short. Accordingly, the second controller consumes a relatively small amount of electric power during the period from the time the second controller starts slowing down the vehicle until the vehicle stops (hereinafter referred to as the "deceleration period"). On the other hand, when the vehicle speed is relatively high at the time the second controller starts controlling the vehicle, the deceleration period is relatively long. The second controller therefore consumes a relatively large amount of electric power during the deceleration period. As described above, power consumption of the second controller during the deceleration period varies depending on the vehicle speed at the time the second controller starts controlling the vehicle. It is therefore necessary to determine the capacity of the battery in view of the maximum power consumption of the second controller. Accordingly, the vehicle needs to be equipped with a large-capacity battery. This increases the cost of the battery and thus increases the parts cost of the vehicle.

[0005] The present disclosure provides a vehicle electronic control device, vehicle electronic control method, and non-temporary storage medium that can reduce the parts cost of a vehicle.

[0006] A vehicle electronic control device according to a first aspect of the present disclosure includes: a detection device configured to detect a state of an occupant sitting in a seat where the occupant operates a driving operator of a vehicle; a first control device; and a second control device. The first control device is configured to be powered by a first battery mounted on the vehicle. The first control device is configured to refer to a database that defines in advance a relationship between the state of the occupant and a maximum allowable speed of the vehicle. The first control device is configured to identify the maximum allowable speed of the vehicle that corresponds to the state of the occupant. The state of the occupant is detected by the detection device. The first control device is configured to autonomously drive the vehicle at speeds equal to or lower than the identified maximum allowable speed of the vehicle. The second control device is configured to be powered by a second battery mounted on the vehicle. The second control device is configured to refer to a database that defines in advance a relationship between the state of the occupant and a first time. The first time is a time period required from when information for causing the

occupant to start manual driving by operating the driving operator is presented until the occupant starts the manual driving. The database that defines in advance the relationship between the state of the occupant and the first time is set in such a manner that the maximum allowable speed of the vehicle corresponding to a second state of the occupant is lower than the maximum allowable speed of the vehicle corresponding to a first state of the occupant when the first time corresponding to the second state is longer than the first time corresponding to the first state. The second control device is configured to identify the first time corresponding to the detected state of the occupant. The second control device is configured to start presenting the information to the occupant of the vehicle at a switching time that is a time at which the first control device becomes unable to control the vehicle; The second control device is configured to autonomously drive the vehicle from the switching time at speeds equal to or lower than the maximum allowable speed of the vehicle at the switching time. The maximum allowable speed of the vehicle at the switching time is such a speed that the vehicle is able to be stopped within a second time by slowing down the vehicle at deceleration whose absolute value is smaller than a predetermined value. The second time is battery duration minus the first time. The battery duration is a time period from when the second battery is in a fully charged state until the second battery is no longer able to continue to operate the second control device without being charged. The second control device is configured to stop the vehicle when the occupant does not start the manual driving during a period from the switching time until the identified first time elapses.

[0007] For example, the battery duration is a time period from the time at which the first battery becomes unable to supply electric power until the second battery can no longer supply electric power to the second control device in the case where the second battery continues to supply electric power to the second control device with maximum power consumption (value calculated in view of all driving conditions) of the second control device.

[0008] In order to apply the vehicle electronic control device according to the present disclosure to a vehicle, as large a space as possible is first secured in the vehicle and an energy storage device that can be housed in this space is used as the second battery. The maximum allowable speed for each state of the occupant may then be defined according to the capacity of the second battery. For example, when the mounting space for the second

of the vehicle. The vehicle electronic control method includes referring to a database that defines in advance a relationship between the state of the occupant and a maximum allowable speed of the vehicle by the first control device. The vehicle electronic control method includes identifying by the first control device the maximum allowable speed of the vehicle that corresponds to the state of the occupant. The state of the occupant is detected by the detection device. The vehicle electronic control method includes autonomously driving the vehicle at speeds equal to or lower than the identified maximum allowable speed of the vehicle by the first control device. The vehicle electronic control method includes referring to a database that defines in advance a relationship between the state of the occupant and a first time by the second control device. The first time is a time period required from when information for causing the occupant to start manual driving by operating the driving operator is presented until the occupant starts the manual driving. The database that defines in advance the relationship between the state of the occupant and the first time is set in such a manner that the maximum allowable speed of the vehicle corresponding to a second state of the occupant is lower than the maximum allowable speed of the vehicle corresponding to a first state of the occupant when the first time corresponding to the second state is longer than the first time corresponding to the first state. The vehicle electronic control method includes identifying the first time corresponding to the detected state of the occupant by the second control device. The vehicle electronic control method includes starting presenting the information to the occupant of the vehicle at a switching time that is a time at which the first control device becomes unable to control the vehicle by the second control device. The vehicle electronic control method includes autonomously driving the vehicle from the switching time at speeds equal to or lower than the maximum allowable speed of the vehicle at the switching time by the second control device. The maximum allowable speed of the vehicle at the switching time is such a speed that the vehicle is able to be stopped within a second time by slowing down the vehicle at deceleration whose absolute value is smaller than a predetermined value. The second time is battery duration minus the first time. The battery duration is a time period from when the second battery is in a fully charged state until the second battery is no longer able to continue to operate the second control device without being charged. The vehicle electronic control method includes

