OPERATION ASSIST APPARATUS

Abstract

An operation assist apparatus is configured to execute an operation assist control, which includes a first mode and a second mode, for assisting an operation of a driver when a vehicle travels to a target space. Whether the operation assist control is executed in the first mode or the second mode is selected. The operation assist apparatus acquires a target route to the target space when the operation assist control is executed. The operation assist apparatus execute an automatic driving control for automatically controlling at least a steered angle of the vehicle such that the vehicle travels along the target route when the first mode is selected, and controls a travel state of the vehicle according to a manual operation of the driver without executing the automatic driving control and display the target route on a display of the vehicle, when the second mode is selected.

Inventors:	**SHIMOMURA; Ichiya (Nagoya-shi, JP)**
Applicant:	**TOYOTA JIDOSHA KABUSHIKI KAISHA** (Aichi, JP)
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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates to an operation assist apparatus configured to execute an operation assist control for assisting a driver's operation for traveling the vehicle to a target space.

[0002] Conventionally, there has been known an operation assist apparatus configured to execute an automatic parking control as an operation assist control. For example, the operation assist apparatus described in Patent Document 1 (hereinafter referred to as a "conventional apparatus") executes the automatic parking control. More specifically, in the automatic parking control, the conventional apparatus obtains a target route from the current position of a vehicle to a target space, and controls a travel state of the vehicle such that the vehicle automatically travels along the target route. [0003] Patent Document 1: Japanese Patent Application Laid-Open No. 2021-062679

SUMMARY

[0004] The conventional apparatus automatically parks the vehicle in the target space, so the driver does not need to perform any operations for parking the vehicle. For this reason, the conventional apparatus is unlikely to improve a parking skill of the driver to park the vehicle.

[0005] The present disclosure is made to address the above problem. That is, one of objects of the present disclosure is to provide the operation assist apparatus that can improve the driver's operation skill for traveling the vehicle to the target space.

[0006] An operation assist apparatus (hereinafter, referred to as "the present disclosure apparatus") according to the present disclosure executes an operation assist control for assisting an operation of a driver when a vehicle travels to a target space. The operation assist control includes a first mode and a second mode. Whether the operation assist control is executed in the first mode or the second mode is selected.

[0007] The operation assist apparatus is configured to: [0008] acquire a target route to the target space when the operation assist control is executed (step **330**); [0009] execute an automatic driving control for automatically controlling at least a steered angle of the vehicle such that the vehicle travels along the target route (step **525** to step **530**) when the first mode is selected ("Yes" at step **515**); and [0010] control a travel state of the vehicle according to a manual operation of the driver without executing the automatic driving control ("No" at step **515**) and display the target route on a display of the vehicle ("Yes" at step **435**, step **445**), when the second mode is selected.

[0011] According to the present disclosure apparatus, the automatic driving control is not executed when the second mode is selected. Therefore, the driver needs to perform the manual operation. In this case, the target route is displayed on the display, so the driver performs the manual operation such that the vehicle travels along the target route. Accordingly, the operation assist can improve the driver's operation skill.

[0012] In one aspect of the present disclosure apparatus, the operation assist apparatus is configured to be able to execute a guidance control for outputting at least one of an operation guidance relating to the manual operation that the driver should perform and a confirmation guidance relating to an area to which the driver should pay attention, when the operation assist control is executed (FIG. **7**).

[0013] According to the aspect, the driver can perform the manual operation for moving the vehicle to the target space based on the operation guidance. The driver can pay attention to the area which the driver should pay attention until the vehicle arrives at the target space based on the confirmation guidance. Accordingly, the operation assist can improve the driver's operation skill.

[0014] In one aspect of the present disclosure apparatus, [0015] the operation assist apparatus is configured to a steering assist control for notifying the driver that an excessive condition is satisfied (step **835**, step **845**) when the excessive condition is satisfied.

[0016] The excessive condition is satisfied when a steering wheel of the vehicle is operated such that a steering angle of the steering wheel is greater than a target steering angle for the vehicle to travel along the target route ("Yes" at step **828**, "Yes" at step **838**) and a magnitude of a difference between the steering angle and the target steering angle is equal to or greater than a predetermined threshold ("Yes" at step **830**, "Yes" at step **840**).

