lamps 16. As will be described later, the vehicle 1 of the present embodiment can switch the driving mode to either the advanced automation mode or the basic mode, and each automatic driving operation lamp 16 is turned on in a predetermined lighting pattern while the driving mode is set to the advanced automation mode. The lighting state of each automatic driving operation lamp 16 can be visually recognized from the outside of the vehicle 1. Therefore, when the driving mode is set to the advanced automation mode, it is possible to appeal to a vehicle traveling around the vehicle 1, a pedestrian, or the like that the vehicle is traveling in the advanced automation mode. Various lighting patterns of the automatic driving operation lamps 16 are conceivable, and for example, the automatic driving operation lamps may be turned on at all times during the advanced automation mode, or may be alternately turned on and off at a constant cycle.

[0026]

(2) Electrical configuration of vehicle 1

An electrical configuration of the vehicle 1 will be specifically described with reference to FIG. 2. As illustrated in FIG. 2, vehicle 1 includes automatic driving control unit 30. The automatic driving control unit 30 mainly has a mode switching function and an automatic driving function. The mode switching function is a function of setting the driving mode of the vehicle 1 to either the advanced automation mode or the basic mode. The automatic driving function is a function that executes automatic driving corresponding to an automatic driving level of the set driving mode (see FIG. 3A. Details will be described later.). As will be described later, the automatic driving control unit 30 appropriately switches the driving mode of the vehicle 1 according to various factors such as the traveling state of the vehicle 1, the surrounding situation of the vehicle 1, and the state of the driver of the vehicle 1.

[0027]

Types of automatic driving of the vehicle include partial automatic driving, fully automatic driving, and the like. The partial automatic driving is automatic driving in which a part of various driving operations of the driver necessary for traveling the vehicle is automated. Here, automation means that it can be executed without requiring an operation or the like of the driver. The fully automatic driving is automatic driving in which traveling to a set destination is entirely automated without requiring an operation or the like of the driver to the destination. A parameter indicating the degree of type and number of driving operations automated in the automatic driving is hereinafter referred to as an automatic driving level. The fully automatic driving has a higher automatic driving level than the partial automatic driving. In addition, there are various levels of partial automated driving according to the type and number of automated driving operations.

[0028]

The vehicle 1 of the present embodiment is configured to be able to perform not only partial automatic driving but also fully automatic driving by the automatic driving control unit 30. In the present embodiment, it is configured such that the driver can arbitrarily change the setting of the automatic driving level, that is, which operation is to be automated and which operation is to be performed by the driver among the various driving operations necessary for traveling.

[0029]

More specifically, in the present embodiment, there are seven types of main automatic control functions for realizing fully automatic driving, automatic start/stop control, lane keeping control, inter-vehicle distance control, lane change control, right/left turn control, collision prevention control, and parking control. The automatic driving control unit 30 can execute these seven types of automatic control functions, and can realize fully automatic driving by executing these seven types of automatic control functions.

[0030]

On the contrary, the partial automatic driving is realized by executing six or less arbitrary automatic control functions among the seven types of automatic control functions. In the present embodiment, which of the seven types of automatic control functions is to be executed in the advanced automation mode can be arbitrarily set.

[0031]

Specific contents of the seven types of automatic control functions will be described later in detail.

The automatic driving level becomes higher as the number of functions to be executed among the seven types of automatic control functions increases. Specifically, the automatic driving level when none of the seven types of automatic control functions is executed is level 0. The automatic driving level when n types of the seven types of automatic control functions are executed is level n. Therefore, in the driving mode of level 0, it is necessary for the driver to determine and operate on their own the control operation corresponding to the seven types of automatic control functions. On the other hand, the driving modes of levels 1 to 6 are driving modes in which partial automatic driving is performed. The driving mode of level 7 is a driving mode in which fully automatic driving is performed.

[0032]

In the present embodiment, the advanced automation mode is a driving mode in which the automatic driving at the automatic driving level of level 1 or higher is performed. On the other hand, the basic mode is a driving mode in which the automatic driving level is relatively low with respect to the advanced automation mode. For example, when the advanced automation mode is level n, the basic mode can be set to any one of level n -1 to level 0.

[0033]

In the present embodiment, in order to simplify and make the description easy to understand, the basic mode will be described assuming that the automatic driving level is set to level 0. The level 0 is a level at which all the seven types of automatic control functions are not executed and the driver needs to perform most of various driving operations necessary for traveling.

[0034]

The automatic driving control unit 30 includes an arithmetic unit 30a and memory 30b. Specifically, the memory 30b includes at least one of a ROM, a RAM, and other various storage media (e.g., EEPROM and flash memory). The arithmetic unit 30a realizes various functions including the mode switching function and the automatic driving function described above by executing various programs stored in the memory 30b. The arithmetic unit 30a includes at least a CPU.

[0035]

The various programs stored in the memory 30b include a program (so-called security software) capable of detecting an external unauthorized operation, a computer virus, unauthorized software, data, and the like (hereinafter collectively referred to as an "unauthorized factor"). The arithmetic unit 30a monitors the presence or absence of the unauthorized factor at any time by having the security software reside during the startup. When the unauthorized factor occurs, various types of unauthorized handling processes are executed. The unauthorized handling process includes a process of forcibly setting the automatic driving level to level 0 so as not to actuate the automatic control function at all. In addition, various specific contents of the unauthorized handling processes are conceivable, and for example, a warning by voice or the like may be output to the driver, or the vehicle 1 may be forcibly decelerated or stopped. Furthermore, the connection between the automatic driving control unit 30 and each communication unit 31 to 35 may be physically cut off so that access from the outside to the automatic driving control unit 30 via wireless communication cannot be made.

[0036]

Each camera 2 to 8, each radar device 11 to 14, each sensor 21 to 23, and four automatic driving operation lamps 16 illustrated in FIGS. 1A and 1B are connected to the automatic driving control unit 30. The arithmetic unit 30a of the automatic driving control unit 30 individually controls the operation of each camera 2 to 8, acquires the photographing result (image data) from each camera 2 to 8, and stores the photographing result in the memory 30b. The image data is repeatedly acquired and stored at every predetermined time.

[0037]

The arithmetic unit 30a can recognize various situations inside and outside the vehicle on the basis of the image data of each camera 2 to 8. For example, the driver's line-of-sight, state of the eye, gesture, and the like can be recognized from the image data of the indoor camera 3. In addition, it is possible to detect a state in which sunlight is incident on the vehicle and the driver feels glare (so-called back light) from the image data of the first front camera 2. Furthermore, from the image data of the first front camera 2 and the second front camera 5, it is possible to recognize a front vehicle, an oncoming vehicle, a vehicle in an adjacent lane traveling diagonally ahead, a lane mark, a pedestrian crossing, jumping out of a pedestrian, a bicycle, or the like, entry of another vehicle into a crossway at an intersection, contents of a sign, a traffic light, a signboard, or the like in an advancing direction, and other objects around the vehicle.

[0038]

In addition, the arithmetic unit 30a of the automatic driving control unit 30 individually controls each radar device 11 to 14, acquires a detection result of a target from each radar device 11 to 14, and stores the detection result in the memory 30b. The detection result from each radar device 11 to 14 is repeatedly acquired and stored at every predetermined time. The arithmetic unit 30a can calculate and acquire the presence or absence of a target, the distance to the target, the direction of the target, the relative speed of the target viewed from the vehicle 1, and the like based on the detection result of each radar device 11 to 14.

[0039]

In addition, the arithmetic unit 30a of the automatic driving control unit 30 determines whether or not the driver is touching the steering wheel 20 based on the detection signal from the biological sensor 21. In addition, while the driver is touching the steering wheel 20 (specifically, while the driver is touching the biological sensor 21), biological information such as the pulse and the perspiration state of the driver is acquired based on a detection signal from the biological sensor 21. The arithmetic unit 30a can estimate the physical condition and the mental state of the driver based on the acquired biological information.

[0040]

In addition, the arithmetic unit 30a of the automatic driving control unit 30 can determine the brightness of the traveling environment based on the detection signal from the solar sensor 22, and determine whether it is the brightness at night or in a situation similar thereto (hereinafter, simply referred to as “night ”).

Furthermore, the arithmetic unit 30a of the automatic driving control unit 30 can determine the presence or absence of rainfall and the amount of rainfall based on the detection signal from the rainfall sensor 23.

[0041]

As illustrated in FIG. 2, the vehicle 1 includes a seating sensor 25 and a belt sensor 26 as components connected to the automatic driving control unit 30. The seating sensor 25 is a sensor for detecting whether or not an occupant is seated on a seat of the vehicle 1. Although only one seating sensor 25 is illustrated in FIG. 2 for simplification of illustration, the seating sensor is actually provided individually for each seat. Specifically, in a case of the vehicle 1 having a riding capacity of N people, the seating sensor 25 is individually provided for each of the N seats.

[0042]

The belt sensor 26 is a sensor for detecting whether or not an occupant is wearing a seat belt when the occupant is seated in a seat of the vehicle 1. Although only one belt sensor 26 is illustrated in FIG. 2 for simplification of illustration, it is actually provided individually for every seat belt of each seat. Specifically, in a case of the vehicle 1 with a riding capacity of N people, seat belts are individually provided for each of the N seats, and the belt sensor 26 is individually provided for each of the seat belts.

[0043]

Furthermore, as illustrated in FIG. 2, the vehicle 1 includes a GPS communication unit 31, a vehicle-to-vehicle communication unit 32, a road-to-vehicle communication unit 33, a pedestrian-to-vehicle communication unit 34, an LTE communication unit 35, and a TV/radio reception unit 36 as components connected to the automatic driving control unit 30.

[0044]

The GPS communication unit 31 receives radio waves from a plurality of global positioning system (GPS) satellites, and outputs information (GPS information) included in the received radio waves to the automatic driving control unit 30. The arithmetic unit 30a of the automatic driving control unit 30 can calculate the current position of vehicle 1 based on the information received by the GPS communication unit 31.

[0045]

In addition, the automatic driving control unit 30 has a route guidance function which is one of the various element functions for realizing the automatic driving function. The route guidance function is a function of calculating an appropriate route from the current position to the destination on the basis of the current position of the vehicle 1 calculated based on the GPS information and the destination set by the driver, and performing guidance control of the vehicle 1 so that the vehicle 1 travels along the route to the destination. The content of the guidance control of the vehicle 1 in the route guidance function varies depending on the automatic driving level. For example, the guidance control when the automatic driving level is set to level 7 of fully automatic driving is provision of route information (information on which direction and which route the vehicle should travel) necessary for execution of the automatic control functions with respect to a plurality of types (in the present embodiment, seven types as described above) of automatic control functions for realizing the fully automatic driving. Furthermore, for example, the guidance control when the automatic driving level is set to a predetermined level 1 to 6 (partial automatic driving) lower than the level of the fully automatic driving is provision of the route information for the automatic control function necessary for the partial automatic driving among the plurality of types of automatic control functions, and guidance (e.g., voice guidance) of the travel route to the driver as necessary.

[0046]

Map data and various other data necessary for the route guidance function are stored in the memory 30b. The arithmetic unit 30a realizes a route guidance function (specifically, the above guidance control) by executing a program for a route guidance function stored in the memory 30b while referring to the various data. The arithmetic unit 30a can also recognize the road situation around the vehicle 1 based on the route guidance function. Specifically, for example, a shape of a route from the current position to the destination, a vehicle width, and the like can also be recognized.

