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Control device and control method

Abstract

A control device includes an acquisition unit configured to acquire a position at which one or more occupants of a vehicle are seated, and a controller configured to determine necessity of reduction of noise of a drive source of the vehicle based on a distance between the position and the drive source of the vehicle, and reduce the noise by controlling the drive source according to a determination result of the necessity of the reduction of the noise.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION
(1) This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2022-172401, filed on Oct. 27, 2022, the entire contents of which are incorporated herein by reference.
FIELD
(2) The present disclosure relates to a control device and a control method.
BACKGROUND
(3) For example, Japanese Patent Application Laid-Open No. 2018-30510 (Patent document 1) describes that a control device of a vehicle capable of performing automatic driving reduces noise by limiting the rotation speed and torque of the engine so as to narrow the operation region when an occupant is present.
SUMMARY

(4) However, since the occupant may not feel the noise as uncomfortable depending on the boarding position, it is conceivable that the control of reducing the noise of the engine is not appropriate. This problem also occurs in a hybrid vehicle using not only an engine but also a motor generator as a drive source.

(5) Therefore, an object of the present disclosure is to provide a control device and a control method capable of appropriately improving comfort of the occupant of a vehicle.

(6) In one aspect of the present disclosure, there is provided a control device including: an acquisition unit configured to acquire a position at which one or more occupants of a vehicle are seated; and a controller configured to determine necessity of reduction of noise of a drive source of the vehicle based on a distance between the position and the drive source of the vehicle, and reduce the noise by controlling the drive source according to a determination result of the necessity of the reduction of the noise.

(7) In the above control device, the control unit may reduce the noise by reducing an output of the drive source according to the distance between the position and the drive source.

(8) In the above control device, the control unit may reduce the output of the drive source based on a correlation between the output of the drive source and a magnitude of the noise so that the noise of the drive source is reduced according to the distance between the position and the drive source.

(9) In the above control device, the drive source may be an internal combustion engine.

(10) In another aspect of the present disclosure, there is provided a control method implemented by a computer, the control method including: acquiring a position at which one or more occupants of a vehicle are seated; determining necessity of reduction of noise of a driving source of the vehicle based on a distance between the position and the driving source of the vehicle; and reducing the noise by controlling the driving source according to a determination result of the necessity of the reduction of the noise.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a configuration diagram illustrating a vehicle and a control device therefor;

(2) FIG. **2** illustrates an example of noise characteristic data;

(3) FIG. **3** is a flowchart illustrating a noise reduction process;

(4) FIG. **4** is a diagram illustrating an example of the magnitude of the noise level according to the boarding pattern of occupants;

(5) FIG. **5** is a diagram illustrating an example of the magnitude of the noise level according to a boarding pattern of occupants in another vehicle; and

(6) FIG. **6** is a flowchart illustrating another noise reduction process.

DETAILED DESCRIPTION

Configuration of Control Device

(7) FIG. **1** is a configuration diagram illustrating a vehicle **9** and a control device **1** therefor. The vehicle **9** is, for example, a hybrid vehicle, and includes an engine (ENG) **92**, an inverter (INV) **93**, and a motor generator (MG) **94** as drive sources. The engine **92** is an example of an internal combustion engine and is, for example, a gasoline engine, but may be a diesel engine. The inverter **93** generates a three phase alternating current for driving the motor generator **94**. The vehicle **9** of the present example is a front engine vehicle, and the engine **92**, the inverter **93**, and the motor generator **94** are located in the front of the vehicle **9**. In this example, reduction of the noise of the engine **92** will be described as an example.

(8) The vehicle **9** has a three-row seat arrangement, as an example, and includes a front seat **90***a*, a middle seat **90***b*, and a rear seat **90***c*. The front seat **90***a* is located at the most front side of the vehicle **9**, the rear seat **90***c* is located at the most rear side of the vehicle **9**, and the middle seat **90***b*

is located between the front seat **90***a* and the rear seat **90***c* in the front-rear direction of the vehicle **9**. The vehicle **9** has an automatic driving function and can travel even when the driver is not seated on the front seat **90***a.*

(9) The front seat **90***a*, the middle seat **90***b*, and the rear seat **90***c* are provided with weight sensors **91***a* to **91***c*, respectively. The weight sensors **91***a* to **91***c* detect the presence or absence of seated occupants by detecting a load applied to the front seat **90***a*, the middle seat **90***b*, and the rear seat **90***c*, respectively. In other words, the weight sensors **91***a* to **91***c* detect the position at which the occupant is seated. The detection means of the boarding position is not limited to the weight sensors **91***a* to **91***c*, and other detection means such as human sensors may be used.