stopping the vehicle by the second control device when the occupant does not start the manual driving during a period from the switching time until the identified first time elapses.

[0013] A non-transitory storage medium according to a third aspect of the present disclosure stores instructions that are executable by one or more processors and that cause the one or more processors to perform functions of a vehicle electronic control device. The vehicle electronic control device includes: a detection device; a first control device configured to be powered by a first battery mounted on a vehicle; and a second control device configured to be powered by a second battery mounted on the vehicle. The functions include detecting by the detection device a state of an occupant sitting in a seat where the occupant operates a driving operator of the vehicle. The functions include referring to a database that defines in advance a relationship between the state of the occupant and a maximum allowable speed of the vehicle by the first control device. The functions include identifying by the first control device the maximum allowable speed of the vehicle that corresponds to the state of the occupant. The state of the occupant is detected by the detection device. The functions include autonomously driving the vehicle at speeds equal to or lower than the identified maximum allowable speed of the vehicle by the first control device. The functions include referring to a database that defines in advance a relationship between the state of the occupant and a first time by the second control device. The first time is a time period required from when information for causing the occupant to start manual driving by operating the driving operator is presented until the occupant starts the manual driving. The database that defines in advance a relationship between the state of the occupant and a first time is set in such a manner that the maximum allowable speed of the vehicle corresponding to a second state of the occupant is lower than the maximum allowable speed of the vehicle corresponding to a first state of the occupant when the first time corresponding to the second state is longer than the first time corresponding to the first state. The functions include identifying the first time corresponding to the detected state of the occupant by the second control device. The functions include starting presenting the information to the occupant of the vehicle at a switching time that is a time at which the first control device becomes unable to control the vehicle by the second control device. The functions include autonomously driving the

vehicle from the switching time at speeds equal to or lower than the maximum allowable speed of the vehicle at the switching time by the second control device. The maximum allowable speed of the vehicle at the switching time is such a speed that the vehicle is able to be stopped within a second time by slowing down the vehicle at deceleration whose absolute value is smaller than a predetermined value. The second time is battery duration minus the first time. The battery duration is a time period from when the second battery is in a fully charged state until the second battery is no longer able to continue to operate the second control device without being charged. The functions include stopping the vehicle by the second control device when the occupant does not start the manual driving during a period from the switching time until the identified first time elapses.

[0014] Other objects, other features, and accompanying advantages of the present disclosure are readily understood from the following description of an embodiment of the present disclosure that is given with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] 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 signs denote like elements, and wherein:

FIG. 1 is a block diagram of a vehicle to which a vehicle electronic control device according to an embodiment of the present disclosure is applied;

FIG. 2 is a block diagram of the vehicle electronic control device shown in FIG. 1;

FIG. 3 is a flowchart of a first autonomous driving program;

FIG. 4 is a conceptual diagram of a first database;

FIG. 5 is a flowchart of a second autonomous driving program;

FIG. 6 is a conceptual diagram of a second database;

FIG. 7A is a conceptual diagram illustrating a process in which a second central processing unit (CPU) takes over control of a vehicle from a first CPU to stop the vehicle; and

second driving force control device 23, the second braking force control device 24, and the second steering angle control device 25 based on the data acquired from the second sensor 21 to autonomously drive the vehicle V. The ~~allowable~~ maximum allowable speed Smax at this time is the speed at the time the second CPU takes over the control of the vehicle V from the first CPU.

[0045] In step 503, the second CPU causes the audio device AU to generate a warning sound AS in order to cause the occupant to operate the driving operators to start manual driving. This warning sound may be a message saying "Please start manual driving." At this time, the second CPU may cause the display device DI to display a message "Please start manual driving." That is, the second CPU warns the occupant using either visual or auditory means.

[0046] It takes a certain amount of time from when the warning sound AS is generated until the occupant is ready to perform the driving operation of the vehicle V. This time depends on the state of the occupant at the time the warning sound AS was generated. Therefore, the second CPU waits for the occupant to start the driving operation while autonomously driving the vehicle V. In the case where the occupant does not start the driving operation even after a predetermined first time T1 according to the state of the occupant at the time the warning sound AS was generated elapses, the second CPU slows down and stops the vehicle V. When the second CPU perceives that the occupant is asleep, the second CPU immediately starts the "process of slowing down and stopping the vehicle V."

