

CONTROL DEVICE FOR VEHICLE, AND CONTROL METHOD FOR VEHICLE

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

[0001] The present invention relates to a control device for a vehicle and a control method for a vehicle, the vehicle including a clutch and a clutch actuator, the clutch being configured to connect and disconnect a power transmission path between a power source and a transmission, the clutch actuator being configured to switch the operating state of the
10 clutch.

2. Description of Related Art

[0002] There is a well-known control device for a vehicle, the vehicle including a transmission that constitutes a part of a power transmission path between a power source and driving wheels, a clutch that connects and disconnects the power transmission path
15 between the power source and the transmission, and a clutch actuator that switches the operating state of the clutch. The control device includes a clutch control unit configured to output to the clutch actuator a switching command for switching the operating state of the clutch based on operation of a clutch pedal by a driver. Examples of the well-known control device include a clutch-by-wire system disclosed in Japanese Patent Application Publication No. 2009-222068. Disclosed in JP 2009-222068 A is controlling the
20 operation of the clutch actuator based on an operation amount of the clutch pedal.

SUMMARY OF THE INVENTION

[0003] On the one hand, a characteristic of the operating state (the state expressed as engagement, slip, and release) of the clutch with respect to the operation amount of the clutch pedal (i.e., a clutch engagement characteristic expressed as a clutch transmission torque that can be transmitted by the clutch) is uniformly set based on the characteristics of components (such as a clutch cover) that constitute the clutch and on the specifications of
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the vehicle (such as a vehicle weight). On the other hand, travel performance, such as acceleration response performance and shock suppression performance, desired by a driver when the driver operates the clutch pedal so as to engage the clutch, is different for each driver, or different depending on the driving status even with the same drive. As a consequence, the uniformly set characteristic of the operating state of the clutch with respect to the operation amount of the clutch pedal may fail to provide desired travel performance, which may result in deterioration in drivability.

[0004] The present invention suppresses deterioration in drivability when the clutch pedal is operated to engage the clutch.

[0005] A first aspect of the present invention relates to a control device for a vehicle. The vehicle includes a transmission provided between a power source and driving wheels, a clutch configured to connect and disconnect a power transmission path between the power source and the transmission, a clutch actuator configured to switch the operating state of the clutch, and an electronic control unit. The electronic control unit is configured to output a switching command to the clutch actuator. The switching command is a command for switching the operating state of the clutch based on operation of the clutch pedal by a driver. The electronic control unit is configured to change the characteristic of the operating state of the clutch with respect to an operation amount of a clutch pedal, in accordance with travel performance desired by the driver.

[0006] With the configuration, the characteristic of the operating state of the clutch with respect to the operation amount of the clutch pedal, which is used as the basis of the switching command for switching the operating state of the clutch, is changed in accordance with the travel performance desired by the driver. This makes it easy to achieve actual travel performance (for example, travel performance such as acceleration response performance and shock suppression performance) matched for the travel performance desired by the driver. Hence, deterioration in drivability can be suppressed when the clutch pedal is operated to engage the clutch.

[0007] In the control device for the vehicle, the electronic control unit may be configured to change the characteristic of the operating state of the clutch at a time of

startup of the vehicle.

[0008] With the configuration, the characteristic of the operating state of the clutch at the time of startup is changed. Hence, at the time of startup, actual travel performance matched for the travel performance desired by the driver is easily obtained.

5 **[0009]** In the control device for the vehicle, the electronic control unit may be configured to change the characteristic of the operating state of the clutch at a time of gear-shift of the transmission.

[0010] With the configuration, the characteristic of the operating state of the clutch at the time of gear-shift of transmission is changed. Hence, at the time of gear-shift,
10 the actual travel performance matched for the travel performance desired by the driver is easily obtained.

[0011] In the control device, the electronic control unit may be configured to change a first characteristic and a second characteristic. The first characteristic may be a characteristic of the operating state of the clutch at a time of startup of the vehicle. The
15 second characteristic may be a characteristic of the operating state of the clutch at a time of gear-shift of the transmission. The first characteristic may be different from the second characteristic.

[0012] With the configuration, the characteristic of the operating state of the clutch at the time of startup is changed separately from the characteristic of the operating
20 state of the clutch at the time of gear-shift which is different from the characteristic at the time of startup. Hence, the actual travel performance matched for the travel performance desired by the driver is easily obtained separately depending on the situations, such as at the time of startup, and at the time of gear-shift.

[0013] In the control device for the vehicle, the electronic control unit may be
25 configured to change the characteristic of the operating state of the clutch such that when the travel performance desired by the driver is the first travel performance, the clutch is engaged faster with respect to the operation of the clutch pedal than when the travel performance desired by the driver is the second travel performance. The first travel performance may be travel performance emphasizing acceleration response performance,

while the second travel performance may be travel performance emphasizing shock suppression performance.

[0014] With the configuration, the characteristic of the operating state of the clutch is changed such that when the travel performance desired by the driver is the travel performance emphasizing the acceleration response performance, the clutch is engaged faster with respect to operation of the clutch pedal for engagement of the clutch than when the travel performance desired by the driver is the travel performance emphasizing the shock suppression performance. Accordingly, the actual travel performance matched for the travel performance desired by the driver can easily be obtained. Hence, deterioration in drivability can be suppressed when the clutch pedal is operated to engage the clutch.

[0015] In the control device for the vehicle, the travel performance desired by the driver may be a travel performance desired by the driver that is received by the electronic control unit from a device outside the vehicle.

[0016] With the configuration, the travel performance desired by the driver is the travel performance desired by the driver that is transferred from a device outside the vehicle and different from the vehicle. Hence, the actual travel performance matched for the travel performance desired by the driver is easily and appropriately obtained.

[0017] In the control device for the vehicle, the travel performance desired by the driver may be a travel performance desired by the driver that is based on a tendency of a driving operation of the driver.

[0018] With the configuration, the travel performance desired by the driver is the travel performance desired by the driver that is based on the tendency of the driving operation of the driver. Hence, the actual travel performance matched for the travel performance desired by the driver is easily and appropriately obtained.

[0019] In the control device for the vehicle, the travel performance desired by the driver may be a travel performance desired by the driver that is selected by the driver.

[0020] With the configuration, the travel performance desired by the driver is the travel performance desired by the driver that is selected by the driver. Hence, the actual travel performance matched for the travel performance desired by the driver is easily and

appropriately obtained.

[0021] In the control device for the vehicle, the electronic control unit may be configured to change the characteristic of the operating state of the clutch in accordance with the travel performance desired by the driver that is selected by the driver when the electronic control unit receives travel performance desired by the driver that is received from a device outside the vehicle and travel performance desired by the driver that is selected by the driver.

[0022] With the configuration, when the travel performance desired by the driver that is transferred from a device outside the vehicle and different from the vehicle, and the travel performance desired by the driver that is selected by the driver are acquired, the characteristic of the operating state of the clutch is changed in accordance with the travel performance desired by the driver that is selected by the driver. Hence, the actual travel performance matched for the travel performance desired by the driver is easily and appropriately obtained.

[0023] In the control device for the vehicle, the electronic control unit may be configured to change the characteristic of the operating state of the clutch in accordance with the travel performance desired by the driver that is selected by the driver when the electronic control unit receives travel performance desired by the driver that is based on a tendency of driving operation of the driver and travel performance desired by the driver that is selected by the driver.

[0024] With the configuration, when the travel performance desired by the driver that is based on the tendency of driving operation of the driver, and the travel performance desired by the driver that is selected by the driver are acquired, the characteristic of the operating state of the clutch is changed in accordance with the travel performance desired by the driver that is selected by the driver. Hence, the actual travel performance matched for the travel performance desired by the driver is easily and appropriately obtained.

[0025] In the control device for the vehicle, the electronic control unit may be configured to change the characteristic of the operating state of the clutch at the time of the startup by changing an operation range of the clutch pedal required to switch the operating

state of the clutch for engagement of the clutch.

[0026] With the configuration, the characteristic of the operating state of the clutch at the time of startup is changed by changing the operation range of the clutch pedal required to switch the operating state of the clutch for engagement of the clutch.

5 Accordingly, at the time of startup, the actual travel performance matched for the travel performance desired by the driver is easily and appropriately obtained.

[0027] In the control device for the vehicle, the electronic control unit may be configured to change the characteristic of the operating state of the clutch at the time of the startup by changing an operation amount of the clutch pedal at a start of switching the
10 operating state of the clutch for engagement of the clutch.