[0047]

The vehicle-to-vehicle communication unit 32 is a communication module for wirelessly transmitting and receiving various data to and from other vehicles other than the own vehicle. The arithmetic unit 30a of the automatic driving control unit 30 can acquire information (e.g., traveling direction, traveling speed, position, etc.) of other surrounding vehicles via the vehicle-to-vehicle communication unit 32. Conversely, the information of the own vehicle 1 can be transmitted to another vehicle.

[0048]

The road-to-vehicle communication unit 33 is a communication module for receiving various types of information wirelessly transmitted from an on-road communication device 81 (see FIG. 4) provided on a road (ground side). Various types of information received by the road-to-vehicle communication unit 33 are input to the automatic driving control unit 30.

[0049]

The on-road communication device 81 is connected to a server (not illustrated), receives various types of information from the server, and wirelessly transmits the information to a surrounding predetermined area. Various types of road traffic information such as various types of infrastructure information (e.g., traffic light information, road regulation information, etc.) and existence information of other vehicles, pedestrians, and the like are aggregated in the server. Based on the aggregated road traffic information, the server transmits, for each of the on-road communication devices 81, individual road information related to the on-road communication device 81. The individual road information is various types of road traffic information regarding the advancing direction of the vehicle traveling in the communication area of the on-road communication device 81. Each on-road communication device 81 wirelessly transmits the individual road information transmitted from the server within a predetermined communication area.

[0050]

The arithmetic unit 30a of the automatic driving control unit 30 can acquire various types of road traffic information regarding the traveling road in the advancing direction via the road-to-vehicle communication unit 33. The information that can be acquired by the arithmetic unit 30a via the road-to-vehicle communication unit 33 includes section information regarding various sections such as a dangerous section (e.g., a section where curves are continuing, a section where a road width is narrow, etc.), a section where construction is being performed, and a certain section close to the accident site. The arithmetic unit 30a can recognize a relative relationship between the section and the vehicle 1, such as whether or not the vehicle 1 is traveling in the section indicated by the section information, by linking the acquired section information and the route guidance function.

[0051]

Note that a camera 82 is mounted on each of the on-road communication devices 81 illustrated in FIG. 4. Each camera 82 photographs the road side and transmits the photographed data to the server via the network. The server can acquire the road traffic information around the camera from the photographed data transmitted from each camera 82.

[0052]

The pedestrian-to-vehicle communication unit 34 is a communication module for performing wireless communication with a communication terminal (e.g., a mobile phone or a smartphone) possessed by a pedestrian on the ground side. When a communication terminal possessed by a pedestrian is configured to be capable of wirelessly transmitting terminal position information indicating the position of the communication terminal (that is, the position of the pedestrian), the pedestrian-to-vehicle communication unit 34 can receive the terminal position information transmitted from the communication terminal. The terminal position information received by the pedestrian-to-vehicle communication unit 34 is input to the automatic driving control unit 30. The automatic driving control unit 30 can also notify the pedestrian of the position information of the vehicle 1 and the like by wirelessly transmitting various types of information such as the position information of the vehicle 1 from the pedestrian-to-vehicle communication unit 34 to the communication terminal of the pedestrian.

[0053]

The arithmetic unit 30a of the automatic driving control unit 30 is able to know the position and movement of the pedestrian based on the terminal position information received via the pedestrian-to-vehicle communication unit 34. The presence or absence and the movement of the pedestrian can also be detected by each of the cameras and the radar devices described above, and in addition, the presence or absence of the pedestrian, the jumping out of the pedestrian, and the like can also be detected from information obtained via the pedestrian-to-vehicle communication unit 34.

[0054]

The LTE communication unit 35 is a communication module for realizing wireless communication based on the LTE which is a well-known mobile phone communication standard. The TV/radio reception unit 36 is a reception module for receiving radio waves of television broadcasting and radio broadcasting. The arithmetic unit 30a can acquire various types of information necessary for automatic driving of the vehicle 1 or update existing information (e.g., update map data) via the LTE communication unit 35 (that is, by LTE wireless communication). Note that such acquisition and updating of various types of information do not need to be performed by the LTE wireless communication, and may be performed by using other wireless communication.

[0055]

As illustrated in FIG. 2, vehicle 1 includes display 37, an HUD (abbreviation of head-up display) 38, a microphone 39, a speaker 40, a blinker operation unit 41, an automatic driving operation lamp 16, an automatic driving start switch 42, an automatic driving stop switch 43, an emergency stop switch 44, and a level setting operation unit 45, as components connected to automatic driving control unit 30. As described above, four automatic driving operation lamps 16 are provided in the present embodiment. Hereinafter, the switch is also referred to as “SW”.

[0056]

The display 37 is a display device for displaying various types of information including map information in the route guidance function. The display 37 has a touch panel function, and can perform various input operations by touching the display 37 (specifically, touching the touch panel) in accordance with the display content of the display 37.

[0057]

The HUD 38 is a display device capable of projecting various types of information to the vicinity of the front window 10. The microphone 39 acquires voices of the driver and other occupants, and inputs the voice signals to the automatic driving control unit 30. The speaker 40 outputs voice based on various voice signals output from the automatic driving control unit 30.

[0058]

The blinker operation unit 41 includes an operation lever operated by a driver to blink a blinker (not illustrated), and outputs a blinker operation signal indicating an operation state of the operation lever to the automatic driving control unit 30.

[0059]

The automatic driving start SW 42 is a switch for setting the vehicle 1 to the advanced automation mode. The driver of the vehicle 1 needs to press the automatic driving start SW 42 in order to set the vehicle 1 to the advanced automation mode and execute automatic driving. The automatic driving stop SW 43 is a switch for forcibly switching the automatic driving level of the vehicle 1 to level 0 regardless of the set driving mode. The emergency stop SW 44 is a switch for forcibly stopping the vehicle 1. The level setting operation unit 45 is a user interface for accepting an operation of setting an automatic driving level (details will be described later) by the driver.

[0060]

When the driver recognizes that an unauthorized factor such as a computer virus or an unauthorized operation has occurred, the driver presses the automatic driving stop SW 43 to forcibly cancel the automatic driving, and the vehicle 1 can be caused to travel by the driver's own driving operation.

[0061]

The automatic driving start SW 42, the automatic driving stop SW 43, and the emergency stop SW 44 are provided, for example, in the vicinity of the driver's seat in the vehicle interior at positions that can be operated by the driver sitting in the driver's seat during driving. However, installing locations of the SWs 42, 43, and 44 may be appropriately determined, or the same SW may be provided at a plurality of places. For example, the emergency stop SW 44 may be provided in the vicinity of another seat (e.g., a passenger seat) other than the driver's seat. By doing so, for example, when an abnormality occurs in the driver who is driving and it becomes difficult for the driver to perform a normal driving operation, the occupant sitting in the passenger seat can operate the emergency stop SW 44 to cause the vehicle 1 to make an emergency stop.

[0062]

The vehicle 1 is also provided with an accelerator pedal 27a and a brake pedal 28a. The accelerator pedal 27a is depression operated by the driver when the driver desires to travel the vehicle 1. The brake pedal 28a is depression operated by the driver when the driver desires to decelerate or stop the traveling vehicle 1.

[0063]

In addition, as illustrated in FIG. 2, the vehicle 1 includes a vehicle speed sensor 24, a travel driving control unit 27, a brake control unit 28, a pedal sensor 28b, and a steering control unit 29 as components connected to the automatic driving control unit 30.

[0064]

The pedal sensor 28b is a sensor for detecting whether or not the driver's foot is placed on the brake pedal 28a, and is provided on a surface of the brake pedal 28a where the driver's foot touches. Signals output from the pedal sensor 28b are different between a case where the driver's foot is placed on the brake pedal 28a and a case where the driver's foot is not placed on the brake pedal. The automatic driving control unit 30 is configured to be able to determine whether or not the driver's foot is placed on the brake pedal 28a based on a signal output from the pedal sensor 28b.

[0065]

The travel driving control unit 27 includes an accelerator sensor (not illustrated) for detecting the depression amount of the accelerator pedal 27a. The travel driving control unit 27 controls the traveling of the vehicle 1 by controlling an engine and a transmission device (not illustrated) on the basis of various information such as a depression amount of the accelerator pedal 27a detected by the accelerator sensor, an operated position of a shift lever (not illustrated), a vehicle speed, and an engine speed. On the other hand, when the driving mode is set to the advanced automation mode (specifically, when any one of the seven types of automatic control functions is executed), the automatic driving control unit 30 outputs control information necessary for realizing the automatic control function to be executed to the travel driving control unit 27. In this case, even when the accelerator pedal 27a is not depressed, the travel driving control unit 27 controls the engine and the transmission device according to the control information from the automatic driving control unit 30. Although the vehicle 1 of the present embodiment includes the engine as the driving source for traveling, the automatic driving control device of the present disclosure can also be applied to a vehicle including a driving source for traveling other than the engine. In this case, the travel driving control unit 27 illustrated in FIG. 2 has a function of controlling the driving source for traveling of the vehicle.

[0066]

The brake control unit 28 includes a brake sensor (not illustrated) for detecting the depression amount of the brake pedal 28a. The brake control unit 28 controls a brake device (not illustrated) based on the depression amount of the brake pedal 28a detected by the brake sensor. On the other hand, when the driving mode is set to the advanced automation mode (specifically, when any one of the seven types of automatic control functions is executed), the brake control unit 28 controls the brake device according to the control information from the automatic driving control unit 30 even if the brake pedal 28a is not depressed.

[0067]

The steering control unit 29 mainly has two functions. One is a so-called electric power steering function. The electric power steering function is a function of assisting the operation of the steering wheel 20 by the driver with the motor. The other is an automatic steering function that automatically steers a turning wheel (e.g., a front wheel) of the vehicle 1 without requiring a driver's operation. Basically, the steering of the turning wheel is performed by the driver operating the steering wheel 20, but when the driving mode is set to the advanced automation mode (specifically, at least one of the seven types of automatic control functions excluding the automatic start/stop control and the inter-vehicle distance control is executed), the steering control unit 29 automatically controls the steering of the turning wheel by controlling the motor according to the control information from the automatic driving control unit 30 even if the driver is not operating the steering wheel 20.

[0068]

(3) Description of automatic driving function

In the vehicle 1 of the present embodiment, the automatic driving control unit 30 can acquire and detect various types of information necessary for realizing the automatic driving function described above.

[0069]

As information that can be used to realize the automatic driving function, first, there is information (own vehicle information) such as the position and speed of the own vehicle. The own vehicle position can be acquired by calculation based on the GPS information. The own vehicle speed can be acquired by calculation based on a vehicle speed signal from the vehicle speed sensor 24, a steering angle signal from a steering angle sensor (not illustrated), a yaw rate signal from a yaw rate sensor (not illustrated), and the like. The own vehicle speed can also be calculated from a change rate of the own vehicle position.