[0047] Specifically, in step 504, the second CPU acquires data representing the state of the occupant from an occupant sensor 212, and perceives the state of the occupant based on the data.

[0048] A storage device of the second autonomous driving control device 22 stores a database D2 representing the relationship between the state of the occupant and the first time T1 shown in FIG. 6 in the form of a lookup table (map). Statistically obtained standard values (e.g., average values) have been assigned to the first time T1 corresponding to each state of the occupant. In step 505, the second CPU refers to the database D2 and identifies

is set in advance to such a value that neither makes the occupant feel uneasy nor requires the following vehicle to suddenly slow down.

[0052] The second time T2 is the battery duration Tmax (e.g., “60 seconds,” see FIGS. 7A and 7B) minus the first time T1 (T2 = Tmax – T1). The battery duration Tmax is the maximum time until the second battery P2 that is fully charged and that is not charged any more can no longer continue to operate the second controller 20. That is, the second time T2 is the time for which the second controller 20 can be operated with the maximum capacity of the second battery P2 minus the amount of power consumed by the second controller 20 within the first time T1. Accordingly, when the first time T1 is relatively short (e.g., “5 seconds”), the time T2 available to stop the vehicle V is relatively long (e.g., “55 seconds” (see FIG. 7A)). In this case, a relatively large value has therefore been assigned to the ~~allowable~~ maximum allowable speed Smax (see (a) of FIG. 4). On the other hand, when the first time T1 is relatively long (e.g., “30 seconds”), the time T2 available to stop the vehicle V is relatively short (e.g., “30 seconds” (see FIG. 7B)). A relatively small value has therefore been assigned to the maximum allowable speed Smax so that the vehicle V can be stopped within such a relatively short time T2 without making the occupant feel uneasy and without requiring the following vehicle to suddenly slow down (see (d) in FIG. 4).

[0053] As described above, the speed at which the first CPU autonomously drives the vehicle V is limited to values equal to or lower than the maximum allowable speed Smax according to the state of the occupant. The maximum allowable speed Smax is equal to the maximum value of the speed at which the second CPU can stop the vehicle V (e.g., the second CPU can slow down and stop the vehicle V at constant deceleration) within the second time T2, namely within the battery duration Tmax minus the first time T1, out of the speeds at the time the second CPU starts slowing down the vehicle V. In order to apply the vehicle electronic control device 1 configured as described above to the vehicle V, as large a space as possible is first secured in the vehicle V and an energy storage device that can be housed in this space is used as the second battery P2. The maximum allowable speed Smax for each state of the occupant is then defined according to the capacity of the second battery P2. For example, when the vehicle V is a small vehicle and the mounting space for the

CLAIMS

1. A vehicle electronic control device, characterized by comprising:

a detection device configured to detect a state of an occupant sitting in a seat where the occupant operates a driving operator of a vehicle;

a first control device configured to

be powered by a first battery mounted on the vehicle,

refer to a database that defines in advance a relationship between the state of the occupant and a maximum allowable speed of the vehicle,

identify the maximum allowable speed of the vehicle that corresponds to the state of the occupant, the state of the occupant being detected by the detection device, and

autonomously drive the vehicle at speeds equal to or lower than the identified maximum allowable speed of the vehicle; and

a second control device configured to

be powered by a second battery mounted on the vehicle,

refer to a database that defines in advance a relationship between the state of the occupant and a first time, the first time being a time period required from when information for causing the occupant to start manual driving by operating the driving operator is presented until the occupant starts the manual driving, and the database that defines in advance the relationship between the state of the occupant and the first time being set in such a manner that the maximum allowable speed of the vehicle corresponding to a second state of the occupant is lower than the maximum allowable speed of the vehicle corresponding to a first state of the occupant when the first time corresponding to the second state is longer than the first time corresponding to the first state,

identify the first time corresponding to the detected state of the occupant,

start presenting the information to the occupant of the vehicle at a switching time that is a time at which the first control device becomes unable to control the vehicle,

autonomously drive the vehicle from the switching time at speeds equal to or lower than the maximum allowable speed of the vehicle at the switching time, the maximum allowable speed of the vehicle at the switching time being such a speed that the vehicle is able to be stopped within a second time by slowing down the vehicle at deceleration whose absolute value is smaller than a predetermined value, the second time being battery duration minus the first time, and the battery duration being a time period from when the second battery is in a fully charged state until the second battery is no longer able to continue to operate the second control device without being charged, and

stop the vehicle when the occupant does not start the manual driving during a period from the switching time until the identified first time elapses.