[0028] With the configuration, the characteristic of the operating state of the clutch at the time of startup is changed by changing the operation amount of the clutch pedal at the start of switching the operating state of the clutch for engagement of the clutch. Accordingly, at the time of the startup, the actual travel performance matched for the travel
15 performance desired by the driver is easily and appropriately obtained.

[0029] In the control device for the vehicle, the electronic control unit may be configured to change the characteristic of the operating state of the clutch at the time of the gear-shift by changing a rate of change of a clutch transmission torque when the operating state of the clutch is switched with respect to an identical operation pattern of the clutch
20 pedal for engagement of the clutch.

[0030] With the configuration, the operating state characteristic of the clutch at the time of gear-shift is changed by changing the rate of change of the clutch transmission torque when the operating state of the clutch is switched for engagement of the clutch with respect to an identical operating pattern of the clutch pedal for engagement of the clutch.
25 Hence, the actual travel performance matched for the travel performance desired by the driver is easily and appropriately obtained at the time of gear-shift.

[0031] A second aspect of the present invention relates to a control method for a vehicle. The vehicle includes a transmission provided between a power source and driving wheels, a clutch configured to connect and disconnect a power transmission path

between the power source and the transmission, a clutch actuator configured to switch an operating state of the clutch, and an electronic control unit. The control method includes: outputting, by the electronic control unit, a switching command to the clutch actuator; and changing, by the electronic control unit, a characteristic of an operating state of the clutch with respect to an operation amount of the clutch pedal in accordance with travel performance desired by a driver. The switching command is a command for switching the operating state of the clutch based on operation of the clutch pedal by a driver.

[0032] With the configuration, the characteristic of the operating state of the clutch with respect to the operation amount of the clutch pedal, which is used as the basis of the switching command for switching the operating state of the clutch, is changed in accordance with the travel performance desired by the driver. This makes it easy to achieve actual travel performance (for example, travel performance such as acceleration response performance and shock suppression performance) matched for the travel performance desired by the driver. Hence, deterioration in drivability can be suppressed when the clutch pedal is operated to engage the clutch.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is an explanatory view illustrating the schematic configuration of a vehicle to which the present invention is applied, the explanatory view illustrating principle parts of a control function and a control system for various kinds of control in a vehicle;

FIG. 2 illustrates one example of a clutch engagement characteristic at the time of a plurality of types of startup in one embodiment;

FIG. 3 is a block diagram illustrating a principal part of control operation of an electronic control unit, that is, control operation for suppressing deterioration in drivability when a clutch pedal is operated to engage a clutch, the block diagram illustrating one example in the case where driver's favorite startup performance is analyzed travel

performance information;

FIG. 4 is a block diagram illustrating a principal part of the control operation of the electronic control unit, that is, control operation for suppressing deterioration in drivability when the clutch pedal is operated to engage the clutch, the block diagram illustrating one example in the case where the driver's favorite startup performance is transferred travel
5 performance information;

FIG. 5 is a block diagram illustrating a principal part of the control operation of the electronic control unit, that is, control operation for suppressing deterioration in drivability when the clutch pedal is operated to engage the clutch, the block diagram illustrating one
10 example in the case where the driver's favorite startup performance is selected travel performance information;

FIG. 6 is a flowchart illustrating a principal part of the control operation of the electronic control unit, that is, control operation for suppressing deterioration in drivability when the clutch pedal is operated to engage the clutch in one embodiment;

15 FIG. 7 illustrates one example of the clutch engagement characteristic at the time of a plurality of types of startup in an embodiment different from the embodiment of FIG. 2;

FIG. 8 illustrates one example of a clutch engagement characteristic at the time of a plurality of types of gear-shift;

FIG. 9 is a block diagram illustrating a principal part of the control operation of the electronic control unit, that is, control operation for suppressing deterioration in drivability when the clutch pedal is operated to engage the clutch, the block diagram illustrating one
20 example in the case where driver's favorite gear-shift performance is the analyzed travel performance information;

FIG. 10 is a block diagram illustrating a principal part of the control operation of the electronic control unit, that is, control operation for suppressing deterioration in drivability when the clutch pedal is operated to engage the clutch, the block diagram illustrating one
25 example in the case where driver's favorite gear-shift performance is the transferred travel performance information;

FIG. 11 is a block diagram illustrating a principal part of the control operation of the

electronic control unit, that is, control operation for suppressing deterioration in drivability when the clutch pedal is operated to engage the clutch, the block diagram illustrating one example in the case where driver's favorite gear-shift performance is the selected travel performance information; and

FIG. 12 is a flowchart illustrating a principal part of the control operation of the electronic control unit, that is, control operation for suppressing deterioration in drivability when the clutch pedal is operated to engage the clutch in an embodiment different from the embodiment of FIG. 6.

10 DETAILED DESCRIPTION OF EMBODIMENTS

[0034] Hereinbelow, embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[0035] FIG. 1 is an explanatory view illustrating the schematic configuration of a vehicle 10 to which the present invention is applied, the explanatory view illustrating principle parts of a control function and a control system for various kinds of control in the vehicle 10. In FIG. 1, the vehicle 10 includes an engine 12 as a power source, driving wheels 14, and a vehicle drive-train 16 (hereinafter referred to as the drive-train 16) provided in a power transmission path between the engine 12 and the driving wheels 14. The drive-train 16 includes a transmission 18 constituting a part of the power transmission path between the engine 12 and the driving wheels 14, a clutch 20 configured to connect and disconnect the power transmission path between the engine 12 and the transmission 18, a clutch actuator 22 configured to switch the operating state (the state including an engagement state, a slip state, and a release state) of the clutch 20, a propeller shaft 26 coupled with a transmission output shaft 24 serving as an output rotation member of the transmission 18, a differential gear 28 coupled with the propeller shaft 26, and a pair of drive shafts 30 coupled with the differential gear 28. In the drive-train 16, the power (equivalent to torque and force unless otherwise specified) output from the engine 12 is transmitted to the driving wheels 14 through the component members such as the clutch 20, the transmission 18, the propeller shaft 26, the differential gear 28, and the drive shaft 30 in

sequence.

[0036] The engine 12 is a public-known internal combustion engine, such as a gasoline engine and a diesel engine. The engine 12 has the operating state, including an intake air amount, a fuel supply amount, and ignition timing, controlled by a
5 later-described electronic control unit 50, by which an engine torque T_e is controlled.

[0037] For example, the transmission 18 is a publicly-known parallel shaft-type constant-mesh manual transmission including a plurality of pairs of transmission gears constantly meshed with each other between two shafts. In the transmission 18, any one of forward gear stages (for example, five forward gears), a backward gear stage (for example,
10 one backward gear), and neutral is selectively formed by manual operation of a shift lever 32 provided in the vicinity of a driver seat of the vehicle 10. Thus, the transmission 18 allows switching of the gear stage by manual operation.

[0038] For example, the clutch 20 is a publicly-know dry single-plate type friction clutch. When the later-described electronic control unit 50 drives the clutch
15 actuator 22, a release sleeve (not illustrated) is moved, and an inner end of a diaphragm spring (not illustrated) is displaced, so that the operating state of the clutch 20 is switched. The clutch 20 is engaged in the state where the release sleeve is not moved by the clutch actuator 22, and thereby the power transmission path between the engine 12 and the transmission 18 is connected. In the clutch 20, when the clutch actuator 22 moves the
20 release sleeve, the release sleeve presses an inner peripheral end of the diaphragm spring. This lowers pressing force of the diaphragm spring, which lowers a clutch transmission torque T_{cl} that can be transmitted by the clutch 20. When a moving position of the release sleeve (i.e., a clutch position POS_{cl}) reaches a specified position, the clutch 20 is released, and the power transmission path between the engine 12 and the transmission 18 is
25 cut off (disconnected). Thus, the clutch 20 is provided so as to be able to connect and disconnect the power transmission path between the engine 12 and the transmission 18 (i.e., the power transmission path between a crankshaft 34 of the engine 12 and a transmission input shaft 36 serving as an input rotation member of the transmission 18) upon switching of the operating state by the clutch actuator 22.

[0039] The operating state of the clutch 20 can be switched when the later-described electronic control unit 50 drives the clutch actuator 22 based on the operation of a clutch pedal 38 by a driver. The clutch pedal 38 is provided in the vicinity of the driver seat of the vehicle 10. When the clutch pedal 38 is depressed, the clutch
5 is slipped or released. When depression of the clutch pedal 38 is released, the clutch pedal 38 is engaged. The operating state of the clutch actuator 22 can be switched when the electronic control unit 50 drives the clutch 20, irrespective of the operation of the clutch pedal 38. For example, even when the clutch pedal 38 is not depressed, the clutch 20 can be slipped or released when the clutch actuator 22 moves the release sleeve. The
10 clutch actuator 22 is of an electric or hydraulic type. In the clutch 20, the clutch transmission torque T_{cl} corresponds to the moving position of the release sleeve (i.e., the clutch position POS_{cl}) that is variable by operation of the clutch actuator 22. The clutch 20 in a slipped state is the state where the clutch 20 generates difference rotation while being engaged.