[0070]

In addition, the information that can be used to realize the automatic driving function also includes information on a surrounding moving object. Specifically, the information is information related to a relative position, distance, and speed with respect to the own vehicle, of a front vehicle, a rear vehicle, a side vehicle, an oncoming vehicle, a vehicle crossing an intersection of an approaching destination, a pedestrian, and a bicycle.

[0071]

The information on the surrounding moving object can be acquired based on the photographed data of each camera 2 to 8, detection results by each radar device 11 to 14, and the like. Various techniques for recognizing surrounding objects based on the photographed data and the detection result of a radar device have been proposed and put into practical use, and thus description thereof will be omitted here.

[0072]

The information on the surrounding moving object can also be acquired by vehicle-to-vehicle communication, road-to-vehicle communication, and pedestrian-to-vehicle communication. For example, by performing vehicle-to-vehicle communication with the surrounding vehicle, it is possible to recognize not only the position and movement of the surrounding vehicle visible from the own vehicle but also the position and movement of the surrounding vehicle existing in a place that is in a blind spot from the own vehicle and is not directly visible. In the road-to-vehicle communication, as described above, existence information of surrounding vehicles, pedestrians, and the like can be acquired. In the pedestrian-to-vehicle communication, as described above, the position and movement of the pedestrian can be known based on the terminal position information received via the pedestrian-to-vehicle communication unit 34.

[0073]

By any one or a plurality of the vehicle-to-vehicle communication, the road-to-vehicle communication, and the pedestrian-to-vehicle communication, for example, it is possible to acquire oncoming vehicle information at the time of normal traveling (particularly a curve) or right turn in order to prevent a frontal collision with an oncoming vehicle, to acquire two-wheeled vehicle information on the left side or the rear side in order to prevent two-wheeled vehicle winding at the time of left turn, to acquire information of a vehicle on the side (rear side) at the time of lane change, to acquire front vehicle information in order to prevent a rear-end collision, to acquire information of another vehicle traveling on the crossway side in order to prevent a head-to-head collision at an intersection, and to acquire information of a pedestrian or the like in order to prevent a collision with a pedestrian or the like.

[0074]

In addition, as information that can be used to realize the automatic driving function, there are also information regarding various road displays directly drawn on the road, such as a lane mark (including a parking division line), a pedestrian crossing, and a temporary stop line. Examples of the information regarding the road display include the position and content of the road display. The information regarding the road display can be acquired based on the photographed data of each camera 2 to 8. Various techniques for recognizing the road display from the photographed data have been proposed and put into practical use, and thus description thereof will be omitted here.

[0075]

The information on the road display in the advancing direction can also be acquired by the road-to-vehicle communication. Although the vehicle 1 of the present embodiment is not provided, it is also possible to acquire information regarding various road displays using a laser radar.

[0076]

In addition, as information that can be used to realize the automatic driving function, there are information on a traffic light, a railroad crossing, a sign (including a signboard), an intersection, a merging/separating point, a sidewalk, an obstacle, a dangerous site, other ground structures, and the like (hereinafter collectively referred to as "infrastructure-related information"). The infrastructure-related information includes, in addition to the presence or absence and the position of the various objects described above, information on the color in the case of a traffic light, the operation state in the case of a railroad crossing, the display content in the case of a sign, a signboard, or the like. The infrastructure-related information can also be recognized and acquired based on the photographed data of each camera 2 to 8, and can also be acquired by the road-to-vehicle communication. Furthermore, various types of infrastructure information can also be acquired from the above-described route guidance function based on the GPS information, map data, and the like.

[0077]

Furthermore, as information that can be used to realize the automatic driving function, there is regulation information. For example, when traveling regulation due to construction, an accident, a natural disaster, or the like is implemented in the advancing direction, the regulation information can be acquired by the road-to-vehicle communication.

[0078]

Various types of information that can be used to realize the automatic driving function, such as the information regarding the surrounding moving object, the infrastructure-related information, the information regarding the road display, and the regulation information described above, correspond to an example of the surrounding information of the present disclosure.

[0079]

The automatic driving control unit 30 acquires the various types of information described above, and controls the travel driving control unit 27, the brake control unit 28, the steering control unit 29, other necessary in-vehicle devices, and the like on the basis of the information, thereby realizing automatic driving. Specifically, the above-described seven types of automatic control functions can be executed. As described above, the seven types of automatic control functions in the present embodiment are automatic start/stop control, lane keeping control, inter-vehicle distance control, lane change control, right/left turn control, collision prevention control, and parking control.

[0080]

The automatic start/stop control is a control to automatically stop the vehicle 1 when a condition to stop is satisfied during traveling, and to automatically start the vehicle 1 when the condition to stop is canceled after the stop. This control is performed using information regarding the surrounding moving objects obtained from each camera 2 to 8 and each radar sensor 11 to 14, infrastructure-related information and regulation information obtained by the road-to-vehicle communication, and the like, in addition to the own vehicle information.

[0081]

According to the automatic start/stop control, for example, control is performed to cause the vehicle to travel as it is when the color of the traffic light is green at an intersection or the like and to cause the vehicle to stop when the color is red or yellow, cause the vehicle to stop when the crossing is recognized ahead and it is recognized that the crossing is descended, and to cause the vehicle to temporary stop and then started again when the crossing is not descended. In addition, when an obstacle or the like is recognized in front of the vehicle, the vehicle is automatically stopped.

[0082]

Various control parameters necessary for executing the automatic start/stop control, such as deceleration when automatically stopping and acceleration when automatically starting in the automatic start/stop control, are set in advance to default values and stored in the memory 30b. However, the setting of these control parameters may be arbitrarily changed from the default value.

[0083]

The lane keeping control is a control configured to automatically steer the turning wheels so that the own vehicle travels along the lane without deviating from the lane mark. This control is performed in cooperation with the route guidance function using information regarding road display (particularly, vehicle dividing lines) obtained from each camera 2 to 8 and each radar sensor 11 to 14 in addition to the own vehicle information.

[0084]

The inter-vehicle distance control is a control method in which, when another vehicle is traveling in front of the own vehicle, speed control is performed so as to travel following the other vehicle while keeping an inter-vehicle distance from the other vehicle at a constant distance. The inter-vehicle distance control also includes so-called cruise control. Specifically, when there is no other vehicle within a certain range (e.g., within 100 m ahead) in front of the own vehicle, in other words, when there is no vehicle to be followed in front of the own vehicle, the own vehicle is caused to travel at a set speed. The inter-vehicle distance control is mainly performed using, in addition to the own vehicle information, information on surrounding moving objects (particularly, front vehicle) obtained from each camera 2 to 8 and each radar sensor 11 to 14.

[0085]

Various parameters used in the inter-vehicle distance control and necessary for traveling following the front vehicle, such as an inter-vehicle distance with the front vehicle when traveling following the front vehicle and an upper limit value of an own vehicle speed, are set in advance. However, the setting of these control parameters may be arbitrarily changed. In addition, in the inter-vehicle distance control, a vehicle speed, which is one of the control parameters used when there is no other vehicle within a certain range in front of the own vehicle, is in principle, set to a legal speed of a road on which the own vehicle is traveling. However, the vehicle speed in this case may be arbitrarily set. At that time, the speed may be arbitrarily set within a range not exceeding the legal speed.

[0086]

The lane change control is a control in which, when a lane change (steering for lane change) is required, another vehicle in the adjacent lane to which the lane is to be changed is detected, and the lane change is automatically performed while controlling the driving force, the braking force, and the steering so as not to collide with another vehicle according to the presence or absence, the position, the speed, and the like of the other vehicle. This control is performed using, in addition to the own vehicle information, information regarding surrounding moving objects (particularly, other vehicles in the adjacent lane) and information regarding vehicle dividing lines obtained from each camera 2 to 8 and each radar sensor 11 to 14, information regarding other vehicles (traveling vehicles in the adjacent lane) obtained by the vehicle-to-vehicle communication, and the like.

[0087]

The right/left turn control is a control to automatically make a right turn or a left turn without colliding with an oncoming vehicle, a vehicle traveling on a crossway, a vehicle around the own vehicle, a pedestrian, or the like when a right turn or a left turn is required.

This control is performed using, in addition to the own vehicle information, information regarding surrounding moving objects obtained from each camera 2 to 8 and each radar sensor 11 to 14, information regarding other vehicles obtained by the vehicle-to-vehicle communication, information regarding pedestrians and the like obtained by pedestrian-to-vehicle communication, and the like.

[0088]

The collision prevention control is a control for automatically steering, braking, stopping, or the like the vehicle so as not to collide with an obstacle when the obstacle exists on a road in the vehicle advancing direction. The control is performed using information on the surrounding moving objects obtained from each camera 2 to 8 and each radar sensor 11 to 14, infrastructure-related information and regulation information obtained by the road-to-vehicle communication, and the like.

[0089]

The parking control is a control in which, when a specific target parking position (e.g., in a parking section of a specific parking lot) is set as a destination, calculates a traveling track to the target parking position, and controls the driving force, braking force, and steering of the vehicle along the traveling track to automatically park the vehicle.

[0090]

A driver or the like can arbitrarily set which one of the seven types of control functions to execute, that is, the automatic driving level. Specifically, as illustrated in FIG. 3A, the automatic driving level can be arbitrarily set in both the advanced automation mode and the basic mode. However, for the basic mode, level 7 cannot be set, and any one of level 0 to level 6 can be set. On the other hand, for the advanced automation mode, level 0 cannot be set, and any one of level 1 to level 7 can be set. Furthermore, the level of the basic mode can be set within a range of levels lower than the level of the advanced automation mode. Conversely, the level of the advanced automation mode can be set within a range of levels higher than the level of the basic mode.

[0091]

In the present embodiment, as illustrated in FIG. 3A, control A (e.g., lane keeping control) is executed at level 1. At level 2, control B (e.g., inter-vehicle distance control) is executed in addition to control A. At level 3, control C (e.g., automatic start/stop control) is executed in addition to controls A and B. At level 4, control D (e.g., collision prevention control) is executed in addition to controls A, B, and C. At level 5, control E (e.g., lane change control) is executed in addition to controls A, B, C, and D. At level 6, control F (e.g., right/left turn control) is executed in addition to controls A, B, C, D, and E. At level 7, control G (e.g., parking control) is executed in addition to controls A, B, C, D, E, and F. That is, as the level becomes higher, the number of types of automatic control functions to be executed increases, and fully automatic driving is performed at level 7.

[0092]

The setting of level for each driving mode can be performed by operating a level setting operation unit 45 provided in the vicinity of the driver's seat for each driving mode. In the present embodiment, the automatic driving level of the basic mode is set to level 0 by default, and the automatic driving level of the advanced automation mode is set to level 7 by default. Then, the currently set automatic driving level can be arbitrarily set and changed for each driving mode. For example, when the basic mode is set to level 0, the advanced automation mode can be arbitrarily set and changed between levels 1 to 7. Furthermore, for example, when the basic mode is set to level 1, the advanced automation mode can be arbitrarily set and changed between levels 2 to 7. Moreover, for example, when the advanced automation mode is set to level

4, the basic mode can be arbitrarily set and changed between level 0 and level 3.

[0093]

Which automatic control function is to be executed at which level is not limited to the content illustrated in FIG. 3A. For example, it is not essential that the automatic control function to be executed is increased by one every time the level is raised by one. Which automatic control function is to be executed at which level may be appropriately determined. In addition, the above-described seven types of automatic control functions are merely examples, and the number of automatic control functions and specific contents of each automatic control function may be appropriately determined.