[0017] According to the aspect, when the excessive condition is satisfied, the driver can know that the driver turns the steering wheel too much. Accordingly, the operation assist apparatus can increase a probability that the driver operates the steering wheel in the appropriate position.

[0018] In one aspect of the present disclosure apparatus, [0019] the operation assist apparatus is configured to inhibit the steering wheel from being operated to a direction where the steering angle exceeds the target steering angle (step **835**, step **845**), when the excessive condition is satisfied.

[0020] According to the aspect, the operation of the steering wheel in the direction that exceeds the target steering angle is inhibited (interfered), so the driver can quickly know the driver turns the steering wheel too much.

[0021] In one aspect of the present disclosure, [0022] the second mode includes a third mode and a fourth mode (FIG. **9**), and [0023] the operation assist apparatus is configured to provide weaker assist to the driver when the fourth condition is selected than when the third condition is selected.

[0024] The driver can select between the third mode, which provides strong assist, and the fourth mode, which provides weak assist, based on the driver's operation skill.

[0025] In the above aspect, [0026] the fourth mode is can be selected when a predetermined release condition is satisfied, and [0027] the operation assist apparatus is configured to: [0028] acquire a route deviation amount representing an amount of deviation from the target route and a completion deviation amount representing an amount of deviation from the target space when parking is complete in the target space (step **1020**, step **1030**), when the third mode is selected ("Yes" at step **1010**, "Yes" at step **1025**); [0029] determine whether or not a pass condition is satisfied each time at which parking is complete in the target space in the third mode (step **1035**, step **1040**), [0030] wherein, the pass condition is satisfied when the route deviation amount is equal to or smaller than a predetermined first threshold amount and the completion deviation amount is equal to smaller than a predetermined second threshold amount; and [0031] determine that the release condition is satisfied when the number of times that the pass condition is satisfied is equal to or greater than a predetermined threshold.

[0032] According to the aspect, the fourth mode, which provides the weak assist, can only be selected when it is determined that the driver's operation skill improves in the third mode, which provides the strong assist. This provides an incentive for the driver to select the second mode.

[0033] In the above aspect, [0034] the operation assist apparatus is configured to: [0035] be able to execute a guidance control and a steering assist control for when the second mode is selected, [0036] wherein, the guidance control is a control for outputting at least one of an operation guidance relating to the manual operation that the driver should perform and a confirmation guidance relating to an area to which the driver should pay attention (FIG. **6**, FIG. **7**), [0037] wherein, the steering assist control for notifying the driver that an excessive condition is satisfied when the excessive condition is satisfied (step **835**, step **845**), [0038] wherein, the excessive condition is satisfied when a steering wheel of the vehicle is operated such that a steering angle of the steering wheel is greater than a target steering angle for the vehicle to travel along the target route and a magnitude of a difference between the steering angle and the target steering angle is equal to or greater than a predetermined threshold; [0039] execute at least one of the guidance control and the steering assist control (FIG. **9**) when the third mode is selected; and [0040] execute neither the guidance control nor the steering assist control (FIG. **9**) when the fourth mode is selected.

[0041] According to the aspect, at least one of the guidance control and the steering assist control is executed in the third mode, and neither of the guidance control and the steering assist control is

executed in the fourth mode. As a result, the fourth mode provides weaker assist than the third mode.

[0042] In one aspect of the present disclosure apparatus, [0043] the operation assist apparatus is configured to: [0044] evaluate the manual operation until the vehicle arrives at the target space (step **1110**, step **1115**) when parking is complete in the target space in the second mode; and [0045] output a result of evaluating (step **1120**).

[0046] According to the aspect, the driver can know the objective evaluation results of the manual operation until the vehicle arrives at the target space.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0047] FIG. **1** is a schematic system configuration diagram of an operation assist apparatus according to an embodiment of the present disclosure.

[0048] FIG. **2** is a diagram for explaining an assist screen displayed on a display shown in FIG. **1**.

[0049] FIG. **3** is a flowchart illustrating a start determination routine executed by a CPU of an ECU shown in FIG. **1**.

[0050] FIG. **4** is a flowchart illustrating an assist screen display routine executed by the CPU of the ECU shown in FIG. **1**.