2. The vehicle electronic control device according to claim 1, wherein:

the detection device includes a first detection device and a second detection device;

the first control device is configured to identify the maximum allowable speed of the vehicle that corresponds to the state of the occupant, the state of the occupant being detected by the first detection device; and

the second control device is configured to identify the first time corresponding to the state of the occupant detected by the second detection device.

3. A vehicle electronic control method applied to a vehicle electronic control device including a detection device, a first control device configured to be powered by a first battery mounted on a vehicle, and a second control device configured to be powered by a second battery mounted on the vehicle, the vehicle electronic control method characterized by comprising:

detecting by the detection device a state of an occupant sitting in a seat where the occupant operates a driving operator of the vehicle;

referring to a database that defines in advance a relationship between the state of the occupant and a maximum allowable speed of the vehicle by the first control device;

identifying by the first control device the maximum allowable speed of the vehicle that corresponds to the state of the occupant, the state of the occupant being detected by the detection device;

autonomously driving the vehicle at speeds equal to or lower than the identified maximum allowable speed of the vehicle by the first control device;

referring to a database that defines in advance a relationship between the state of the occupant and a first time by the second control device, the first time being a time period required from when information for causing the occupant to start manual driving by operating the driving operator is presented until the occupant starts the manual driving, and the database that defines in advance the relationship between the state of the occupant and the first time being set in such a manner that the maximum allowable speed of the vehicle corresponding to a second state of the occupant is lower than the maximum allowable speed of the vehicle corresponding to a first state of the occupant when the first time corresponding to the second state is longer than the first time corresponding to the first state,;

identifying the first time corresponding to the detected state of the occupant by the second control device;

starting presenting the information to the occupant of the vehicle at a switching time that is a time at which the first control device becomes unable to control the vehicle by the second control device;

autonomously driving the vehicle from the switching time at speeds equal to or lower than the maximum allowable speed of the vehicle at the switching time by the second control device, the maximum allowable speed of the vehicle at the switching time being such a speed that the vehicle is able to be stopped within a second time by slowing down the vehicle at deceleration whose absolute value is smaller than a predetermined value, the second time being battery duration minus the first time, and the battery duration being a time period from when the second battery is in a fully charged state until the second battery is no longer able to continue to operate the second control device without being charged; and

stopping the vehicle by the second control device when the occupant does not start the manual driving during a period from the switching time until the identified first time elapses.

4. A non-transitory storage medium storing instructions that are executable by one or more processors and that cause the one or more processors to perform functions of a vehicle electronic control device, the vehicle electronic control device including a detection device, a first control device configured to be powered by a first battery mounted on a vehicle, and a second control device configured to be powered by a second battery mounted on the vehicle, the functions characterized by comprising:

detecting by the detection device a state of an occupant sitting in a seat where the occupant operates a driving operator of the vehicle;

referring to a database that defines in advance a relationship between the state of the occupant and a maximum allowable speed of the vehicle by the first control device;

identifying by the first control device the maximum allowable speed of the vehicle that corresponds to the state of the occupant, the state of the occupant being detected by the detection device;

autonomously driving the vehicle at speeds equal to or lower than the identified maximum allowable speed of the vehicle by the first control device;

referring to a database that defines in advance a relationship between the state of the occupant and a first time by the second control device, the first time being a time period required from when information for causing the occupant to start manual driving by operating the driving operator is presented until the occupant starts the manual driving, and the database that defines in advance the relationship between the state of the occupant and the first time being set in such a manner that the maximum allowable speed of the vehicle corresponding to a second state of the occupant is lower than the maximum allowable speed of the vehicle corresponding to a first state of the occupant when the first time corresponding to the second state is longer than the first time corresponding to a first state of the occupant;

identifying the first time corresponding to the detected state of the occupant by the

second control device;

starting presenting the information to the occupant of the vehicle at a switching time that is a time at which the first control device becomes unable to control the vehicle by the second control device;

autonomously driving the vehicle from the switching time at speeds equal to or lower than the maximum allowable speed of the vehicle at the switching time by the second control device, the maximum allowable speed of the vehicle at the switching time being such a speed that the vehicle is able to be stopped within a second time by slowing down the vehicle at deceleration whose absolute value is smaller than a predetermined value, the second time being battery duration minus the first time, and the battery duration being a time period from when the second battery is in a fully charged state until the second battery is no longer able to continue to operate the second control device without being charged; and

stopping the vehicle by the second control device when the occupant does not start the manual driving during a period from the switching time until the identified first time elapses.