[0094]

Furthermore, as illustrated in FIG. 3B, the driver or the like may arbitrarily set the contents of control A to control G on the assumption that the automatic control function to be executed increases by one every time the level is raised by one as illustrated in FIG. 3A.

[0095]

In the vehicle 1 of the present embodiment, the driving mode is normally set to the basic mode. On the other hand, when the automatic driving start SW 42 is pressed, the driving mode becomes the advanced automation mode under a certain condition. When the lane change control, the right/left turn control, and the parking control are set to be executed, the destination (the target parking position in the case of the parking control) may be set. Specifically, a route guidance function may be activated and the destination may be input via the touch panel. The automatic driving when the destination is set is basically performed along the calculated route to the destination while confirming the position of the own vehicle in cooperation with the route guidance function.

[0096]

When the automatic driving level is set to the driving mode of level 1 or higher and the destination is not set, how to specifically execute the automatic control function applied in the current driving mode may be appropriately determined. For example, in a case where the driving mode is set such that the right/left turn control function is executed and the destination is not set, the right/left turn control function may be executed so that the vehicle travels along the road in principle. Then, for example, in a case where it is necessary to select the advancing direction as in a case where the vehicle is about to reach a bifurcated branch point, for example, the right/left turn control function may be executed so that the vehicle travels in a predetermined direction. When the destination is not set, the right/left turn control function may be disabled. The parking control function may also be disabled when a destination (specifically, a place to park) is not set.

[0097]

Various control examples in the advanced automation mode when the automatic driving level of the advanced automation mode is set to level 7 will be described with reference to FIG. 4. Each vehicle 61 to 67 illustrated in FIG. 4 has the same configuration as the vehicle 1 illustrated in FIGS. 1A, 1B, and 2. The vehicle traveling within the communication area of the on-road communication device 81 can receive the individual road information from the on-road communication device 81. At least four vehicles 61, 65, 66, and 67 among the vehicles in FIG. 4 can receive individual road information from at least two on-road communication devices 81a and 81b in the vicinity thereof. Specifically, information on the traffic light 71 ahead, information on the oncoming vehicle 62, information on the pedestrian 76, and the like can be acquired.

[0098]

In addition, at least the vehicle 63 can receive individual road information from at least the on-road communication device 81c in the vicinity thereof. Specifically, information such as that there is a temporary stop sign 73 (that is, a temporary stop should be made), that another vehicle 64 is approaching from the right side, and the like can be acquired.

[0099]

In addition, at least the vehicle 64 can receive individual road information from at least the on-road communication device 81d in the vicinity thereof. Specifically, information such as that another vehicle 63 is approaching from the left side can be acquired.

[0100]

Furthermore, at least the vehicle 62 can receive individual road information from at least the on-road communication device 81e in the vicinity thereof. Specifically, information such as information of a traffic light 72 ahead, the existence of an oncoming vehicle 61 that is about to turn right, the presence of a pedestrian crossing in the left turning direction, and the presence of a pedestrian 76 at the pedestrian crossing can be acquired.

[0101]

In addition, each vehicle 61 to 66 can also obtain various types of information from each camera 2 to 8 and each radar device 11 to 14 provided therein, and can also obtain various types of information by vehicle-to-vehicle communication and pedestrian-to-vehicle communication. For example, the vehicle 65 can detect the vehicle 67 in front and the vehicle 66 on the right side by the camera or the radar device, and thus, can travel while appropriately maintaining the inter-vehicle distance with the vehicle 67 in front, or can change the lane at an appropriate timing while considering the positional relationship with the vehicle 66 on the right side when a lane change is necessary. Furthermore, the vehicle 65 can also detect the jumping out of the pedestrian 77 by a camera or a radar device. When detecting the jumping out of the pedestrian 77, the vehicle 65 can perform appropriate deceleration control so as not to collide with the pedestrian 77 while considering the distance with the vehicle 65 behind.

[0102]

In this manner, each vehicle 61 to 66 can cause the own vehicle to appropriately travel to the destination by automatic driving while using various information such as various types of information obtained by the own vehicle and various types of information obtained from the road side.

[0103]

(4) Switching of driving mode

When the automatic driving start SW 42 is pressed, the automatic driving control unit 30 does not necessarily always operate in the advanced automation mode until the automatic driving stop SW 43 is pressed (or until the destination is reached). When the automatic driving start SW 42 is pressed, the arithmetic unit 30a of the automatic driving control unit 30 executes the main processing illustrated in FIG. 5 to switch between the advanced automation mode and the basic mode. That is, the arithmetic unit 30a executes the main processing in FIG. 5 to realize the mode switching function.

[0104]

When a start switch (not illustrated) (e.g., an ignition switch) of the vehicle 1 is turned on, the arithmetic unit 30a reads and executes the program of the main processing of FIG. 5 from the memory 30b. When the main processing of FIG. 5 starts, in S10, the arithmetic unit 30a sets the driving mode to the basic mode and executes the automatic control function based on the automatic driving level set as the basic mode. For example, when level 1 is set as the basic mode, the automatic control function of control A (see FIG. 3A) is executed. The execution of the automatic control function is performed based on various types of acquired information while acquiring various types of information including the above-described surrounding information as necessary. When level 0 is set as the basic mode, all the automatic control functions are not executed. The automatic control function set as the execution target in the basic mode is automatically executed, but other functions are basically left to the operation of the driver.

[0105]

In S15, whether or not the destination has been set is determined. When the destination has not yet been set (S15: NO), in S20, whether or not the setting of the destination has been input is determined. When the setting of the destination has not been input (S20: NO), the process returns to S15. That is, the basic mode is continued until the destination is set.

[0106]

When the destination has been set (S15: YES) or when the setting of the destination has been input in S20 (S20: YES), in S25, whether or not the automatic driving start SW 42 has been turned on is determined. When the automatic driving start SW 42 is not turned on (S25: NO), the process returns to S15. When the automatic driving start SW 42 is turned on (S25: YES), the automatic driving control process is executed in S30. The automatic driving control process is a process of determining whether or not the driving mode can be switched from the basic mode to the advanced automation mode, and if the driving mode can be switched, switching the driving mode to the advanced automation mode. The automatic driving control process also includes a process of determining whether or not to switch to the basic mode again after switching to the advanced automation mode, and when switch should be made, switching to the basic mode. Details of the automatic driving control process of S30 are as shown in FIG. 6.

[0107]

As the process proceeds to the automatic driving control process of FIG. 6, in S110, whether or not the current driving mode is the advanced automation mode is determined. When determined that the advanced automation mode is already set (S110: YES), the process proceeds to S200. When determined that the mode is not the advanced automation mode but the basic mode (S110: NO), the process proceeds to S120.

[0108]

In S120, whether or not an initial automatic switching confirmation process of S130 has already been executed is determined. The initial automatic switching confirmation process is one of the automatic switching confirmation processes for determining whether or not the driving mode of the vehicle 1 can be switched from the basic mode to the advanced automation mode, and is an automatic switching confirmation process executed first after the start switch of the vehicle 1 is turned on.

[0109]

When the initial automatic switching confirmation process has not been executed yet after the start of the main processing (S120: NO), the process proceeds to S130 to execute the initial automatic switching confirmation process. In a case where the initial automatic switching confirmation process has already been executed after the start of the main processing (S120: YES), whether or not traveling has been performed after the startup is determined in S140. When the vehicle has traveled even a little after the startup regardless of the driving mode (S140: YES), the process proceeds to S150 to execute the normal-time automatic switching confirmation process. In a case where the vehicle has not traveled at all after the startup (S140: NO), the process proceeds to S160. The normal-time automatic switching confirmation process is one of the automatic switching confirmation processes for determining whether or not the driving mode of the vehicle 1 can be switched from the basic mode to the advanced automation mode, and is an automatic switching confirmation process executed when the initial automatic switching confirmation process has already been executed.

[0110]

As the automatic switching confirmation process, it is not essential to separate the initial automatic switching confirmation process and the normal-time automatic switching confirmation process. Either one may be omitted, and only the other may be executed when a negative determination is made in S110. Alternatively, in a case where positive determination is made in S110, one automatic switching confirmation process may be executed as one automatic switching confirmation process for both of them.

[0111]

Details of the initial automatic switching confirmation process in S130 are as shown in FIG. 7. When the process proceeds to the initial automatic switching confirmation process of FIG. 7, the driver's operation state is checked in S310. In the present embodiment, when switching to the advanced automation mode immediately after the startup, it is required that the driver can normally operate the vehicle 1. This is to smoothly return to the basic mode when it is necessary to return to the basic mode after starting traveling in the advanced automation mode. Furthermore, there is also a meaning to prevent a person who is inexperienced in the driving operation (e.g., a child) or a person who should not operate the vehicle 1 from causing the vehicle 1 to travel by automatic driving without permission.

[0112]

What kind of operation state should be specifically checked in S310 may be appropriately determined. For example, a first determination method may be used in which whether or not the driver is gripping the steering wheel 20 and stepping on the brake pedal 28a is determined. Alternatively, a second determination method may be used in which the driver is caused to travel the vehicle 1 for a certain period of time (e.g., several 10 seconds), and whether or not the driving operation at the time of traveling is normal is determined. Specifically, for example, whether or not the driving operation is normal may be determined based on whether the accelerator operation is smooth or the operation of the steering wheel 20 is smooth (whether the operation along the shape of the travel route is performed), whether the vehicle has been able to travel without wobbling with respect to the lane detected by various in-vehicle cameras or radar devices, whether the vehicle has been able to drive according to the signal or the sign detected by various in-vehicle cameras or radar devices, and the like.

[0113]

A method of determining whether or not the driver is seated on the driver's seat may be used alone or in combination with another determination method.

In S320, whether or not switching to the advanced automation mode is possible is determined based on the check result in S310. For example, in a case where the first determination method is used in S310, it may be determined that the switching to the advanced automation mode is possible when it is determined that the driver is gripping the steering wheel 20 and stepping on the brake pedal 28a. At this time, determination on whether or not the driver is seated on the driver's seat may also be made based on the detection signal from the seating sensor 25, where when the driver is seated on the driver's seat, it may be determined that the switching to the advanced automation mode is possible. For example, when the second determination method is used in S310, it may be determined that the switching to the advanced automation mode is possible when it is determined that the driving operation during traveling is normal. At this time as well, determination on whether or not the driver is seated on the driver's seat may also be made based on the detection signal from the seating sensor 25, where when the driver is seated on the driver's seat, it may be determined that the switching to the advanced automation mode is possible. An example of the basic mode switching condition is that the operation state checked in S310 is a state in which it can be determined that the switching to the advanced automation mode is possible in S320.

[0114]

In S330, whether or not switching to the advanced automation mode is possible is determined based on the determination result of S320. When it is determined that the switching to the advanced automation mode is possible in S320 (S330: YES), the process proceeds to S335.