[0051] FIG. **5** is a flowchart illustrating an automatic parking control routine executed by the CPU of the ECU shown in FIG. **1**.

[0052] FIG. **6** is a diagram for explaining a guidance control according to a first modification example of the embodiment of the present disclosure.

[0053] FIG. **7** is a diagram for explaining a confirmation message and a guidance message according to the first modification example of the embodiment of the present disclosure.

[0054] FIG. **8** is a flowchart illustrating a part of an automatic parking control routine according to a second modification example of the embodiment of the present disclosure.

[0055] FIG. **9** is a table summarizing a relationship between learning modes according to a third modification example of the embodiment of the present disclosure and controls performed in each of the learning modes.

[0056] FIG. **10** is a flowchart illustrating an automatic parking control routine according to a fourth modification example of the embodiment of the present disclosure.

[0057] FIG. **11** is a flowchart illustrating an automatic parking control routine according to a fifth modification example of the embodiment of the present disclosure.

DETAILED DESCRIPTION

[0058] As shown in FIG. **1**, an operation assist apparatus **10** is applied to a vehicle VA. The operation assist apparatus **10** comprises components shown in FIG. **1**. In this specification, the "ECU **20**" is an electronic control unit with a microcomputer as a main part. The ECU **20** is also referred to as a control unit, a controller and a computer. The microcomputer includes a CPU (processor), a ROM, a RAM, and an interface (I/F), etc. Functions realized by the ECU **20** may be realized by multiple ECUs.

[0059] A camera **22** acquires image data by capturing a scenery around the vehicle VA. The ECU **20** acquires the image data from the camera **22**. A sonar **24** acquires sonar data on a position of object around the vehicle VA relative to vehicle VA. The ECU **20** acquires the sonar data from the sonar **24**.

[0060] A steering angle sensor **26** measures a steering angle θ of a steering wheel (not shown) of the vehicle VA. When the steering wheel is in a neutral position, the steering angle θ is "0 deg". When the steering wheel is rotated clockwise (to the right) from the neutral position, the steering angle θ becomes a positive value, and when the steering wheel is rotated counterclockwise (to the

left) from the neutral position, the steering angle θ becomes a negative value.

[0061] An assist start switch **28** is arranged in a position (for example, near the steering wheel) where the driver can operate the assist start switch **28** while sitting in a driver's seat in a cabin of the vehicle VA. The driver operates the assist start switch **28** when the driver wants to start the parking assist control.

[0062] A power train actuator **30** changes a driving force generated by a driving device (e.g., an internal combustion engine and/or an electric motor) of the vehicle VA. A brake actuator **32** controls a braking force applied to the vehicle VA. A steering motor **34** is incorporated in a steering mechanism **36**. The steering mechanism **36** is a mechanism for changing a steered angle of steered wheels of the vehicle VA in accordance with the steering angle θ. The steering motor **34** generates an automatic steering torque to change the steered angle in response to an instruction from the ECU **20**.

[0063] A PKB actuator **38** applies a parking brake force to wheels. The ECU **20** can maintain the vehicle VA in a stopped state by applying a parking brake force to the wheels using the PKB actuator **38**. A shift actuator **40** changes a shift range. The shift range includes a parking range (P), a forward range (D), and a reverse range (R).

[0064] A display **42** is arranged in a position where the driver can see the display **22** while sitting in the driver's seat in the cabin of the vehicle VA. For example, the display **42** is a touch panel display. Therefore, the driver can input data by touching the display **42**. A speaker **44** is installed in the cabin of the vehicle VA and outputs a voice message, etc.

Outline of Operation

[0065] The operation assist apparatus **10** executes the parking assist control for assisting a driver's operation for parking the vehicle VA in a target space, as an operation assist control for assisting the driver's operation for traveling the vehicle VA to the target space. The parking assist control is executed in either an automatic mode (a first mode) or a learning mode (a second mode). The driver can select which mode to execute the parking assist control in.

[0066] When the parking assist control is executed, the operation assist apparatus **10** acquires a target route to the target space. When the parking assist control is executed in the automatic mode, the operation assist apparatus **10** executes an automatic parking control, which is a type of an automatic driving control. In the automatic parking control, the operation assist apparatus **10** automatically controls at least the steering angle θ such that the vehicle VA can travel along the target route.