[0040] The vehicle 10 includes a transmitter-receiver 40. The transmitter-receiver 40 is a device that communicates with a center 100 as a device outside the vehicle 10, the device being an entity other than the vehicle 10 and independent of the vehicle 10. The later-described electronic control unit 50 exchanges a variety of information with the center 100 through the transmitter-receiver 40. The center 100 has a
20 function as a server that receives, processes, analyzes, stores, and provides the variety of information. The center 100 exchanges the variety of information with other vehicles 110a, 110b (referred to as other vehicles 110 unless otherwise specified) other than the vehicle 10, as in the case with the vehicle 10. The other vehicles 110 basically have the same function as the vehicle 10.

[0041] The vehicle 10 includes the electronic control unit 50 as a controller that includes a control device of the vehicle 10 relevant to operation such as switching control of the operating state of the clutch 20. The electronic control unit 50 is configured to include a so-called microcomputer including a CPU, a RAM, a ROM, and an input-output interface, for example. The CPU executes a variety of control of the vehicle 10 by

performing signal processing in accordance with the programs prestored in the ROM, while using a temporary storage function of the RAM. The electronic control unit 50 is divided into electronic control units (ECUs) such as an engine control ECU and a clutch control ECU (see, for example, "automatic clutch ECU" illustrated in FIG. 3) as necessary.

5 **[0042]** The electronic control unit 50 receives information such as various signals each based on detection values from component members such as various sensors included in the vehicle 10. For example, the various signals include an engine speed N_e that is the speed of the crankshaft 34, a transmission input speed N_i that is the speed of the transmission input shaft 36, a transmission output speed N_o that is the speed of the transmission output shaft 24 corresponding to a vehicle speed V , an accelerator operation amount θ_{acc} that is an operation amount of an accelerator operation member such as an accelerator pedal, the operation amount indicating the magnitude of accelerating operation of the driver, a throttle valve opening θ_{th} that is an opening degree of an electronic throttle valve, a brake-on B_{on} that is a signal indicative of a brake operation state provided by
10 brake pedal operation performed by the driver to operate a wheel brake, a clutch pedal operation amount θ_{clp} that is an operation amount (depression amount) of depressing operation of the clutch pedal 38 by the driver, a clutch position POS_{cl} that is a moving position of the release sleeve, a position information S_{vp} of the vehicle 10 on a ground or on a map indicated by a GPS signal and the like, favorite travel performance information
15 (selected travel performance information) Sp_{fms} selected by the driver, and information (driver identification information) S_{psn} for identifying an occupant (driver). For example, the various sensors include an engine speed sensor 60, an input speed sensor 62, an output speed sensor 64, an accelerator operation amount sensor 66, a throttle valve opening degree sensor 68, a brake switch 70, a clutch pedal sensor 72, a clutch position sensor 74, a
20 vehicle position sensor 76 including a GPS antenna, a travel performance selector 78, and an occupant detector 80. The electronic control unit 50 also outputs information such as various command signals to each of the component members such as devices each included in the vehicle 10. For example, the command signals include an engine control command signal Se for controlling the engine 12, and a clutch control command signal S_{cl}
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as a switching command for switching the operating state of the clutch 20. For example, the devices include engine control devices, such as a throttle actuator, a fuel injection device, and an ignition device, and the clutch actuator 22. The clutch control command signal Scl is a command signal for moving the release sleeve that switches the operating
5 state of the clutch 20 to a target clutch position POScl. The clutch control command signal Scl is output to the clutch actuator 22.

[0043] The travel performance selector 78 is an operating device that enables the driver to select the vehicle travel with travel performance desired by the driver (i.e., driver's favorite travel performance). The travel performance includes shock (for
10 example, shock at the time of engagement of the clutch 20) suppression performance, and acceleration response (for example, rising of vehicle acceleration at the time of engagement of the clutch 20) performance, for example. Specifically, the travel performance includes travel performance A emphasizing the acceleration response performance more than the shock suppression performance, travel performance B
15 emphasizing the shock suppression performance more than the acceleration response performance, and travel performance N having both the shock suppression performance and the acceleration response performance (i.e., with the shock suppression performance and the acceleration response performance being balanced). For example, the travel performance selector 78 is a button, a switch, or a touch panel. For example, the travel
20 performance selector 78 is configured to enable the driver to select any one of "sport" corresponding to the travel performance A, "comfort" corresponding to the travel performance B, and "normal" corresponding to the travel performance N. Alternatively, the travel performance selector 78 is configured to enable the driver to select any one of "sport" corresponding to the travel performance A and "comfort" corresponding to the
25 travel performance B, for example.

[0044] For example, the occupant detector 80 is a sensor to detect a driving position (such as a driver seat position, a steering position, and a mirror surface position of a rear-view mirror), and/or a device that detects the information stored in a key possessed by the driver.

[0045] The electronic control unit 50 includes engine control means that is an engine control unit 52, clutch control means that is a clutch control unit 54, and inertial travel control means that is an inertial travel control unit 56, in order to implement the control function for a variety of control in the vehicle 10.

5 **[0046]** The engine control unit 52 calculates a target throttle valve opening θ_{tgt} by applying the accelerator operation amount θ_{acc} to a relation (for example, a throttle valve opening degree map) between the accelerator operation amount θ_{acc} and the throttle valve opening degree θ_{th} , the relation being obtained (i.e., predetermined) by experiments or by design and being stored in advance. The engine control unit 52 performs output
10 control of the engine 12 by outputting the engine control command signal S_e that commands such operation as the throttle actuator be driven to obtain the target throttle valve opening θ_{tgt} or the fuel injection device be operated in accordance with a parameter such as an intake air amount.

[0047] The clutch control unit 54 outputs the clutch control command signal S_{cl}
15 for switching the operating state of the clutch 20 by the clutch actuator 22. Specifically, the clutch control unit 54 outputs to the clutch actuator 22 the clutch control command signal S_{cl} for switching the operating state of the clutch 20 based on the operation of the clutch pedal 38 by the driver. For example, the clutch control unit 54 outputs to the clutch actuator 22 the clutch control command signal S_{cl} for controlling the clutch position
20 POS_{cl} so as to achieve the operating state of the clutch 20 corresponding to the clutch pedal operation amount θ_{clp} .

[0048] The clutch control unit 54 can switch the operating state of the clutch 20 by the clutch actuator 22 irrespective of the operation of the clutch pedal 38. For example,
25 when the clutch pedal operation amount θ_{clp} is zero, and the inertial travel control unit 56 executes inertial travel control, the clutch control unit 54 outputs to the clutch actuator 22 the clutch control command signal S_{cl} for controlling the clutch position POS_{cl} to release the clutch 20.

[0049] When a predetermined specified start condition for starting the inertial travel control is established during traveling in which any gear stage of the transmission 18

is formed and the clutch 20 is engaged, the inertial travel control unit 56 outputs to the clutch control unit 54 a command for releasing the clutch 20, and executes the inertial travel control. While executing the inertial travel control, the inertial travel control unit 56 outputs to the engine control unit 52 a command for stopping operation of the engine 12 by fuel cut that stops fuel supply to the engine 12, or a command for idle operation of the engine 12 at idle speed, for example.

[0050] When a predetermined specified termination condition for terminating inertial travel control is established during execution of the inertial travel control, the inertial travel control unit 56 outputs to the clutch control unit 54 a command for engaging the clutch 20, and terminates the execution of the inertial travel control. When terminating the execution of the inertial travel control, the inertial travel control unit 56 outputs to the engine control unit 52 a command for increasing the engine speed N_e so as to synchronize the engine speed N_e with the transmission input speed N_i , for example. When a difference speed ($= |N_e - N_i|$) between the engine speed N_e and the transmission input speed N_i becomes less than a specified difference speed, the inertial travel control unit 56 outputs to the clutch control unit 54 a command for engaging the clutch 20 by the clutch actuator 22. Alternatively, when terminating the execution of the inertial travel control, the inertial travel control unit 56 may output to the clutch control unit 54 a command for engaging the clutch 20 by taking a specified engagement time, for example. This makes it possible to suppress the shock at the time of terminating the execution of the inertial travel control.