(10) The vehicle **9** also includes a sensor system **95**. The sensor system **95** includes various sensors that determine operations of the engine **92** and the motor generator **94**, such as an accelerator opening degree sensor that detects the opening degree of the accelerator and a vehicle speed sensor that detects a vehicle speed. The location of the sensor system **95** in FIG. **1** is independent of the actual location in the vehicle **9**.

(11) The control device **1** is, for example, a computer such as an electronic control unit (ECU), and is provided at a predetermined position of the vehicle **9**. The control device **1** includes a central processing unit (CPU) **10**, a read only memory (ROM) **11**, a random access memory (RAM) **12**, a storage memory **13**, and a communication interface unit (communication IF) **14**. The CPU **10** is electrically connected to the ROM **11**, the RAM**12**, the storage memory **13**, and the communication IF **14** via a bus **19** so that signals can be input and output to and from each other.

(12) The ROM **11** stores a program for driving the CPU **10**. The RAM**12** serves as a working memory for the CPU **10**. The communication IF **14** is a communication circuit and transmits, for example, various instructions to the engine **92**, the inverter **93**, and the motor generator **94**.

(13) When reading the program from the ROM **11**, the CPU **10** generates a control unit **100**, a sensor value acquisition unit **101**, and a boarding position acquisition unit **102** as functions. Noise characteristic data **130** is stored in the storage memory **13**. The storage memory **13** is a nonvolatile memory such as a flash memory, for example.

(14) The sensor value acquisition unit **101** acquires various sensor values such as the accelerator opening degree and the vehicle speed from the sensor system **95** via the communication IF **14**. The sensor value acquisition unit **101** outputs various sensor values to the control unit **100**.

(15) The boarding position acquisition unit **102** is an example of an acquisition unit that acquires each of the positions on which the occupants are seated. The boarding position acquisition unit **102** acquires a detection result of the presence or absence of an occupant in each of the front seat **90***a*, the middle seat **90***b*, and the rear seat **90***c* from the weight sensors **91***a* to **91***c*. Here, the front seat **90***a*, the middle seat **90***b*, and the rear seat **90***c* are examples of positions at which the occupants are seated. The boarding position acquisition unit **102** outputs the detection result of the boarding position to the control unit **100**.

(16) The control unit **100** controls the engine **92**, the inverter **93**, and the motor generator **94**. The control unit **100** calculates a command torque from each sensor value and controls, for example, a fuel injection amount of the engine **92** and a duty ratio of a pulse width modulation (PWM) signal of the inverter **93** according to the command torque. In the case of automatic driving, the control unit **100** controls the engine **92**, the inverter **93**, and the motor generator **94** based on an image of an in-vehicle camera (not illustrated), a detection result of a peripheral vehicle, location information of the vehicle **9**, and the like. In this manner, the outputs of the engine **92** and the motor generator **94** are determined.

(17) Further, the control unit **100** determines whether the noise of the engine **92** is required to be reduced based on the distance between the boarding position of the occupant and the engine **92**, and reduces the noise by controlling the engine **92** according to the determination result. For example, based on the detection result of the boarding position, when the front seat **90***a* and the middle seat **90***b*, which are close to the engine **92**, are the boarding positions, the control unit **100**

reduces the noise, and when the rear seat **90***c*, which is farther from the engine **92**, is the boarding position, the control unit **100** does not reduce the noise.

(18) Therefore, when an occupant is seated only in the rear seat **90***c* where noise is lower than that in the front seat **90***a* and the middle seat **90***b*, the control unit **100** does not reduce noise and can omit unnecessary control. Thus, the control unit **100** can appropriately improve the comfort of the occupant.

(19) The control unit **100** reduces the noise of the engine **92** by reducing the output of the engine **92** based on the distance between the boarding position of the occupant and the engine **92**. For example, when the middle seat **90***b* is the boarding position, the control unit **100** reduces the output of the engine **92** so that noise is reduced according to the distance between the middle seat **90***b* and the engine **92**. Therefore, the control unit **100** can appropriately improve the comfort of the occupant according to the boarding position of the occupant.