[0115]

In S335, whether or not the occupant is wearing the seat belt is determined. This determination is made based on detection signals from the seating sensor 25 and the belt sensor 26. Specifically, the determination in S335 may be, for example, a determination targeting all occupants as to whether or not all the occupants are wearing the seat belt, or may be, for example, a determination targeting at least occupants of a specific seat (e.g., driver’s seat and the passenger’s seat) as to whether or not the occupants of a specific seat are wearing the seat belt. When it is determined in S335 that all the occupants to be determined are wearing the seat belts (S335: YES), the process proceeds to S340.

[0116]

In S340, whether or not the basic mode maintaining flag is cleared is determined. The basic mode maintaining flag and various flags described later are all cleared as initial values at the start of the main processing.

[0117]

When the basic mode maintaining flag is cleared (S340: YES), the advanced automation switching flag is set in S350. After the process of S350, the process proceeds to S160 (FIG. 6). When it is determined in S330 that the switching to the advanced automation mode is not possible, the process proceeds to S360. When the occupant to be determined includes an occupant not wearing a seat belt in S335 (S335: NO), the process also proceeds to S360. When it is determined that the basic mode maintaining flag is not cleared (that is, set) in S340 (S340: NO), the process also proceeds to S360. In S360, the advanced automation switching flag is cleared. After the process of S360, the process proceeds to S160 (FIG. 6).

[0118]

Next, details of the normal-time automatic switching confirmation process in S150 (FIG. 6) are as shown in FIG. 8. When the process proceeds to the normal-time automatic switching confirmation process in FIG. 8, whether or not the normal-time transition condition to the advanced automation mode is satisfied is determined in S410. Various normal time transition conditions to the advanced automation mode are conceivable, and for example, it may be that the driver is gripping the steering wheel 20. In addition, for example, it may be that the vehicle 1 is traveling within a legal speed, and is in a state of being able to travel straight or travel similarly thereto (less curve) for a certain period of time. That is, the normal-time transition condition may be set so that the mode can be switched to the advanced automation mode in a stable state. As the normal-time transition condition, for example, the fact that the driver is seated in the driver's seat may be used alone or in combination with other conditions (e.g., as a logical sum or a logical product with other conditions). The normal-time transition condition is an example of an advanced automation switching condition.

[0119]

When the normal-time transition condition to the advanced automation mode is satisfied (S410: YES), in S480, whether or not the basic mode maintaining flag is cleared is determined. When the basic mode maintaining flag is not cleared (S480: NO), the advanced automation switching flag is cleared in S470, and the process proceeds to S160 (FIG. 6). When the basic mode maintaining flag is cleared (S480: YES), the advanced automation switching flag is set in S490, and the process proceeds to S160 (FIG. 6).

[0120]

When it is determined that the normal-time transition condition to the advanced automation mode is not satisfied in S410 (S410: NO), basically, the basic mode is prioritized and maintained. However, when the driver is seated on the driver's seat, the state of the driver is checked by the processes after S420, and the advanced automation switching flag is set to switch to the advanced automation mode when any abnormality (abnormality in which the driver may not be able to drive normally) occurs in the state of the driver.

[0121]

That is, basically, the switching from the basic mode to the advanced automation mode is performed after confirming that the driver or the vehicle 1 is in a stable state, but when the driver is in a state of not being able to normally drive (or is not driving) the vehicle 1, it is necessary to forcibly switch to the advanced automation mode and appropriately drive the vehicle 1 depending on such a state. Therefore, in S420 and subsequent steps, the advanced automation switching flag is set when the driver is in a situation where the driver cannot normally drive the vehicle 1.

[0122]

Specifically, when it is determined in S410 that the normal-time transition condition to the advanced automation mode is not satisfied (S410: NO), whether or not the driver is seated in the driver's seat is determined in S415. When the driver is not seated in the driver's seat (S415: NO), the normal-time automatic switching confirmation process in FIG. 8 is terminated, and the process proceeds to S160 (FIG. 6). In this case, the driving mode is maintained in the basic mode. On the other hand, when the driver is seated in the driver's seat (S415: YES), the process proceeds to S420.

[0123]

In S420, whether or not the line-of-sight of the driver is directed forward is determined. This determination may be made on the basis of image data photographed by the indoor camera 3. As a case where the driver's line-of-sight is not directed forward, for example, it is assumed that the driver is watching a television, operating a mobile phone, a smartphone, or the like, or looking aside while driving.

[0124]

When the line-of-sight of the driver is directed forward (S420: YES), the process proceeds to S450. When the line-of-sight of the driver is not directed forward (S420: NO), whether or not the vehicle is stopped is determined in S430. When the vehicle 1 is stopped (S430: YES), the process proceeds to S450. When the vehicle 1 is traveling (S430: NO), whether or not a state in which the line-of-sight of the driver is not directed forward has continued for a specified time is determined in S440. When the state in which the line-of-sight of the driver is not directed forward has not continued for the specified time (S440: NO), the process proceeds to S450. When the state in which the line-of-sight of the driver is not directed forward has continued for the specified time (S440: YES), the process proceeds to S490 and the advanced automation switching flag is set.

[0125]

In S450, whether or not the state of the driver's eyes is normal is determined. Specifically, it is determined as normal when the drowsy state or a state close thereto is not obtained, and it is determined as abnormal when the drowsy state or a state close thereto is obtained. This determination may be made on the basis of image data photographed by the indoor camera 3.

[0126]

When the state of the driver's eye is normal (S450: YES), the process proceeds to S460. When the state of the driver's eye is abnormal (S450: NO), the process proceeds to S490 and the advanced automation switching flag is set.

[0127]

In S460, whether or not the physical condition of the driver is normal is determined. Specifically, the determination is made on the basis of the biological information obtained from the biological sensor 21. For example, when the pulse is within the normal range and the perspiration state is not abnormal, it is determined that the physical condition is normal. Conversely, when the pulse exceeds the normal range or the perspiration state is abnormal, it is determined that the physical condition is abnormal.

[0128]

When the physical condition of the driver is normal (S460: YES), the process proceeds to S470 and the advanced automation switching flag is cleared. When the physical condition of the driver is abnormal (S460: NO), the process proceeds to S490 and the advanced automation switching flag is set. After the process of S470 and after the process of S490, the process proceeds to S160 (FIG. 6). Note that the state of the driver being in the state determined to be positive in S440, the state determined to be negative in S450, and the state determined to be negative in S460 are all examples of the advanced automation switching condition.

[0129]

In S160, whether or not the advanced automation switching flag has been set is determined. When the advanced automation switching flag has not been set (cleared) (S160: NO), the process proceeds to S200. When the advanced automation switching flag is set (S160: YES), in S170, the driving mode is set to the advanced automation mode and the automatic driving to the destination is started. More specifically, in S170, the driving mode is set to the advanced automation mode, and the automatic control function based on the automatic driving level set as the advanced automation mode is executed. For example, when level 6 is set as the advanced automation mode, six types of automatic control functions (see FIG. 3A) of controls A to F are executed. Furthermore, for example, when level 7 is set as the advanced automation mode, the fully automatic driving is realized by executing all seven types of automatic control functions of controls A to G. Note that the execution of the automatic control function is performed based on various types of acquired information while acquiring various types of information including the above-described surrounding information as necessary.

[0130]

In S180, the start of the automatic driving in the advanced automation mode is notified. Specifically, the driver is notified of the switching to the advanced automation mode by voice or the like. This notification may be performed only when the mode is switched to the advanced automation mode, or may be performed as appropriate (e.g., repeated at specified time intervals) even after the switching. In addition, the notification method is not limited to voice. For example, the notification may be performed by various methods such as vibrating the steering wheel in a specific pattern or displaying a specific display on an instrument panel in the vehicle.

[0131]

In step S185, the vehicle 1 makes a notification to the periphery of the vehicle 1 that cut-in traveling is not possible to cause the periphery of the vehicle 1 to recognize that it is not allowed to cut in front of the vehicle 1. A specific method of the notification that cut-in traveling is not possible may be appropriately determined. For example, a lamp for notification that cut-in traveling is not possible may be provided and turned on. In addition, for example, an image indicating that cut-in is not desired may be displayed on a side surface or a window of the vehicle 1 so as to be visible from the outside of the vehicle. Furthermore, for example, a specific sound may be generated from the horn. The specific sound is, for example, a sound different from a normal sound generated when the driver presses the horn sounding button. In addition, for example, it is also possible to notify the outside of the vehicle that cut-in is not desired using radio communication such as road-to-vehicle communication, vehicle-to-vehicle communication, and pedestrian-to-vehicle communication together with the own vehicle information (e.g., position information, number information, etc.).

[0132]

In S190, the four automatic driving operation lamps 16 are turned on. As a result, when the vehicle 1 is viewed from the outside, it is possible to recognize that the vehicle 1 is traveling in the advanced automation mode. As a method for notifying the outside that the vehicle is traveling in the advanced automation mode, a method other than turning on the four automatic driving operation lamps 16 may be adopted. For example, an image indicating that the vehicle 1 is traveling in the advanced automation mode may be displayed on a side surface or a window of the vehicle 1 so as to be visible from the outside of the vehicle. Furthermore, for example, it is possible to notify the outside of the vehicle that the advanced automation mode is set by using radio communication such as road-to-vehicle communication, vehicle-to-vehicle communication, and pedestrian-to-vehicle communication together with the own vehicle information (e.g., position information, number information, etc.).

[0133]

In S200, a basic mode switching confirmation process is executed. Details of the basic mode switching confirmation process in S200 are as shown in FIG. 10. The basic mode switching confirmation process of FIG. 10 is a process of determining whether a condition for switching from the advanced automation mode to the basic mode is satisfied and switching to the basic mode when the condition is satisfied (specifically, clearing the advanced automation switching flag therefor).

[0134]

Prior to the description of the basic mode switching confirmation process of FIG. 10, an example of a condition for switching to the basic mode in the present embodiment will be described with reference to FIG. 9. FIG. 9 illustrates a road 90 having a curve. On the road 90, road construction is being performed in some sections, and a signboard 91 indicating the start of a construction site is installed near point A. In addition, a signboard 92 indicating the end of the construction site is installed near point D. The vehicle 1 is about to enter point A.

[0135]

The vehicle 1 can recognize the contents of the respective signboards 91 and 92 from the photographing results of the front cameras 2 and 5, and detect that the vehicle 1 has entered the construction site or has left the construction site. In addition, by acquiring the position information of the construction site from the on-road communication device 81, it is possible to detect that the vehicle 1 is approaching the construction site start point, that the vehicle 1 has entered the construction site, that the vehicle 1 has left the construction site, and the like. The construction site (which may include a section a predetermined distance before the construction site start point) corresponds to a specific traveling region to be described later.

[0136]

In addition, the section from point B to point C is a travel caution section in which the road width is narrow and there are many curves, and is a section where the driver should reduce the vehicle speed and try to drive more safely. By acquiring the position information of the travel caution section from the on-road communication device 81, the vehicle 1 can detect that the vehicle 1 is approaching the travel caution section start point, that the vehicle 1 has entered the travel caution section, that the vehicle 1 has left the travel caution section, or the like. The travel caution section from point B to point C (which may include a section a predetermined distance before the start of the travel caution section) also corresponds to a specific traveling region to be described later.