[0051] The inertial travel control is the control for performing inertial traveling in which the vehicle travels with the clutch 20 being released (i.e., inertial travel in which the vehicle travels with the clutch 20 being released by the clutch actuator 22), when the vehicle is put in such a traveling state that causes operation of the engine brake during traveling with any gear stage of the transmission 18 being formed. By executing the inertial travel control during deceleration traveling with an accelerator being turned off, a longer travel distance and an enhanced fuel efficiency are achieved as compared with the case where the engine brake is operated. On one hand, stopping the engine 12 during the

inertial travel control is more advantageous than performing idle operation of the engine 12 in the point that the fuel efficiency is enhanced. On the other hand, idle operation of the engine 12 during the inertial travel control is more advantageous than stopping the engine 12 in the point that the engine speed N_e rises swiftly when the inertial travel control is ended.

[0052] For example, the specified start condition is that the vehicle is in a traveling state including the state where all the accelerator pedal, the brake pedal, and the clutch pedal 38 are not depressed and therefore are in OFF state. More specifically, the specified start condition is that the vehicle is in the traveling state including the state where the accelerator operation amount θ_{acc} is zero, the brake-on Bon signal is not output, and the clutch pedal operation amount θ_{clp} is zero. The specified start condition may also include such conditions as a steering angle in a steering wheel being equal to or below a specified steering angle, an inter-vehicle distance between the vehicle and another vehicle ahead being equal to or above a specified distance, and warm-up of the engine 12 being completed, for example. The specified termination condition is that the vehicle is in a traveling state that does not satisfy the specified start condition. Examples of the traveling state include the state where at least one pedal out of the accelerator pedal, the brake pedal, and the clutch pedal 38 is depressed and is therefore in ON state. More specifically, the specified termination condition is that the vehicle is in the traveling state including the state where at least one condition is established out of an accelerator pedal being turned on (or accelerator being turned on) as the accelerator operation amount θ_{acc} is not equal to zero, the brake-on Bon signal being output, and the clutch pedal being turned on as the clutch pedal operation amount θ_{clp} is not equal to zero.

[0053] A detailed description is now given of the switching of the operating state of the clutch 20 based on the operation of the clutch pedal 38 by the clutch control unit 54. The clutch control unit 54 outputs to the clutch actuator 22 the clutch control command signal Scl for controlling the clutch position POScl to attain the clutch position POScl that can provide the operating state (i.e., clutch transmission torque Tcl) of the clutch 20 corresponding to the clutch pedal operation amount θ_{clp} , with use of the characteristic of

the operating state of the clutch 20 (also referred to as a clutch engagement characteristic) with respect to the clutch pedal operation amount θ_{clp} . For example, the clutch engagement characteristic is a predetermined relation (map) between the clutch pedal operation amount θ_{clp} and the clutch transmission torque T_{cl} . When the clutch engagement characteristic is set uniformly, driver's favorite travel performance may not be obtained.

[0054] The clutch control unit 54 changes the clutch engagement characteristic used as the basis of the clutch control command signal S_{cl} , in accordance with the driver's favorite travel performance. When the driver's favorite travel performance is the travel performance A emphasizing the acceleration response performance, the clutch control unit 54 changes the clutch engagement characteristic so as to engage the clutch 20 faster, with respect to the operation of the clutch pedal 38 performed by the driver for engagement of the clutch 20, than when the driver's favorite travel performance is the travel performance B emphasizing the shock suppression performance.

[0055] The clutch control unit 54 acquires the driver's favorite travel performance, in order to change the clutch engagement characteristic in accordance with the driver's favorite travel performance. For example, the driver's favorite travel performance to be acquired is driver's favorite travel performance transferred from the center 100 (i.e., driver's favorite travel performance information (transferred travel performance information) $Spfmt$ received through the transmitter-receiver 40 from the center 100). Alternatively, the driver's favorite travel performance to be acquired is driver's favorite travel performance based on the tendency of the driving operation of the driver (i.e., driver's favorite travel performance information (analyzed travel performance information) $Spfma$ analyzed based on tendency of the driving operation of the driver by the later-described information analysis unit 59), for example. Alternatively, the driver's favorite travel performance to be acquired is driver's favorite travel performance (i.e., selected travel performance information $Spfms$) selected by the driver with the travel performance selector 78, for example. The selected travel performance information $Spfms$ may be driver's favorite travel performance information that is selected with use of a

mobile terminal, communicable with the vehicle 10 and possessed by a passenger, and that is transferred to the vehicle 10.

[0056] When the transferred travel performance information Spfmt and the selected travel performance information Spfms are acquired, the clutch control unit 54 changes the clutch engagement characteristic in accordance with the driver's favorite travel performance selected by the driver. When the analyzed travel performance information Spfma and the selected travel performance information Spfms are acquired, the clutch control unit 54 changes the clutch engagement characteristic in accordance with the driver's favorite travel performance selected by the driver. Thus, when a plurality of types of the driver's favorite travel performance including the driver's favorite travel performance selected by the driver are acquired, the clutch engagement characteristic is changed with a priority given to the driver's favorite travel performance selected by the driver. Accordingly, actual travel performance matched for the driver's favorite travel performance is obtained more accurately. When the selected travel performance information Spfms is not acquired, and the transferred travel performance information Spfmt and the analyzed travel performance information Spfma are acquired, the travel performance information to be prioritized may be determined in accordance with, for example, how much data on the tendency of the driving operation of the driver is accumulated. Specifically, when the data on the tendency of the driving operation of the driver is relatively large, the analyzed travel performance information Spfma is prioritized. When the data is relatively small, the transferred travel performance information Spfmt is prioritized.

[0057] The function to change the clutch engagement characteristic will be described below by exemplifying a clutch engagement characteristic (also referred to as a startup characteristic) at the time of startup when the clutch pedal 38 is operated by the driver for engagement of the clutch 20.

[0058] FIG. 2 illustrates one example of a plurality of types of startup characteristic. In FIG. 2, a solid line illustrates a startup characteristic of "normal pattern N", a broken line illustrates a startup characteristic of "gradient optimization pattern A", and a two-dot chain line illustrates a startup characteristic of "gradient optimization pattern

B". When the clutch pedal 38 is operated by the driver for engagement of the clutch 20 (i.e., during the operation in which a large clutch pedal operation amount θ_{clp} caused by release of the clutch 20 is reduced to a small clutch pedal operation amount θ_{clp} so as to achieve engagement of the clutch 20), the clutch pedal operation amount θ_{clp} at the start of increase of the clutch transmission torque T_{cl} (i.e., the clutch pedal operation amount θ_{clp} at the start of switching of the operating state of the clutch 20 for engagement of the clutch 20) is the same in all the startup characteristics of the respective patterns. As for a clutch operation range at the time of engagement, "a clutch operation range A" corresponding to "the gradient optimization pattern A" has a shortest range, "a clutch operation range B" corresponding to "the gradient optimization pattern B" has a longest range, and "a clutch operation range N" corresponding to "the normal pattern N" has a range between "the clutch operation range A" and "the clutch operation range B." The clutch operation range at the time of engagement is the operation range of the clutch pedal 38 required to switch the operating state of the clutch 20 for engagement of the clutch 20 (i.e., the range where the clutch actuator 22 actually operates when the driver operates the clutch pedal 38 for engagement of the clutch 20) in one clutch pedal stroke (i.e., in a largest stroke that can operate the clutch pedal 38). Therefore, as for the gradient (absolute value) after the clutch transmission torque T_{cl} starts to increase, "the gradient optimization pattern A" has a largest gradient, "the gradient optimization pattern B" has a smallest gradient, and "the normal pattern N" has a gradient between "the gradient optimization pattern A" and the "gradient optimization pattern B."

[0059] When the clutch 20 is engaged, a larger vehicle acceleration can be obtained as the clutch transmission torque T_{cl} is larger. Accordingly, the startup characteristic illustrated by "the gradient optimization pattern A" is the startup characteristic suitable when the travel performance desired by the driver at the time of startup (also referred to as driver's favorite startup performance) is the travel performance A emphasizing the acceleration response performance. When the clutch 20 is engaged, the shock at the time of engaging the clutch 20 is considered to be suppressed more as the gradient (absolute value) after the clutch transmission torque T_{cl} starts to increase is

smaller. Therefore, the startup characteristic illustrated by "the gradient optimization pattern B" is the startup characteristic suitable when the driver's favorite startup performance is the travel performance B emphasizing the shock suppression performance. The startup characteristic illustrated by "the normal pattern N" is the startup characteristic
5 suitable when the driver's favorite startup performance is the travel performance N having well-balanced performance. Thus, the startup characteristics of the present embodiment are the clutch engagement characteristics focusing on the acceleration response and the suppression of shock at the time of startup.