(20) When a plurality of occupants are on board, the control unit **100** reduces the output of the engine **92** based on the shortest distance among the distances between the boarding positions of the occupants and the engine **92**. For example, when the front seat **90***a* and the middle seat **90***b* are the boarding positions, the distance between the front seat **90***a* and the engine **92** is shorter than the distance between the middle seat **90***b* and the engine **92**. Therefore, the control unit **100** reduces the output of the engine **92** so that the noise is reduced according to the distance between the front seat **90***a* and the engine **92**. Therefore, the control unit **100** can control the degree of noise reduction based on the boarding position closest to the engine **92**.

(21) The control unit **100** reduces the output of the engine **92** based on the correlation between the output of the engine **92** and the magnitude of the noise so that the noise of the engine **92** is reduced according to the distance between the boarding position of the occupant and the engine **92**. The noise characteristic data **130** indicates a correlation between the output of the engine **92** and the magnitude of noise.

(22) FIG. **2** illustrates an example of the noise characteristic data **130**. In FIG. **2**, the horizontal axis represents the rotation speed (rotation number) (rpm) of the engine **92**, and the vertical axis represents the torque (N/m) of the engine **92**. Each of the noise-level contours La to Le indicates rotation speeds and torques at which the noise level (for example, decibel (dB)) is the same. The noise level increases in the order of the noise-level contours La to Le.

(23) The control unit **100** determines the base operating point Po based on the detection result of the sensor system **95** or the like. Here, the base operating point Po is located, for example, on the noise-level contour Ld. When reducing noise, the control unit **100** reduces the output of the engine **92** to the output of one of, for example, the operating points Pa and Pb on the respective noise-level contours La and Lb whose noise level are lower than that of the noise-level contour Ld of the base operating point Po. For example, when reducing the output of the engine **92** to the operating point Pb, the control unit **100** reduces the torque and the rotation speed by the torque difference ΔT and the rotation speed difference ΔN from those of the base operating point Po, respectively.

(24) The control unit **100** determines the target operating point Pa or Pb based on the shortest distance between the boarding position and the engine **92**. Specifically, the control unit **100** selects the operating points Pa or Pb of the noise level suitable for the boarding position of the occupant closest to the engine **92**. For example, when the boarding position closest to the engine **92** is the front seat **90***a*, the operating point Pa is selected, and when the boarding position closest to the engine **92** is the middle seat **90***b*, the operating point Pb is selected. Therefore, as the shortest distance between the boarding position and the engine **92** becomes shorter, the output of the engine **92** is reduced and the magnitude of the noise is appropriately reduced.

(25) The noise characteristic data **130** is generated in advance based on a simulation or an experiment related to the noise of the engine **92**. The control unit **100** does not need to reduce both the torque and the rotation speed of the engine **92**, and may reduce only one of the torque and the rotation speed.

Noise Reduction Process

(26) FIG. **3** is a flowchart illustrating an example of the noise reduction process. This process is an example of a control method, and is executed periodically, for example. First, a boarding position acquisition unit **102** acquires the detection result of the boarding position from each of the weight sensors **91***a* to **91***c* (step SU). Then, the control unit **100** determines whether an occupant is seated on the front seat **90***a* (step St**2**).

(27) When an occupant is seated on the front seat **90***a* (Yes in step St**2**), the control unit **100** determines the noise reduction level to be "high" (step St**3**). In this case, the control unit **100** selects the operating point Pa on the noise-level contour La in the example described above.

(28) When no occupant is seated on the front seat **90***a* (No in step St**2**), the control unit **100** determines whether an occupant is seated on the middle seat **90***b* (step St**6**). When an occupant is seated on the middle seat **90***b* (Yes in step St**6**), the control unit **100** determines the noise reduction level to be "low" (step St**7**). In this case, the control unit **100** selects the operating point Pb on the noise-level contour Lb in the example described above.

(29) Then, the control unit **100** calculates a reduction amount of the output of the engine **92** corresponding to the noise reduction level (step St**4**). Based on the noise characteristic data **130**, the control unit **100** calculates the reduction amounts (ΔT and ΔN in FIG. **2**) of the output of the engine **92** corresponding to the selected operating point Pa or Pb.

(30) Then, the control unit **100** reduces the output of the engine **92** by the reduction amount (step St**5**). Specifically, the control unit **100** reduces the output of the engine **92** so that the control point transitions from the base operating point Po to the selected operating point Pa or Pb. In this manner, the control unit **100** reduces the output of the engine **92** based on the noise characteristic data **130** so that the noise is reduced according to the shortest distance between the engine **92** and the boarding position. This improves the comfort of the occupants in the front seat **90***a* and the middle seat **90***b*.