[0137]

In addition, a substantially intermediate point between point E and point F is an accident site 95 where a traffic accident has occurred. An accident section from point E to point F around the accident site 95 is also a section where the vehicle should reduce the vehicle speed and be carefully traveled. By acquiring the position information of the accident section from the on-road communication device 81, the vehicle 1 can detect that the vehicle 1 is approaching the accident section start point, that the vehicle 1 has entered the accident section, that the vehicle 1 has left the accident section, or the like. The accident section from point E to point F (which may include a section a predetermined distance before the start of the accident section) also corresponds to a specific traveling region to be described later.

[0138]

In the present embodiment, when the vehicle 1 travels in the specific traveling region, the advanced automation mode is switched to the basic mode. The basic mode switching confirmation process of S200 (FIG. 6) for realizing this will be described with reference to FIG. 10.

[0139]

When transitioning to the basic mode switching confirmation process of FIG. 10, the arithmetic unit 30a determines in S510 whether or not the blinker operation is in the right turn direction is performed by the blinker operation unit 41. When the blinker operation in the right turn direction is performed (S510: YES), in order to switch to the basic mode, the basic mode maintaining flag is set in S550, the advanced automation switching flag is cleared in S560, and the process proceeds to S210 (FIG. 6). Note that the blinker operation in the right-turn direction is an example of the basic mode switching condition.

[0140]

When the blinker operation in the right turn direction is not performed in S510 (S510: NO), whether or not the vehicle is traveling in the specific traveling region as illustrated in FIG. 9 is determined in S520. When the vehicle is traveling in the specific traveling region (S520: YES), in order to switch to the basic mode, the basic mode maintaining flag is set in S550, the advanced automation switching flag is cleared in S560, and the process proceeds to S210 (FIG. 6). Note that traveling in the specific traveling region is an example of the basic mode switching condition.

[0141]

When determined that the vehicle is not traveling in the specific traveling region in S520 (S520: NO), whether or not the jumping out of the pedestrian is detected is determined in S530. This determination may be made based on the photographing results of the front cameras 2 and 5, detection signal of the front radar device 11, reception information of the road-to-vehicle communication, and reception information of the pedestrian-to-vehicle communication. When the jumping out of the pedestrian is detected (S530: YES), in order to switch to the basic mode, the basic mode maintaining flag is set in S550, the advanced automation switching flag is cleared in S560, and the process proceeds to S210 (FIG. 6). The detection of the jumping out of the pedestrian is an example of the basic mode switching condition.

[0142]

Note that, when the jumping out of the pedestrian is detected, a voice warning may be issued or an image (dummy pedestrian image) that highlights the jumping out of the pedestrian from the road side using the HUD 38 may be displayed for alert to the driver.

[0143]

When the jumping out of the pedestrian is not detected in S530 (S530: NO), whether or not the outside of the vehicle is in a specific environment is determined in S540. The specific environment to be switched to the basic mode may be appropriately set. In the present embodiment, at least in bad weather with a large amount of rainfall, at night with a dark field of view, and a state in which the driver feels glare by backlight are set as the specific environment.

[0144]

whether or not the weather is bad with a large amount of rainfall can be determined based on a detection signal from the rainfall sensor 23. whether or not it is at night can be determined based on a detection signal from the solar sensor 22. whether or not the driver feels glare by the incident backlight can be determined from, for example, the photographing result of the first front camera 2.

[0145]

In S540, when the outside of the vehicle is in the specific environment (S540: YES), in order to switch to the basic mode, the basic mode maintaining flag is set in S550, the advanced automation switching flag is cleared in S560, and the process proceeds to S210 (FIG. 6). When the outside of the vehicle is not in the specific environment (S540: NO), it is determined that there is no need to switch to the basic mode, the basic mode maintaining flag is cleared in S570, and the process proceeds to S210 (FIG. 6). The fact that the outside of the vehicle is in a specific environment is an example of the basic mode switching condition.

[0146]

In S210, whether or not the advanced automation switching flag is cleared is determined. When the advanced automation switching flag is cleared (S210: YES), the driving mode is switched to the basic mode in S220, and the process proceeds to S35 (FIG. 5). The specific processing content of S220 is basically the same as that of S10, and the driving mode is set to the basic mode, and the automatic control function based on the automatic driving level set as the basic mode is executed. In S220, the four automatic driving operation lamps 16 are turned off. As a result, when the vehicle 1 is viewed from the outside, it is possible to recognize that the vehicle 1 is traveling in the basic mode.

[0147]

When the mode is switched to the basic mode in S220, the traveling speed of the vehicle 1 may be appropriately decelerated. When the mode is switched to the basic mode in S220, the driver may be notified of the switching to the basic mode by various methods such as voice, vibration of a steering wheel, and display on an instrument panel in the vehicle.

[0148]

When the advanced automation switching flag is not cleared in S210 (S210: NO), the process proceeds to S35 (FIG. 5) while maintaining the advanced automation mode.

In S35, whether or not the automatic driving stop SW 43 is turned on is determined. When the automatic driving stop SW 43 is turned on (S35: YES), all the above flags (including a forced stop flag to be described later) are cleared in S40, the driving mode is set to the basic mode in S45, and the process returns to S15. In S45, as in S10, the driving mode is set to the basic mode, and the automatic control function based on the automatic driving level set as the basic mode is executed.

[0149]

When automatic driving stop SW 43 is not turned on (S35: NO), whether or not the vehicle has arrived at the destination is determined in S50. When the vehicle has arrived at the destination (S50: YES), the destination setting is cleared in S55, and the process proceeds to after S40. When the vehicle has not arrived at the destination (S50: NO), whether the emergency stop SW 44 is turned on or whether or not the forced stop flag is set is determined in S60. Note that the forced stop flag is a flag set in each process of FIGS. 11 and 13 described later.

[0150]

When the emergency stop SW 44 is not turned on and the forced stop flag is not set (S60: NO), the process returns to S30. When the emergency stop SW 44 is turned on or the forced stop flag is set (S60: YES), all the flags described above are cleared in S65, similarly to S40. Then, in S70, the forced stopping process is executed to forcibly stop the vehicle 1, and the main processing is terminated. Thereafter, in order to execute the main processing again, at least the start switch needs to be turned on again (e.g., the ignition switch is once turned off and turned on again). The forced stopping process in S70 is a process of automatically and forcibly stopping the vehicle 1. Specifically, how to stop the vehicle may be appropriately determined. For example, the vehicle may be immediately decelerated and stopped on a road on which the vehicle is traveling. Furthermore, for example, instead of stopping the vehicle 1 on the road, the vehicle 1 may be stopped by being automatically caused to travel to a place (e.g., a parking lot near the vehicle) where the vehicle 1 can be stopped other than the road.

[0151]

(5) Effects of embodiment

According to the vehicle 1 of the present embodiment described above, the advanced automation mode and the basic mode are provided as the driving mode, and during the advanced automation mode, the mode is switched to the basic mode when a condition to transition (or possibly transition) to the basic mode is satisfied. Therefore, switching from the advanced automation mode to the basic mode can be performed at an appropriate timing. On the contrary, during the basic mode, the mode is switched to the advanced automation mode when a condition to transition (or possibly transition) to the advanced automation mode is satisfied. Therefore, switching from the basic mode to the advanced automation mode can be performed at an appropriate timing.

[0152]

However, in a case where the driving mode is the basic mode, the basic mode is maintained when a state in which the basic mode is to be maintained is continued (specifically, the basic mode maintaining flag is set) even in a situation where the driving mode may be switched to the advanced automation mode (specifically, even when the advanced automation switching flag is set). Therefore, it is possible to realize an appropriate vehicle control in which the driver's driving operation is respected in a situation where the basic mode should be maintained.

[0153]

Note that the arithmetic unit 30a, S10 and S45 in FIG. 5, and S170 and S220 in FIG. 6 correspond to an example of a surrounding information acquisition unit, an example of a driving mode setting unit, and an example of an automatic control unit. In FIG. 8, the process in which a positive determination is made in S410 and the process proceeds to S480, and the process in which a negative determination is made in S480 and the process proceeds to S470 corresponds to an example of the driving mode setting unit.

[0154]

[Other Embodiments]

(1) As the basic mode switching confirmation process in S200 of FIG. 6, various other contents can be adopted separately from the processes illustrated in FIG. 10 or in addition to the process illustrated in FIG. 10.

[0155]

For example, the basic mode switching confirmation process shown in FIG. 11 may be adopted. In the basic mode switching confirmation process shown in FIG. 11, first, in S610, basic mode switching necessity determination is performed. This determination is a determination on whether or not it is a state in which the mode needs to be switched to the basic mode, and may be made based on various criteria. For example, when the vehicle 1 is traveling in the specific traveling region or the outside of the vehicle is in a specific environment, it may be determined that the mode needs to be switched to the basic mode. For example, it may be determined that it is necessary to switch to the basic mode when the occupant wearing the seat belt removes the seat belt,. In addition, for example, when another vehicle around the own vehicle exhibits a specific behavior with respect to the own vehicle, it may be determined that it is necessary to switch to the basic mode.

[0156]

This determination can be performed, for example, based on a photographed image by each camera 2 to 8, a detection result by each radar device 11 to 14, or the like. The specific behavior may be appropriately determined. For example, the fact that another vehicle has shifted sideways with respect to the own vehicle may be used as the specific behavior. In this case, a method of determining whether or not another vehicle has shifted sideways may also be appropriately determined. For example, it may be determined that vehicle has shifted sideways when the distance from the own vehicle in the left-right direction (direction perpendicular to the front-rear direction) is within a specified distance.

Furthermore, for example, it may be determined that another vehicle has shifted sideways when the change rate of the distance from the own vehicle in the left-right direction becomes less than or equal to the negative specified change rate.

[0157]

In addition, for example, that a vehicle traveling behind suddenly approaches the own vehicle may be set as a specific behavior. In this case, a method of determining whether or not a sudden approach has occurred may also be appropriately determined. For example, similarly to the above-described method of determining the sideway shift, it may be determined based on the distance to the following vehicle or the change rate of the distance.

[0158]

In S620, whether or not switching to the basic mode is necessary is determined based on the determination result in S610. When the switching to the basic mode is unnecessary (S620: NO), the basic mode maintaining flag is cleared in S710, and the process proceeds to S210 (FIG. 6). When switching to the basic mode is necessary (S620: YES), whether or not the basic mode has already been set is determined in S630. When the basic mode has already been set (S630: YES), the process proceeds to S210 (FIG. 6). When the driving mode is not yet the basic mode (that is, in the advanced automation mode) (NO in S630), the driver is notified of an advance notice of switching to the basic mode by using various methods such as voice, vibration of the steering wheel in a specific pattern, or a specific display on an instrument panel in the vehicle in S640.

[0159]

In S650, whether or not the specified operation has been performed by the driver in response to the notification in S640 is determined. As the specified operation, various operations that enable the driver to confirm that the driver is in a state capable of responding to the driving in the basic mode may be adopted. For example, the specified operation may be that the driver grips the steering wheel 20 and looks forward. Furthermore, for example, causing the driver to generate a specific voice, causing the driver to make a specific gesture, causing the driver to operate a specific operation member (e.g., a specific switch) in the vehicle, and the like may be determined as the specified operation.