[0060] The clutch control unit 54 calculates the clutch control command signal
10 Scl output to the clutch actuator 22 with use of the startup characteristic (clutch engagement characteristic at the time of startup) suitable for the driver's favorite startup performance at the time of startup. In short, the clutch control unit 54 changes the startup characteristic in accordance with the driver's favorite startup performance. The clutch control unit 54 changes the startup characteristic by changing the clutch operation range at
15 the time of engagement, for example (see FIG. 2).

[0061] In order to implement the control function to change the clutch engagement characteristic in accordance with the driver's favorite travel performance, the electronic control unit 50 further includes state recognition means that is a state recognition unit 58, and information analysis means that is an information analysis unit 59.

[0062] The state recognition unit 58 identifies the driver of the vehicle 10 based
20 on data such as driver identification information Spsn from the occupant detector 80. The state recognition unit 58 also determines whether or not the information on the driver's favorite travel performance acquired by the clutch control unit 54 is available. The state recognition unit 58 also determines whether or not the information on the driver's favorite
25 travel performance selected by the driver (i.e., the selected travel performance information Spfms) is available.

[0063] The information analysis unit 59 analyzes the driver's favorite travel performance based on the tendency of the driving operation of the driver. Examples of the tendency of the driving operation of the driver include a rate of change of the clutch

pedal operation amount θ_{clp} when the driver operates the clutch pedal 38 for engagement of the clutch 20, a magnitude and a rate of change of the accelerator operation amount θ_{acc} when the clutch pedal 38 is operated, a vehicle speed V when the clutch pedal 38 is operated, and a magnitude and a rate of change of the accelerator operation amount θ_{acc} after the clutch pedal 38 is operated. The information analysis unit 59 collects the tendency of the driving operation of the driver, and stores the data on the tendency of the driving operation in a nonvolatile memory and the like. The information analysis unit 59 analyzes the driver's favorite travel performance based on the data on the tendency of the driving operation, and obtains analyzed travel performance information $Spfma$. When, for example, the rate of change of the accelerator operation amount θ_{acc} is relatively fast, the information analysis unit 59 sets the driver's favorite travel performance to the travel performance A emphasizing the acceleration response performance. When the rate of change of the accelerator operation amount θ_{acc} is relatively slow, the information analysis unit 59 sets the driver's favorite travel performance to the travel performance B emphasizing the shock suppression performance.

[0064] FIG. 3 is a block diagram illustrating a principal part of the control operation of the electronic control unit 50, that is, the control operation for suppressing deterioration in drivability when the clutch pedal 38 is operated to engage the clutch 20, the block diagram illustrating one example in the case where the driver's favorite startup performance is the analyzed travel performance information $Spfma$. In FIG. 3, in a block (hereinafter a term "block" is omitted) B10 corresponding to the function of the information analysis unit 59, the tendency of the driving operation of the driver is collected, and the collected data on the tendency of the driving operation is stored in a nonvolatile memory and the like. In B12 corresponding to the function of the information analysis unit 59, driver's favorite startup performance is analyzed based on the stored data on the tendency of the driving operation to obtain the analyzed travel performance information $Spfma$. In B50 corresponding to the function of the clutch control unit 54 (automatic clutch ECU), the driver's favorite startup performance (the analyzed travel performance information $Spfma$) is acquired, and the clutch engagement characteristic at the time of

startup (startup characteristic) is changed in accordance with the analyzed travel performance information Spfma. At the time of startup when the clutch pedal 38 is operated for engagement of the clutch 20, the clutch control command signal Scl based on the clutch pedal operation amount θ_{clp} , calculated with the startup characteristic, is output to the clutch actuator 22. Hence, target startup performance matched for the driver's favorite startup performance is achieved. In the vehicle 10, the automatic clutch ECU and the clutch actuator 22 constitute an automatic clutch system.

[0065] FIG. 4 is a block diagram illustrating a principal part of the control operation of the electronic control unit 50, that is, the control operation for suppressing deterioration in drivability when the clutch pedal 38 is operated to engage the clutch 20, the block diagram illustrating one example in the case where the driver's favorite startup performance is the transferred travel performance information Spfmt. In FIG. 4, in B20 corresponding to the function of the center 100, information including past driving history, sex, and age of each driver in the vehicle 10 or in the other vehicles 110 is collected through communication, and the information is stored as big data. Examples of the past driving history of the driver include the rate of change of the clutch pedal operation amount θ_{clp} , the magnitude and the rate of change of the accelerator operation amount θ_{acc} , and the vehicle speed V, which are associated with the position information of each vehicle. In B22 corresponding to the function of the center 100, the driver's favorite startup performance of the vehicle 10 is analyzed based on the stored big data to obtain the transferred travel performance information Spfmt. For example, the driver's favorite startup performance of the vehicle 10 is analyzed based on the position of the driving history of the driver of the vehicle 10 in the driving history of the big data. More specifically, when the driving history of the driver of the vehicle 10 is close to the driving history emplacing the acceleration response performance, the driver's favorite travel performance is set to the travel performance A emphasizing the acceleration response performance. When the driving history of the driver of the vehicle 10 is close to the driving history emphasizing the shock suppression performance, the driver's favorite travel performance is set to the travel performance B emphasizing the shock suppression

performance. In B50 corresponding to the function of the clutch control unit 54 (automatic clutch ECU), the driver's favorite startup performance (transferred travel performance information Spfmt) is acquired through communication (for example, through connected technology which allows communication between the center 100 and the vehicle 10). The clutch engagement characteristic at the time of startup (startup characteristic) is changed in accordance with the transferred travel performance information Spfmt. At the time of startup, the clutch control command signal Scl based on the clutch pedal operation amount θ_{clp} , calculated with the startup characteristic, is output to the clutch actuator 22. Hence, target startup performance matched for the driver's favorite startup performance is achieved.

[0066] FIG. 5 is a block diagram illustrating a principal part of the control operation of the electronic control unit 50, that is, the control operation for suppressing deterioration in drivability when the clutch pedal 38 is operated to engage the clutch 20, the block diagram illustrating one example in the case where the driver's favorite startup performance is the selected travel performance information Spfms. In FIG. 5, in B30 corresponding to the function of an operating device (for example, travel performance selector 78) or a mobile terminal, the driver's favorite startup performance selected by the driver is received. In B50 corresponding to the function of the clutch control unit 54 (automatic clutch ECU), the driver's favorite startup performance (selected travel performance information Spfms) is acquired from the travel performance selector 78 or through communication (for example, connected technology that allows communication between the mobile terminal and the vehicle 10). The clutch engagement characteristic at the time of startup (startup characteristic) is changed in accordance with the selected travel performance information Spfms. At the time of startup, the clutch control command signal Scl based on the clutch pedal operation amount θ_{clp} , calculated with the startup characteristic, is output to the clutch actuator 22. Hence, target startup performance matched for the driver's favorite startup performance is achieved.

[0067] FIG. 6 is a flowchart illustrating a principal part of the control operation of the electronic control unit 50, that is, control operation for suppressing deterioration in

drivability when the clutch pedal 38 is operated to engage the clutch 20. The flow chart is repeatedly executed, for example.

[0068] In FIG. 6, first in step (hereinafter a term "step" is skipped) S10 corresponding to the function of the state recognition unit 58, it is determined whether or not the information on the driver's favorite startup performance is available. When negative determination is made in S10, the startup characteristic of "normal pattern N" suitable the travel performance N having well-balanced performance is set as the clutch engagement characteristic at the time of startup (startup characteristic), the current startup characteristic is maintained in S20 corresponding to the function of the clutch control unit 54. When positive determination is made in S10, it is determined whether or not the information on the favorite startup performance selected by the driver (selected travel performance information Spfms) is available in S30 corresponding to the function of the state recognition unit 58. When positive determination is made in S30, the startup characteristic is changed in accordance with the selected travel performance information Spfms in S40 corresponding to the function of the clutch control unit 54. In short, optimum startup characteristic corresponding to the selected travel performance information Spfms is set. When negative determination is made in S30, the startup characteristic is changed in accordance with the favorite startup performance information (the transferred travel performance information Spfmt or the analyzed travel performance information Spfma) based on the result of analysis in S50 corresponding to the function of the clutch control unit 54. In short, optimum startup characteristic corresponding to the transferred travel performance information Spfmt or the analyzed travel performance information Spfma is set.