(31) When no occupant is seated on the middle seat **90***b* (No in step St**6**), the control unit **100** ends the process without reducing the output of the engine **92**. That is, when the rear seat **90***c* is the boarding position, the influence of the noise on the occupant in the rear seat **90***c* is small, and thus the control unit **100** does not reduce the noise. In this manner, the control unit **100** determines whether noise reduction is necessary based on the distance between the boarding position and the engine **92**. Therefore, when the effectiveness of the noise reduction is low, unnecessary control of the engine **92** can be omitted.

Example of Noise Reduction

(32) FIG. **4** is a diagram illustrating an example of the magnitude of the noise level according to boarding patterns A to C of occupants. In FIG. **4**, the same components as those in FIG. **1** are denoted by the same reference numerals, and the description thereof is omitted.

(33) In the boarding pattern A, occupants **8** are seated on the front seat **90***a*, the middle seat **90***b*, and the rear seat **90***c*, respectively. In the boarding pattern B, no occupant **8** is seated on the front seat **90***a*, and the occupants **8** are seated on the middle seat **90***b* and the rear seat **90***c*. In the boarding pattern C, no occupant **8** is seated on the front seat **90***a* and the middle seat **90***b*, and the occupant **8** is seated on the rear seat **90***c*.

(34) The boarding position acquisition unit **102** identifies the boarding position of the occupant **8** from the detection results acquired from the weight sensors **91***a* to **91***c*. The control unit **100** sets the noise reduction level based on the boarding position.

(35) In the case of the boarding pattern A, the boarding position closest to the engine **92** is the front seat **90***a*. Here, the distance between the front seat **90***a* and the engine **92** is defined as Da. In the case of the boarding pattern B, the boarding position closest to the engine **92** is the middle seat **90***b*. Here, the distance between the middle seat **90***b* and the engine **92** is defined as Db. In the case of the boarding pattern C, the boarding position closest to the engine **92** is the rear seat **90***c*. Here, the distance between the rear seat **90***c* and the engine **92** is defined as Dc. Among the distances Da to

Dc of the boarding patterns A to C, Da<Db<Dc is established. In the cases of the boarding patterns B and C in which there is no occupant **8** in the front seat **90***a*, the vehicle **9** is driven by automatic driving.

(36) The control unit **100** determines whether noise reduction is necessary based on the distances Da to Dc. In the case of the boarding pattern C, since the distance Dc is longer than other distances Da and Db, the control unit **100** determines that noise reduction is unnecessary and does not execute noise reduction. On the other hand, in the case of the boarding patterns A and B, noise reduction is executed.

(37) When executing noise reduction, the control unit **100** sets the noise reduction level so that the noise level is lower as the distances Da and Db are longer. In the case of the boarding pattern A, the noise reduction level is set to "high", and in the case of the boarding pattern B, the noise reduction level is set to "low".

(38) Therefore, the noise level of the engine **92** is the lowest in the boarding pattern A, and is the second lowest in the boarding pattern B. Further, the noise level of the boarding pattern C is the highest. As described above, the control device **1** can appropriately execute noise reduction according to the distance between the engine **92** and the boarding position.

(39) Although noise reduction of the engine **92** has been described as an example in the present embodiment, the above-described control method can also be used for noise reduction of the motor generator **94**, for example. In this case, the control unit **100** executes noise reduction by controlling the carrier frequency of the inverter **93**. As the carrier frequency increases, the noise decreases but the switching loss increases. The control unit **100** can appropriately reduce noise by controlling the carrier frequency according to the distances Da to Dc between the motor generator **94** and the respective boarding positions in the same manner as described above. Further, the control unit **100** is not limited to this, and may control the rotation speed of the motor generator **94** or the duty ratio of the PWM signal of the inverter **93** so that noise is reduced.

Other Embodiments

(40) In the above example, the vehicle **9** is a front-engine vehicle. However, this does not intend to suggest any limitation, and the above control method can be similarly used in a rear-engine vehicle.

(41) FIG. **5** is a diagram illustrating an example of the magnitude of the noise level according to boarding patterns X to Z of occupants in another vehicle **9***a*. In FIG. **5**, the same components as those in FIG. **4** are denoted by the same reference numerals, and description thereof is omitted. The vehicle **9***a* is a rear-engine vehicle, and the engine **92**, the invertor **93**, and the motor generator **94** are located in the rear of the vehicle **9***a*.