[0160]

When the specified operation by the driver has been performed (S650: YES), the basic mode maintaining flag is set in S660, the advanced automation switching flag is cleared in S670, and the process proceeds to S210 (FIG. 6). When the specified operation by the driver has not been performed (S650: NO), in S680, whether or not a timeout has occurred since the start of the notification in S640 without the specified operation by the driver, that is, whether or not a state without the specified operation by the driver has continued for a certain period of time.

[0161]

If the timeout has not occurred yet, the process returns to S650. When a timeout occurs, the advanced automation switching flag is cleared in S690, the forced stop flag is set in S700, and the process proceeds to S210 (FIG. 6). That is, in a case where a state in which there is no specified operation by the driver is continued for a certain period of time after the notification of S640 even though it is a state to be switched to the basic mode, the forced stop flag is set to forcibly stop the vehicle 1 assuming there is a possibility that some abnormality has occurred in the driver.

[0162]

Furthermore, as the basic mode switching confirmation process of S200 of FIG. 6, for example, the basic mode switching confirmation process shown in FIG. 12 may be adopted. In the basic mode switching confirmation process shown in FIG. 12, first, in S1010, whether or not the inter-vehicle distance control is executed among the plurality of types of automatic control functions. In the above embodiment, as illustrated in FIG. 3A, the inter-vehicle distance control is executed when the automatic driving level is level 2 or higher.

[0163]

When the inter-vehicle distance control is not executed (S1010: NO), the basic mode switching confirmation process is terminated. When the inter-vehicle distance control is executed (S1010: YES), the process proceeds to S1020.

[0164]

In S1020, whether or not another vehicle cuts-in in front of the own vehicle is determined. This determination can be made, for example, based on the photographed image by each camera 2 to 8, a detection result by each radar device 11 to 14, or the like. A specific method of this determination may be appropriately determined. For example, when another vehicle enters in front of the own vehicle in the lane in which the own vehicle is traveling, it may be determined that there is a cut-in. At that time, it may be determined that there is a cut-in not only when the vehicle has simply entered but also when the entered state continues for a specified time or more.

[0165]

When it is determined that there is no other vehicle cutting in front of the own vehicle (S1020: NO), the process proceeds to S1040. When it is determined that there is another vehicle cutting in front of the own vehicle (S1020: YES), a warning process is performed in S1030, and the process proceeds to S1040. The warning process in S1030 is a process for calling attention (e.g., the own vehicle is present behind another vehicle, the own vehicle does not desire any cut-in, and the like) to another vehicle cutting in front of the own vehicle. The specific content of the warning process may be appropriately determined. For example, the same process as that of the notification that cut-in traveling is not possible in S185 of FIG. 6 may be performed.

[0166]

In S1040, whether or not the driver's foot is placed on the brake pedal 28a is determined based on the detection signal from the pedal sensor 28b. When the driver's foot is placed on the brake pedal 28a (S1040: YES), the process proceeds to S1060. When the driver’s foot is not placed on the brake pedal 28a (S1040: NO), an alert process is performed in S1050, and the process proceeds to S1060.

[0167]

The alert process in S1050 is a process for urging the driver to place his/her foot on the brake pedal 28a. The specific content of the alert process may be appropriately determined. For example, it may be urged by voice, may be urged by vibrating a specific place (e.g., a seat, a steering wheel 20, etc.) in the vehicle, or may be urged by displaying attention information on the display 37 or the HUD 38. In a case where the foot is not placed on the brake pedal 28a even if the alert process is performed, a specific process may be executed. The specific process in this case may be, for example, a process of forcibly stopping the vehicle 1 or a process of switching the driving mode to the basic mode.

[0168]

In S1060, it is determined whether or not the brake pedal 28a is depressed. When the brake pedal 28a is not depressed (S1060: NO), the process proceeds to S1080. When the brake pedal 28a is depressed (S1060: YES), brake handling process is performed in S1070, and the process proceeds to S1080.

[0169]

The specific content of the brake handling process of S1070 may be appropriately determined. For example, the inter-vehicle distance, which is one of the control parameters used in the inter-vehicle distance control, may be changed to a value larger than the current value so that the inter-vehicle distance from the front vehicle becomes longer. In addition, when there is no other vehicle within a certain range in front of the own vehicle and so-called cruise control is performed, the vehicle speed, which is one of control parameters used in the inter-vehicle distance control, may be changed to a value lower than the current value so as to reduce the speed of the own vehicle.

[0170]

In S1080, whether or not the accelerator pedal 27a is depressed is determined. When the accelerator pedal 27a is not depressed (S1080: NO), the process proceeds to S1100. When the accelerator pedal 27a is depressed (S1080: YES), an accelerator handling process is performed in S1090, and the process proceeds to S1100.

[0171]

The specific content of the accelerator handling process in S1090 may be appropriately determined. For example, the inter-vehicle distance, which is one of the control parameters used in the inter-vehicle distance control, may be changed to a value smaller than the current value so that the inter-vehicle distance from the front vehicle becomes shorter. In addition, when there is no other vehicle within a certain range in front of the own vehicle and so-called cruise control is performed, the vehicle speed, which is one of control parameters used in the inter-vehicle distance control, may be changed to a value higher than the current value so as to increase the speed of the own vehicle.

[0172]

In S1100, whether or not the sudden brake is automatically operated by the automatic control function including the inter-vehicle distance control is determined. What is determined as sudden brake may be appropriately determined. For example, it may be determined that the sudden brake is operated when the deceleration of the vehicle 1 becomes greater than or equal to a predetermined threshold value.

[0173]

When the sudden brake is not operated in S1100 (S1100: NO), the process proceeds to S1140. In S1140, the basic mode maintaining flag is cleared. When it is determined that the sudden brake is operated in S1100 (S1100: YES), the process proceeds to S1110.

[0174]

In S1110, whether or not it is necessary to switch the driving mode from the advanced automation mode to the basic mode is determined. This determination method may be appropriately determined. For example, it may be determined that it is necessary to switch to the basic mode by determining that the operation of the sudden brake itself as a state in which the mode should be switched to the basic mode. Furthermore, for example, every time it is determined in S1100 that the sudden brake is operated, the determined number of times may be accumulated and stored, and when the accumulated value reaches a predetermined upper limit number of times, it may be determined that it is necessary to switch to the basic mode.

[0175]

When it is determined in S1110 that there is no need to switch to the basic mode (S1110: NO), the process proceeds to S1140. When it is determined in S1110 that it is necessary to switch to the basic mode (S1110: YES), the basic mode maintaining flag is set in S1120, and the advanced automation switching flag is cleared in S1130 in order to switch to the basic mode.

[0176]

When the sudden brake is operated, for example, a possibility is considered in which some kind of abnormality (e.g., occurrence of an accident, an obstacle, or the like) has occurred in front of the own vehicle, and it is preferable that the driver performs the driving operation while paying attention to the surroundings. Furthermore, for example, a possibility is also considered in which an abnormality has occurred in the automatic control function. Therefore, when the sudden brake is automatically operated (S1100: YES), the driving mode is switched to the basic mode by executing the processes of S1120 and S1130 on condition that positive determination is made in S1110.

[0177]

(2) While traveling in the advanced automation mode, a situation may arise in which the mode should be returned to the basic mode in some cases. Therefore, even during traveling in the advanced automation mode, it is preferable that the driver be able to perform the driving operation himself/herself whenever necessary. Therefore, while the vehicle is traveling in the advanced automation mode, for example, whether the mode can be immediately returned to the basic mode may be confirmed by having the driver periodically perform a simple operation by executing the basic mode preparation confirmation process shown in FIG. 13.

[0178]

In the basic mode preparation confirmation process of FIG. 13, first, in S810, whether or not it is the confirmation timing (e.g., periodic timing at intervals of several minutes or non-periodic timing determined in advance) is determined. When it is not the confirmation timing (S810: NO), the basic mode preparation confirmation process is terminated. When it is the confirmation timing (S810: YES), a confirmation operation is requested to the driver by voice or the like in S820. The confirmation operation requested here can be appropriately determined, and for example, the same operation as the specified operation in S650 of FIG. 11 may be performed.

[0179]

In S830, whether or not a confirmation operation by the driver has been performed is determined. When the confirmation operation by the driver has been performed (S830: YES), it is determined that the driver can immediately return to the basic mode, and the basic mode preparation confirmation process is terminated. When the confirmation operation by the driver has not been performed (S830: NO), an alert warning is added to the driver by voice or the like in S840, and the request for the confirmation operation is continued.

[0180]

In S850, similarly to S830, whether or not the confirmation operation by the driver has been performed is determined. When the confirmation operation by the driver has been performed (S850: YES), it is determined that the driver can immediately return to the basic mode, and the basic mode preparation confirmation process is terminated. When the confirmation operation by the driver has not been performed (S850: NO), the advanced automation switching flag is cleared in S860, the forced stop flag is set in S870, and the basic mode preparation confirmation process is terminated to forcibly stop the vehicle 1. When the forced stop flag is set in S870, the process may immediately proceed to S70 (FIG. 5) to execute the forced stopping process.

[0181]

(3) The switching condition from the advanced automation mode to the basic mode may be appropriately determined. When a condition to transition (or possibly transition) to the basic mode is satisfied, whether to immediately and forcibly transition the driving mode or to transition the driving mode after confirming whether or not the driver is in a state capable of normally driving may be appropriately determined.

[0182]

Conversely, the switching condition from the basic mode to the advanced automation mode may also be appropriately determined. For example, when there is an incoming call or e-mail to a mobile phone or a smartphone possessed by the driver, the ringtone may be detected, the advanced automation switching flag may be automatically set, and the mode may be transitioned to the advanced automation mode.

[0183]

Note that the vehicle 1 of the above embodiment has an LTE communication function, and the automatic driving control unit 30 itself can also perform a function of mobile phone or e-mail transmission/reception. In this case, when there is an incoming call or e-mail via the LTE communication network, the advanced automation switching flag may be automatically set and the mode may be transitioned to the advanced automation mode.

[0184]

(4) A part of the switching condition from the advanced automation mode to the basic mode exemplified in the above embodiment may be used as the switching condition from the basic mode to the advanced automation mode. Conversely, a part of the switching condition from the basic mode to the advanced automation mode exemplified in the above embodiment may be used as the switching condition from the advanced automation mode to the basic mode.

[0185]

In which case the switching from the advanced automation mode to the basic mode should be performed and in which case the switching from the basic mode to the advanced automation mode should be performed are not necessarily uniformly determined. For example, in a case where the vehicle travels on a narrow road with many curves, the vehicle may travel smoothly and safely if the driver performs the driving operation himself/herself depending on the accuracy and performance of the automatic driving. On the other hand, for a driver who is unfamiliar with driving, the vehicle can travel smoothly by relying on automatic driving rather than driving operation by such a driver himself/herself. Therefore, the switching condition may be set in consideration of the skill of the driver, preference of the driver with respect to the driving mode (e.g., which of the advanced automation mode and the basic mode the driver desires to prioritize), and other various circumstances.

[0186]

(5) In the above embodiment, a configuration is adopted in which the basic mode continues while the state (the state in which the basic mode maintaining flag is set) in which the operation is to be performed in the basic mode is continued even if the state becomes a state in which the mode is to transition (or possibly transition) to the advanced automation mode after the mode is switched to the basic mode. On the other hand, when the traveling in the advanced automation mode is prioritized and a state becomes a state in which the mode is to transition (possibly transition) to the advanced automation mode, the mode may be forcibly switched to the advanced automation mode even if the state in which the operation is to be performed in the basic mode (the state in which the basic mode maintaining flag is set) is continued.