[0069] As described in the foregoing, according to the present embodiment, the clutch engagement characteristic used as the basis of the switching command (clutch control command signal Scl) for switching the operating state of the clutch 20 is changed in accordance with the driver's favorite travel performance. This makes it easy to achieve actual travel performance (for example, travel performance such as the acceleration response performance and the shock suppression performance) matched for the driver's

favorite travel performance. Hence, deterioration in drivability can be suppressed when the clutch pedal 38 is operated to engage the clutch 20.

[0070] According to the present embodiment, the startup characteristic (clutch engagement characteristic at the time of startup) is changed in accordance with the driver's favorite startup performance. This makes it easy to achieve actual travel performance matched for the driver's favorite startup performance at the time of startup.

[0071] When the driver's favorite travel performance is the travel performance A emphasizing the acceleration response performance, the clutch control unit 54 changes the clutch engagement characteristic so as to engage the clutch 20 faster with respect to the operation of the clutch pedal 38 for engagement of the clutch 20 than when the driver's favorite travel performance is the travel performance B emphasizing the shock suppression performance. Accordingly, the actual travel performance matched for the driver's favorite travel performance is easily obtained. Hence, deterioration in drivability can be suppressed when the clutch pedal 38 is operated to engage the clutch 20.

[0072] According to the present embodiment, the driver's favorite travel performance is one of the driver's favorite travel performance transferred from the center 100 (transferred travel performance information Spfmt), the driver's favorite travel performance based on the tendency of the driving operation of the driver (analyzed travel performance information Spfma), and the driver's favorite travel performance selected by the driver (selected travel performance information Spfms). Accordingly, the actual travel performance matched for the driver's favorite travel performance is easily and appropriately obtained.

[0073] According to the present embodiment, when the transferred travel performance information Spfmt and the selected travel performance information Spfms are acquired, or when the analyzed travel performance information Spfma and the selected travel performance information Spfms are acquired, the clutch engagement characteristic is changed in accordance with the driver's favorite travel performance selected by the driver. Accordingly, the actual travel performance matched for the driver's favorite travel performance is easily and appropriately obtained.

[0074] According to the present embodiment, the startup characteristic is changed when the clutch operation range at the time of engagement is changed. Hence, at the time of startup, the actual startup performance matched for the driver's favorite startup performance is easily and appropriately obtained.

5 **[0075]** A description is now given of other embodiments of the present invention. In the following description, component members in common with those in the embodiments are designated by identical reference signs to omit the description thereof.

[0076] In the first embodiment, as illustrated in FIG. 2, the clutch control unit 54 changes the clutch operation range at the time of engagement so as to change the clutch engagement characteristic at the time of startup (startup characteristic). In the present embodiment, the clutch control unit 54 changes the startup characteristic by changing the clutch pedal operation amount θ_{clp} (also referred to as a clutch operation start point at the time of engagement) at the start of switching the operating state of the clutch 20 for engagement of the clutch 20.

15 **[0077]** FIG. 7 illustrates one example of a plurality of types of startup characteristics in an embodiment different from the embodiment of FIG. 2. In FIG. 7, a solid line illustrates a startup characteristic of "normal pattern N", a broken line illustrates a startup characteristic of "meeting point optimization pattern A", and a two-dot chain line illustrates a startup characteristic of "meeting point optimization pattern B". In all the patterns, the length of the clutch operation range at the time of engagement is the same when the driver operates the clutch pedal 38 for engagement of the clutch 20. That is, "the clutch operation range A", "the clutch operation range B", and "the clutch operation range N" have the same length. As for a clutch operation start point at the time of engagement, "the clutch pedal operation range A" corresponding to "the meeting point optimization pattern A" has a largest start point, "the clutch pedal operation range B" corresponding to "the meeting point optimization pattern B" has a smallest start point, and
25 "the clutch pedal operation range N" corresponding to "the normal pattern N" has the start point between "the clutch pedal operation range A" and "the clutch pedal operation range B."

[0078] As the clutch operation start point at the time of engagement with respect to the operation of the clutch pedal 38 for engagement of the clutch 20 is larger, the clutch transmission torque T_{cl} rises at an earlier state, resulting in quicker startup. Therefore, the startup characteristic illustrated by "the meeting point optimization pattern A" is the startup characteristic suitable when the driver's favorite startup performance is the travel performance (for example, the travel performance A) that emphasizes the acceleration response performance the most. The startup characteristic illustrated by "the normal pattern N" is the startup characteristic suitable when the driver's favorite startup performance is the travel performance (for example, travel performance N) that emphasizes the acceleration response performance to some extent. The startup characteristic illustrated by "the meeting point optimization pattern B" is the startup characteristic suitable when the driver's favorite startup performance is the travel performance (for example, the travel performance B) that does not emphasize the acceleration response performance. Thus, the startup characteristics of the present embodiment are the clutch engagement characteristics focusing on the acceleration response at the time of startup.

[0079] As described in the foregoing, according to the present embodiment, the actual travel performance matched for the driver's favorite travel performance can easily be obtained as in the first embodiment. Hence, deterioration in drivability can be suppressed when the clutch pedal 38 is operated to engage the clutch 20.

[0080] According to the present embodiment, the startup characteristic is changed when the clutch operation start point at the time of engagement is changed. Hence, at the time of startup, the actual startup performance matched for the driver's favorite startup performance is easily and appropriately obtained.

[0081] In the first and second embodiments, the function to change the clutch engagement characteristic has been described by exemplifying the clutch engagement characteristic at the time of startup (i.e., startup characteristic). In the present embodiment, the function to change the clutch engagement characteristic will be described by exemplifying a clutch engagement characteristic (also referred to as a gear-shift

characteristic) at the time of gear-shift of the transmission 18 when the driver operates the clutch pedal 38 for engagement of the clutch 20 in order to switch the gear stage of the transmission 18.

[0082] FIG. 8 illustrates one example of a plurality of types of gear-shift characteristics. In FIG. 8, the clutch pedal operation amount θ_{clp} marks a maximum value when the clutch pedal 38 is depressed the most after the start of the operation of the clutch pedal 38. The clutch pedal operation amount θ_{clp} then reduces and becomes zero at the end of the clutch operation when the depression of the clutch pedal 38 is released completely. A solid line illustrates a gear-shift characteristic of "normal pattern N", a broken line illustrates a gear-shift characteristic of "optimization pattern A", and a two-dot chain line illustrates a gear-shift characteristic of "optimization pattern B". As illustrated in FIG. 8, each of the characteristics represents rise characteristics of the clutch transmission torque T_{cl} in an identical operating pattern of the clutch pedal 38 when the clutch pedal operation amount θ_{clp} is changed (i.e., modes of change in the clutch transmission torque T_{cl} when the operating state of the clutch 20 are switched for engagement of the clutch 20). In the gear-shift characteristics, as in "the normal N", the rise characteristic of the clutch transmission torque T_{cl} can be set such that the clutch 20 is completely engaged after the end of the clutch operation instead of the clutch 20 being completely engaged at the end of the clutch operation. This makes it possible to suppress engagement shock (for example, shock at the time of gear-shift operation (also referred to as gear-shift shock)) of the clutch 20 with respect to fast operation of the clutch pedal 38. However, slowing the increase in clutch transmission torque T_{cl} leads to a decrease in vehicle acceleration (i.e., acceleration response to the operation of the clutch pedal 38). Each gear-shift characteristic in FIG. 8 is set in consideration of the acceleration response performance and the shock suppression performance.

[0083] Specifically, in the gear-shift characteristic illustrated by "the optimization A", increase in the clutch transmission torque T_{cl} is the fastest, and the torque is quickly transmitted. Accordingly, using the gear-shift characteristic can enhance the acceleration response (acceleration response). Therefore, the gear-shift characteristic illustrated by

"the optimization A" is the gear-shift characteristic suitable when the travel performance desired by the driver at the time of gear-shift (also referred to as driver's favorite gear-shift characteristic) is the travel performance A emphasizing the acceleration response performance. In the gear-shift characteristic illustrated by "the optimization B", increase
5 in the clutch transmission torque T_{cl} is the slowest, and the torque is transmitted slowly. Accordingly, using the gear-shift characteristic reduces the gear-shift shock. Therefore, the gear-shift characteristic illustrated by "the optimization B" is the gear-shift characteristic suitable when the driver's favorite startup performance is the travel performance B emphasizing the shock suppression performance. In the gear-shift
10 characteristic illustrated by "normal N", increase in the clutch transmission torque T_{cl} is between "the optimization A" and the "optimization B". Accordingly, using the gear-shift characteristic can balance the acceleration response and the reduction of gear-shift shock. Therefore, the gear-shift characteristic illustrated by "the normal pattern N" is the gear-shift characteristic suitable when the driver's favorite startup performance is the travel
15 performance N having well-balanced performance. Thus, the gear-shift characteristics of the present embodiment are the clutch engagement characteristics focusing on the acceleration response and the suppression of shock at the time of gear-shift.