(42) In the boarding pattern X, the occupants **8** are seated on the front seat **90***a*, the middle seat **90***b*, and the rear seat **90***c*, respectively. In the boarding pattern Y, no occupant **8** is seated on the rear seat **90***c*, and the occupants **8** are seated on the front seat **90***a* and the middle seat **90***b*, respectively. In the boarding pattern Z, no occupant **8** is seated on the middle seat **90***b* and the rear seat **90***c*, and the occupant **8** is seated on the front seat **90***a*.

(43) In the case of the boarding pattern X, the boarding position closest to the engine **92** is the rear seat **90***c*. Here, the distance between the rear seat **90***c* and the engine **92** is defined as Dx. In the case of the boarding pattern Y, the boarding position closest to the engine **92** is the middle seat **90***b*. Here, the distance between the middle seat **90***b* and the engine **92** is defined as Dy. In the case of the boarding pattern Z, the boarding position closest to the engine **92** is the front seat **90***a*. Here, the distance between the front seat **90***a* and the engine **92** is defined as Dz. Among the distances Dx to Dz of the boarding patterns X to Z, Dz>Dy>Dx is established.

(44) The control unit **100** determines whether noise reduction is necessary based on the distances Dx to Dz. In the case of the boarding pattern Z, since the distance Dz is longer than other distances Dx and Dy, the control unit **100** determines that noise reduction is unnecessary and does not execute noise reduction. On the other hand, in the case of the boarding patterns X and Y, noise reduction is executed.

(45) When executing noise reduction, the control unit **100** sets the noise reduction level so that the noise level is lower as the distances Dx and Dy are longer. In the case of the boarding pattern X, the noise reduction level is set to "high", and in the case of the boarding pattern Y, the noise reduction level is set to "low".

(46) Therefore, the noise level of the engine **92** is the lowest in the boarding pattern X, and is the second lowest in the boarding pattern Y. Further, the noise level of the boarding pattern Z is the highest. As described above, the control device **1** can appropriately execute the noise reduction according to the distance between the engine **92** and the boarding position also in the case of the rear-engine vehicle **9***a*.

(47) FIG. **6** is a flowchart illustrating another example of the noise reduction process. This process is executed in the case of the rear-engine vehicle **9***a* described above. In FIG. **6**, the same processes as those in FIG. **3** are denoted by the same reference numerals, and description thereof will be omitted.

(48) After the process of step St**1**, when an occupant is seated on the rear seat **90***c* (Yes in step St**2***a*), the control unit **100** determines the noise reduction level to be "high" (step St**3**). When no occupant is seated on the rear seat **90***c* (No in step St**2***a*), the control unit **100** determines whether an occupant is seated on the middle seat **90***b* (step St**6**). When an occupant is seated on the middle seat **90***b* (Yes in step St**6**), the control unit **100** determines the noise reduction level to "low" (step St**7**). When no occupant is seated on the middle seat **90***b* (No in step St**6**), the control unit **100** ends the process without reducing the output of the engine **92**. The noise reduction process is executed in this manner.

(49) In each of the examples described above, the number of rows of seats in the vehicles **9** and **9***a* is three, but is not limited thereto. For example, even when the number of rows of seats is large as in a bus, the above-described control method can be similarly used.

(50) Although some embodiments of the present invention have been described in detail, the present invention is not limited to the specific embodiments but may be varied or changed within the scope of the present invention as claimed.

Claims

1. A control device comprising: an acquisition unit configured to acquire a position at which one or more occupants of a vehicle are seated; and a controller configured to determine necessity of reduction of noise of a drive source of the vehicle based on a distance between the position and the drive source of the vehicle, and reduce the noise by controlling the drive source according to a determination result of the necessity of the reduction of the noise.

2. The control device according to claim 1, wherein the control unit reduces the noise by reducing an output of the drive source according to the distance between the position and the drive source.

3. The control device according to claim 2, wherein the control unit reduces the output of the drive source based on a correlation between the output of the drive source and a magnitude of the noise so that the noise of the drive source is reduced according to the distance between the position and the drive source.

4. The control device according to claim 1, wherein the drive source is an internal combustion engine.

5. A control method implemented by a computer, the control method comprising: acquiring a position at which one or more occupants of a vehicle are seated; determining necessity of reduction of noise of a driving source of the vehicle based on a distance between the position and the driving source of the vehicle; and reducing the noise by controlling the driving source according to a determination result of the necessity of the reduction of the noise.