[0187]

In addition, the advanced automation mode may be prioritized, and after the mode is switched to the advanced automation mode, the advanced automation mode may be continued even when the state becomes a state in which the mode is to transition (possibly transition) to the basic mode while the state in which the operation is to be performed in the advanced automation mode is continued.

[0188]

(6) In the above embodiment, the automatic driving start SW 42 needed to be pressed in order to set the vehicle 1 to the advanced automation mode and execute the automatic driving, but it is not essential to press the automatic driving start SW 42. The automatic driving start SW 42 may be omitted, and the mode may be automatically switched to the advanced automation mode when a condition for switching (or possibly switching) to the advanced automation mode is satisfied.

[0189]

(7) When switching to the basic mode in a state of transitioning from the advanced automation mode to the basic mode, the automatic driving level may be forcibly set to level 0 regardless of the automatic driving level set as the basic mode. In this case, level 0 may be maintained until a predetermined operation is performed by the driver, and the automatic driving level may be switched to the

automatic driving level set as the basic mode when the predetermined operation is performed by the driver.

[0190]

In addition, when switching to the advanced automation mode in a state of transitioning from the basic mode to the advanced automation mode, if the transition factor is a specific transition factor set in advance, the automatic driving level may be forcibly set to level 7 and the fully automatic driving may be executed regardless of the automatic driving level set as the advanced automation mode.

[0191]

(8) The number of occupants in the vehicle can be detected as needed based on a detection signal from the seating sensor 25. Therefore, the number of occupants may be monitored during traveling in the advanced automation mode, and a predetermined process may be performed in a case where a change occurs in the occupants. As the predetermined process, for example, a change in the number of occupants may be notified to other occupants by voice output, image display, or the like. Furthermore, for example, the driving mode may be switched to the basic mode as the predetermined process. In addition, for example, the vehicle 1 may be forcibly stopped as the predetermined process. In addition, for example, the occupant of the

vehicle may be asked whether traveling in the advanced automation mode may be continued, and the advanced automation mode may be continued when there is a response indicating that traveling may be continued, and the advanced automation mode may be switched to the basic mode or forcibly stopped when there is a response indicating that traveling should not be continued.

[0192]

A specific method for asking the occupant of the vehicle whether traveling in the advanced automation mode may be continued may be appropriately determined. For example, the inquiry may be made by voice. Furthermore, for example, the inquiry may be made by displaying a message on the display 37, the HUD 38, or the like. The response method of the occupant to the inquiry may also be appropriately determined. For example, the voice of the occupant input via the microphone 39 may be recognized, and the response content of the occupant may be determined on the basis of the recognition result. In addition, for example, a button may be displayed on a touch panel, and whether or not continuation is possible may be determined by pressing the button.

[0193]

(9) The content of the driving operation of the driver may be learned, and the learning result may be

reflected in the automatic control function. Specifically, the automatic driving control unit 30 may repeatedly execute the control parameter setting process shown in FIG. 14 at a predetermined cycle after the startup, so that various control parameters used in the automatic control function are appropriately updated according to the driving operation content of the driver.

[0194]

The control parameter setting process in FIG. 14 will be described. When the control parameter setting process of FIG. 14 is started, the arithmetic unit 30a of the automatic driving control unit 30 determines whether or not the driving mode is set to the advanced automation mode in S1310. When the advanced automation mode is not set, that is, when the basic mode is set (S1310: NO), the learning process is performed in S1320.

[0195]

The learning process of S1320 is a process of detecting a habit or a preference of the driver from the content of the driving operation of the driver himself/herself and storing information indicating the detected habit or preference (hereinafter referred to as "driving preference information") in the memory 30b.

[0196]

For example, an accelerator operation of the driver when starting the stopped vehicle 1 may be detected to determine whether the driver tends to slowly depress the accelerator pedal 27a or to relatively quickly depress the accelerator pedal, and the determination result may be stored as one of the driving preference information. Whether or not the depression of the accelerator is slow may be determined based on, for example, whether or not the change rate of the depression operation amount of the accelerator pedal 27a is greater than or equal to a predetermined threshold value.

[0197]

In addition, for example, when the driver operates the blinker before the corner, a distance from the position of the vehicle 1 at the time of the operation to the corner may be detected, and such a distance may be stored as one of the driving preference information.

[0198]

The number of types of driving preference information detected and stored in the learning process may be one or more. Furthermore, the specific content may be appropriately determined. The two examples of the driving preference information described above are merely examples.

[0199]

When the driving mode is set to the advanced automation mode in S1310 (S1310: YES), the process proceeds to S1330. In S1330, whether or not the driving preference information is reflected in the control parameter is determined. More specifically, whether or not the processes of S1340 to S1350 have already been executed after the driving mode is switched from the basic mode to the current advanced automation mode is determined.

[0200]

When the driving preference information has already been reflected in the control parameter, that is, when the processes of S1340 to S1350 have already been executed after the switching to the advanced automation mode (S1330: YES), the control parameter setting process is terminated.

[0201]

When the driving preference information is not yet reflected in the control parameter, that is, when the processes of S1340 to S1350 are not yet executed after the switching to the advanced automation mode (S1330: NO), the process proceeds to S1340.

[0202]

In S1340, the driving preference information stored in the memory 30b is read by the learning process in S1320. In S1350, the control parameter of the automatic control function set as the execution target in the advanced automation mode is calculated based on the driving preference information read in S1340. Then, the currently-used control parameter is updated to the calculated control parameter.

[0203]

For example, in a case where the information regarding the operation speed of the accelerator pedal 27a is stored as the driving preference information, when the accelerator pedal 27a tends to be slowly depressed, a value lower than the default value is calculated as the acceleration at the start which is one of the control parameters in the automatic start/stop control, and is updated to the calculated value. Conversely, in a case where the accelerator pedal 27a tends to be quickly depressed, a value higher than the default value is calculated as the acceleration at the start, and is updated to the calculated value.

[0204]

For example, when the distance from the position where the blinker is operated to the corner is stored as the driving preference information, the distance same as the stored distance or the distance close thereto is calculated as the distance from the position where the blinker is operated to the corner, which is one of the control parameters in the right/left turn control, and is updated to the calculated value.

[0205]

Note that the driver may select whether or not to execute the control parameter setting process of FIG. 14. Then, in a case where it is selected so that the control parameter setting process is not executed, for example, a preset default value may be used as the control parameter. Furthermore, the driver may arbitrarily erase the already stored driving preference information. In addition, when the advanced automation mode is switched to the basic mode, each control parameter may be reset to a default value.

[0206]

(10) While the driving mode is set to the advanced automation mode, the driver's expression, gesture, remark content, and the like may be detected, and the satisfaction level of the driver with respect to the automatic control function currently being automatically executed may be determined based on the result of the detection. For example, the face image of the driver photographed by the camera may be subjected to image recognition process, and when the driver has a displeased expression, it may be determined that the driver is dissatisfied with the content of the current automatic control function. Conversely, when the driver is expressionless or has a pleasant

expression, it may be determined that the driver is not dissatisfied with the content of the current automatic control function.

[0207]

Furthermore, in a case where the voice recognition process recognizes the remark content of the driver and a remark indicating dissatisfaction with respect to the content of the current automatic control function is made, it may be determined that the driver is dissatisfied with the content of the current automatic control function. Conversely, in a case where a remark indicating dissatisfaction with respect to the content of the current automatic control function is made, it may be determined that the driver has no dissatisfaction with the content of the current automatic control function.

[0208]

Then, when it is determined that the driver is dissatisfied with the content of the current automatic control function, the driving mode may be switched to the basic mode.

(11) In addition, the functions of one component in the embodiment described above may be distributed as a plurality of components, or the functions of a plurality of components may be integrated into one component. Moreover, at least a part of the configuration of the above

embodiment may be replaced with a known configuration having a similar function. Furthermore, a part of the configuration of the above embodiment may be omitted as long as the problem can be solved. In addition, at least a part of the configuration of the above embodiment may be added to or replaced with the configuration of another embodiment described above. Note that all aspects included in the technical idea specified from the wording described in the Claims are embodiments of the present disclosure.

[0209]

[Technical idea grasped from embodiments]

At least the following technical ideas can be grasped from the various embodiments described in detail above.

Specifically, an automatic driving control device of the present disclosure configured as in the following (A) may be further configured as in the following (B) to (E).

(A) An automatic driving control device mounted on a vehicle, the automatic driving control device including:
a surrounding information acquisition unit configured to acquire surrounding information, which is information of the surrounding of the vehicle;
a driving mode setting unit configured to set a driving mode of the vehicle to either one of an advanced automation mode in which some or all of a plurality of types of driving operations necessary for traveling of the vehicle

are automatically executed based on the surrounding information and a basic mode in which a type of the driving operation to be automatically executed is fewer than the advanced automation mode or is zero; and

an automatic control unit configured to execute the driving operation set to be automatically executed in the driving mode based on the driving mode set by the driving mode setting unit; wherein

the driving mode setting unit is configured to switch the driving mode to the basic mode when a preset basic mode switching condition is satisfied in a case where the driving mode is set to the advanced automation mode.

(B) The automatic driving control device according to (A) above, further including

a switching notification unit configured to perform a specific notification for notifying a driver of the vehicle that the driving mode is switched to the basic mode when a preset basic mode switching condition is satisfied in a case where the driving mode is set to the advanced automation mode.

[0210]

According to the automatic driving control device configured as described above, the driver of the vehicle can recognize that the driving mode switches from the advanced automation mode to the basic mode at the time of switching. Therefore, the driver can appropriately operate and travel the vehicle even after the mode is switched to the basic mode.

(C) The automatic driving control device according to (A) or (B) above, further including

a specified operation determination unit configured to determine whether or not a driver of the vehicle is performing a specified operation when a preset basic mode switching condition is satisfied in a case where the driving mode is set to the advanced automation mode; where the driving mode setting unit is configured to switch the driving mode to the basic mode when the specified operation determining unit determines that the driver is performing the specified operation, when a preset basic mode switching condition is satisfied in a case where the driving mode is set to the advanced automation mode.

[0211]

According to the automatic driving control device configured as described above, since the driving mode can be switched to the basic mode after the driver confirms whether the driving in the basic mode can be actually supported, the vehicle can be appropriately driven by the driver even after the driving mode is switched to the basic mode.

(D) The automatic driving control device according to any one of (A) to (C) above, further including:

a confirmation operation requesting unit configured to repeatedly request a specific confirmation operation with respect to a driver of the vehicle at a specific timing while the driving mode is set to the advanced automation mode;

a confirmation operation determination unit configured to determine whether or not the confirmation operation has been performed by the driver each time the confirmation operation requesting unit requests the confirmation operation; and

a stopping unit configured to stop the vehicle when determination is not made by the confirmation operation determination unit that the confirmation operation has been performed.

(E) The automatic driving control device according to any one of (A) to (D) above, further including a vehicle outside notification unit configured to notify the outside of the vehicle when the driving mode is set to the advanced automation mode.