[0084] The clutch control unit 54 calculates the clutch control command signal S_{cl} output to the clutch actuator 22 with use of the gear-shift characteristic (clutch
20 engagement characteristic at the time of gear-shift) suitable for the driver's favorite gear-shift performance at the time of gear-shift of the transmission 18. In short, the clutch control unit 54 changes the gear-shift characteristic in accordance with the driver's favorite gear-shift performance. The clutch control unit 54 changes the gear-shift characteristic by changing the rate of change in the clutch transmission torque T_{cl} when the operating state
25 of the clutch 20 is switched for engagement of the clutch 20 with respect to an identical operating pattern of the clutch pedal 38 for engagement of the clutch 20 (see FIG. 8). Changing the rate of change in the clutch transmission torque T_{cl} when the operating state of the clutch 20 is switched for engagement of the clutch 20 is changing the operating speed of the clutch actuator 22 when the clutch 20 is engaged, for example.

[0085] FIG. 9 is a block diagram illustrating a principal part of the control operation of the electronic control unit 50, that is, the control operation for suppressing deterioration in drivability when the clutch pedal 38 is operated to engage the clutch 20, the block diagram illustrating one example in the case where the driver's favorite gear-shift performance is the analyzed travel performance information Spfma. In FIG. 9, in B110 corresponding to the function of the information analysis unit 59, the tendency of the driving operation of the driver is collected, and the collected data on the tendency of the driving operation is stored in a nonvolatile memory and the like. In B112 corresponding to the function of the information analysis unit 59, the driver's favorite gear-shift performance is analyzed based on the stored data on the tendency of the driving operation to obtain the analyzed travel performance information Spfma. In B150 corresponding to the function of the clutch control unit 54 (automatic clutch ECU), the driver's favorite gear-shift performance (the analyzed travel performance information Spfma) is acquired, and the clutch engagement characteristic at the time of gear-shift (gear-shift characteristic) is changed in accordance with the analyzed travel performance information Spfma. At the time of gear-shift when the clutch pedal 38 is operated for engagement of the clutch 20, the clutch control command signal Scl based on the clutch pedal operation amount θ_{clp} , calculated with the gear-shift characteristic, is output to the clutch actuator 22. Hence, target gear-shift performance matched for the driver's favorite gear-shift performance is achieved.

[0086] FIG. 10 is a block diagram illustrating a principal part of the control operation of the electronic control unit 50, that is, the control operation for suppressing deterioration in drivability when the clutch pedal 38 is operated to engage the clutch 20, the block diagram illustrating one example in the case where the driver's favorite gear-shift performance is the transferred travel performance information Spfmt. In FIG. 10, in B120 corresponding to the function of the center 100, information including past driving history, sex, and age of each driver in the vehicle 10 or the other vehicles 110 is collected through communication, and the information is stored as big data. In B122 corresponding to the function of the center 100, the driver's favorite gear-shift performance of the vehicle 10 is

analyzed based on the stored big data to obtain the transferred travel performance information Spfmt. For example, the driver's favorite gear-shift performance of the vehicle 10 is analyzed based on the position of the driving history of the driver of the vehicle 10 in the driving history of the big data. In B150 corresponding to the function of the clutch control unit 54 (automatic clutch ECU), the driver's favorite gear-shift performance (transferred travel performance information Spfmt) is acquired through communication (for example, through connected technology which allows communication between the center 100 and the vehicle 10). The clutch engagement characteristic at the time of gear-shift (gear-shift characteristic) is changed in accordance with the transferred travel performance information Spfmt. At the time of gear-shift, the clutch control command signal Scl based on the clutch pedal operation amount θ_{clp} , calculated with the gear-shift characteristic, is output to the clutch actuator 22. Hence, target gear-shift performance matched for the driver's favorite gear-shift performance is achieved.

[0087] FIG. 11 is a block diagram illustrating a principal part of the control operation of the electronic control unit 50, that is, the control operation for suppressing deterioration in drivability when the clutch pedal 38 is operated to engage the clutch 20, the block diagram illustrating one example in the case where the driver's favorite gear-shift performance is the selected travel performance information Spfms. In FIG. 11, in B130 corresponding to the function of a component member such as the travel performance selector 78 or a mobile terminal, the driver's favorite gear-shift performance selected by the driver is received. In B150 corresponding to the function of the clutch control unit 54 (automatic clutch ECU), the driver's favorite gear-shift performance (selected travel performance information Spfms) is acquired from an operating device (for example, the travel performance selector 78) or through communication (for example, connected technology that allows communication between the mobile terminal and the vehicle 10). The clutch engagement characteristic at the time of gear-shift (gear-shift characteristic) is changed in accordance with the selected travel performance information Spfms. At the time of gear-shift, the clutch control command signal Scl based on the clutch pedal operation amount θ_{clp} , calculated with the gear-shift characteristic, is output to the clutch

actuator 22. Hence, target gear-shift performance matched for the driver's favorite gear-shift performance is achieved.

[0088] FIG. 12 is a flowchart illustrating a principal part of the control operation of the electronic control unit 50, that is, control operation for suppressing deterioration in drivability when the clutch pedal 38 is operated to engage the clutch 20. The flow chart is repeatedly executed, for example. FIG. 12 illustrates an embodiment different from the embodiment of FIG. 6.

[0089] In FIG. 12, first in SB10 corresponding to the function of the state recognition unit 58, it is determined whether or not the information on the driver's favorite gear-shift performance is available. When negative determination is made in SB10, the gear shift characteristic of "normal pattern N" suitable for the travel performance N having well-balanced performance is set as the clutch engagement characteristic at the time of gear-shift (gear-shift characteristic), or the current gear-shift characteristic is maintained in SB20 corresponding to the function of the clutch control unit 54. When positive determination is made in SB10, it is determined whether or not the information on the favorite gear-shift performance selected by the driver (selected travel performance information Spfms) is available in SB30 corresponding to the function of the state recognition unit 58. When positive determination is made in SB30, the gear-shift characteristic is changed in accordance with the selected travel performance information Spfms in SB40 corresponding to the function of the clutch control unit 54. In short, optimum gear-shift characteristic corresponding to the selected travel performance information Spfms is set. When negative determination is made in SB30, the gear-shift characteristic is changed in accordance with the favorite gear-shift performance information (the transferred travel performance information Spfmt or the analyzed travel performance information Spfma) based on the result of analysis in SB50 corresponding to the function of the clutch control unit 54. In short, optimum gear-shift characteristic corresponding to the transferred travel performance information Spfmt or the analyzed travel performance information Spfma is set.

[0090] As described in the foregoing, according to the present embodiment, the

actual travel performance matched for the driver's favorite travel performance is easily obtained as in the first embodiment. Hence, deterioration in drivability can be suppressed when the clutch pedal 38 is operated to engage the clutch 20.

5 **[0091]** According to the present embodiment, the gear-shift characteristic (clutch engagement characteristic at the time of gear-shift of the transmission 18) is changed in accordance with the driver's favorite gear-shift characteristic performance. This makes it easy to achieve actual gear-shift performance matched for the driver's favorite gear-shift performance at the time of gear shift.

10 **[0092]** According to the present embodiment, the gear-shift characteristic is changed by changing the rate of change of the clutch transmission torque T_{cl} when the operating state of the clutch 20 is switched for engagement of the clutch 20 with respect to an identical operating pattern of the clutch pedal 38 for engagement of the clutch 20. Therefore, the actual gear-shift performance matched for the driver's favorite gear-shift performance is easily obtained at the time of gear-shift.

15 **[0093]** Although the embodiments of the present invention have been described in detail based on the drawings, the present invention is also applied to other modes.

20 **[0094]** For example, in the aforementioned embodiments, the clutch 20 is controlled with use of the startup characteristic of FIG. 2 or FIG. 7 at the time of startup, whereas at the time of gear-shift, the clutch 20 is controlled with use of the gear-shift characteristic of FIG. 8 which is different from the startup characteristic. That is, the clutch control unit 54 changes the startup characteristic and the gear-shift characteristic different from the startup characteristic. Hence, the actual travel performance matched for the driver's favorite travel performance is easily obtained depending on the situations, such as at the time of startup, and at the time of gear-shift.

25 **[0095]** In the embodiments, the clutch 20 may be controlled with use of the startup characteristic of FIG. 2 or FIG. 7 at the time of gear-shift. Alternatively, the clutch 20 may be controlled with use of the gear-shift characteristic of FIG. 8 at the time of startup. Alternatively, when the operating speed of the clutch pedal 38 (rate of change in the clutch pedal operation amount θ_{clp}) is relatively high, the clutch 20 may be controlled

with use of the gear-shift characteristic of FIG. 8, whereas when the operating speed of the clutch pedal 38 is relatively low, the clutch 20 may be controlled with use of the startup characteristic of FIG. 2 or FIG. 7.

[0096] In the aforementioned embodiments, the plurality of types of the startup characteristics as illustrated in FIG. 2 or FIG. 7, and the plurality of types of the gear-shift characteristics as illustrated in FIG. 8 have been exemplified as the clutch engagement characteristic. Each of the clutch engagement characteristics is merely an example, and the modes of change in the clutch transmission torque T_{cl} in each of the clutch engagement characteristics, the timing at which the clutch transmission torque T_{cl} rises, and the number of types of the clutch engagement characteristics can take a variety of modes.

[0097] In the embodiments, the relation (map) as illustrated in FIG. 2 or FIG. 7 were exemplified as the startup characteristic, and the relation (map) as illustrated in FIG. 8 was exemplified as the gear-shift characteristic. However, the gear-shift characteristic is not limited to the modes disclosed. For example, it is not necessary to have the maps as in FIGS. 2, 7, and 8 as the clutch engagement characteristic (the startup characteristic, gear-shift characteristic). When controlling the clutch 20, the clutch control unit 54 may output to the clutch actuator 22 the clutch control command signal S_{cl} which is calculated based on the clutch pedal operation amount θ_{clp} so as to be matched for the driver's favorite travel performance without use of the maps. In such configuration, the clutch control unit 54 ends up changing the clutch engagement characteristic used as the basis of the clutch control command signal S_{cl} in accordance with the driver's favorite travel performance.

[0098] In the embodiments, the center 100 analyzes the driver's favorite travel performance (startup performance, gear shift performance) of the vehicle 10 based on the stored big data. However, the present invention is not limited to the mode disclosed. For example, the vehicle 10 may acquire necessary information from the big data stored in the center 100 through communication (for example, connected technology), and may analyze the driver's favorite travel performance based on the information. That is, processes to be conducted in the vehicle 10 and processes to be conducted in the center 100

may be conducted in any one of the vehicle and the center 100 except for the processes that can be conducted only in one of the vehicle 10 and the center 100.

[0099] In the embodiments, the methods for acquiring the driver's favorite travel performance were exemplified as illustrated in FIGS. 3 to 5 and FIGS. 9 to 11. However, 5 the method for acquiring the driver's favorite travel performance is not limited to the methods disclosed. The driver's favorite travel performance may be obtained by some other methods.

[0100] In the embodiments, the driver of the vehicle 10 may be identified with a technology such as biometrics, or the driver of the vehicle 10 may be identified by 10 selecting the driver out of a pre-registered driver list.

[0101] In the embodiments, the vehicle 10 may include a function to encourage the driver to select the driver's favorite travel performance with the travel performance selector 78.

[0102] In the embodiments, the clutch 20 is a dry single-plate type friction clutch. 15 However, the clutch 20 may be a wet single-plate type friction clutch or a wet multiplate friction clutch.

[0103] In the embodiments, the engine 12 was exemplified as a power source. However, as the power source, another motor such as an electric motor may be adopted in combination with the engine 12.

20 **[0104]** The embodiments disclosed are merely example embodiments, and the present invention may be carried out in modes to which various arrangements and modifications are applied based on the knowledge of those skilled in the art.

CLAIMS

1. A control device for a vehicle (10), the vehicle (10) including a transmission (18) provided between a power source (12) and driving wheels (14), a clutch (20) configured to connect and disconnect a power transmission path between the power source (12) and the transmission (18), and a clutch actuator (22) configured to switch an operating state of the clutch (20),

the control device characterized by comprising:

an electronic control unit (50) configured to output a switching command to the clutch actuator (22), the switching command being a command to switch the operating state of the clutch (20) based on operation of a clutch pedal (38) by a driver, wherein

the electronic control unit (50) configured to change a characteristic of the operating state of the clutch (20) with respect to an operation amount of the clutch pedal (38) in accordance with travel performance desired by the driver.

2. The control device for the vehicle (10) according to claim 1, wherein

the electronic control unit (50) is configured to change the characteristic of the operating state of the clutch (20) at a time of startup of the vehicle (10).

3. The control device for the vehicle (10) according to claim 1 or 2, wherein

the electronic control unit (50) is configured to change the characteristic of the operating state of the clutch (20) at a time of gear-shift of the transmission (18).

4. The control device for the vehicle (10) according to claim 1, wherein

the electronic control unit (50) is configured to change a first characteristic and a second characteristic, the first characteristic being a characteristic of the operating state of the clutch (20) at a time of startup of the vehicle (10), the second characteristic being a characteristic of the operating state of the clutch (20) at a time of gear-shift of the transmission (18), the first characteristic being different from the second characteristic.

5. The control device for the vehicle (10) according to any one of claims 1 to 4, wherein

the electronic control unit (50) is configured to change the characteristic of the operating state of the clutch (20) such that when the travel performance desired by the driver is a first travel performance, the clutch (20) is engaged faster with respect to operation of the clutch pedal (38) than when the travel performance desired by the driver is a second travel performance, and

the first travel performance is travel performance emphasizing acceleration response performance, while the second travel performance is travel performance emphasizing shock suppression performance.

6. The control device according to any one of claims 1 to 5, wherein

the travel performance desired by the driver is travel performance desired by the driver that is received by the electronic control unit (50) from a device (100) outside the vehicle (10).

7. The control device according to any one of claims 1 to 6, wherein

the travel performance desired by the driver is a travel performance desired by the driver that is based on a tendency of a driving operation of the driver.

8. The control device according to any one of claims 1 to 7, wherein

the travel performance desired by the driver is a travel performance desired by the driver that is selected by the driver.

9. The control device according to any one of claims 1 to 5, wherein

the electronic control unit (50) is configured to change the characteristic of the operating state of the clutch (20) in accordance with the travel performance desired by the driver that is selected by the driver when the electronic control unit (50) receives travel

performance desired by the driver that is received from a device (100) outside the vehicle (10) and travel performance desired by the driver that is selected by the driver.

10. The control device according to any one of claims 1 to 5, wherein

the electronic control unit (50) is configured to change the characteristic of the operating state of the clutch (20) in accordance with the travel performance desired by the driver that is selected by the driver when the electronic control unit (50) receives travel performance desired by the driver that is based on a tendency of driving operation of the driver and travel performance desired by the driver that is selected by the driver.

11. The control device according to claim 2 or 4, wherein

the electronic control unit (50) is configured to change the characteristic of the operating state of the clutch (20) at the time of the startup by changing an operation range of the clutch pedal (38) required to switch the operating state of the clutch (20) for engagement of the clutch (20).

12. The control device according to claim 2 or 4, wherein

the electronic control unit (50) is configured to change the characteristic of the operating state of the clutch (20) at the time of the startup by changing the operation amount of the clutch pedal (38) at a start of switching the operating state of the clutch (20) for engagement of the clutch (20).

13. The control device according to claim 3 or 4, wherein

the electronic control unit (50) is configured to change the characteristic of the operating state of the clutch (20) at the time of the gear-shift by changing a rate of change of a clutch transmission torque when the operating state of the clutch (20) is switched with respect to an identical operating pattern of the clutch pedal (38) for engagement of the clutch (20).

14. A control method for a vehicle (10), the vehicle (10) including a transmission (18) provided between a power source (12) and driving wheels (14), a clutch (20) configured to connect and disconnect a power transmission path between the power source (12) and the transmission (18), a clutch actuator (22) configured to switch an operating state of the clutch (20), and an electronic control unit (50),

the control method characterized by comprising:

outputting, by the electronic control unit (50), a switching command to the clutch actuator (22); and

changing, by the electronic control unit (50), a characteristic of an operating state of the clutch (20) with respect to an operation amount of a clutch pedal (38) in accordance with travel performance desired by a driver,

the switching command being a command for switching the operating state of the clutch (20) based on operation of the clutch pedal (38) by the driver.