[0067] When the parking assist control is executed in the learning mode, the operation assist apparatus **10** controls a travel state of the vehicle VA according to a driver's manual operation without executing the automatic parking control. In other words, the operation assist apparatus **10** causes the vehicle VA to travel according to the driver's manual operation. In this case, the operation assist apparatus **10** displays the target route on the display **42**.

[0068] When the parking assist control is executed in the learning mode, the operation assist apparatus **10** displays an assist screen **200** shown in FIG. **2** on the display **42**. The assist screen **200** displays a travel direction image **210** and an overhead image **220**. The travel direction image **210** is an image of the scenery in a travel direction of the vehicle VA, and the overhead image **220** is an image of the scenery seen from directly above the vehicle VA.

[0069] Furthermore, in the assist screen **200**, an assist line **230** is displayed on the forward image **210** and the overhead image **220**. The assist line **230** is a line that a left edge and a right edge of a vehicle body of the vehicle VA trace when the vehicle VA travels along the target route. The driver can make the vehicle VA travel along the target route by operating the steering wheel of the vehicle VA such that the left edge and the right edge of the vehicle body of the vehicle trace the assist line **230**. Therefore, in the learning mode, the driver performs the manual operation while watching the assist line **230**, so the operation assist apparatus **10** can improve a parking skill of the driver.

Specific Operation

[0070] The CPU of the ECU **20** executes routines shown by flowcharts in FIGS. **3** to **5** every time a predetermined time elapses.

<Start Determination Routine>

[0071] When an appropriate time point comes, the CPU starts a process from step **300** in FIG. **3**. At step **305**, the CPU determines whether or not an assist flag Xast is "0".

[0072] The assist flag Xast is set to "1" when the parking assist control starts, and is set to "0" when the parking assist control ends. The assist flag Xast is set to "0" in an initialization routine. The initialization routine is executed by the CPU when an ignition key switch (not shown) of the vehicle VA is changed from an off position to an on position.

[0073] When the assist flag Xast is "0", the CPU makes a "Yes" determination at step **305** and the process proceeds to step **310**. At step **310**, the CPU determines whether or not the assist start switch **28** has been operated.

[0074] When the assist start switch **28** has not been operated, the CPU makes a "No" determination at step **310** and the process proceeds to step **395**. At step **395**, the CPU terminates the present routine tentatively.

[0075] When the assist start switch **28** has been operated, the CPU makes a "Yes" determination at step **310** and executes steps **315** and **320**. [0076] Step **315**: The CPU displays an initial screen on the display **42**. On the initial screen, the forward image **210** and the overhead image **220** are displayed in the same manner as on the assist screen **200**. In the forward image **210** and the overhead image **220**, a space where the vehicle VA can be parked is surrounded by a frame, and the driver can designate the target space by touching the frame. Furthermore, in the initial screen, a learning mode button (not shown) is displayed. [0077] Step **320**: The CPU determines whether or not the target space has been designated in the initial screen.

[0078] When the target space has not been designated, the CPU makes a "No" determination at step **320** and the process proceeds to Step **395**. At Step **395**, the CPU terminates the present routine tentatively.

[0079] When the target space has been specified, the CPU makes a "Yes" determination at step **320** and executes steps **325** to **335**. [0080] Step **325**: The CPU sets the assist flag Xast to "1" and sets a learning flag Xlrn to "0".

[0081] The learning flag Xlrn is set to "1" when the parking assist control is executed in the learning mode, and is set to "0" when the parking assist control is executed in the automatic mode. The learning flag Xlrn is set to "0" in the initialization routine. [0082] Step **330**: The CPU recognizes an object around the vehicle VA based on the image data and the sonar data, and sets the target route from the current position of the vehicle VA to the target space such that the vehicle avoids the object. [0083] Step **335**: The CPU determines whether or not the learning mode button displayed on the initial screen has been operated within a predetermined time after the target space is designated.

[0084] When the learning mode button has not been operated, the CPU makes a "No" determination at step **335** and the process proceeds to step **395**. At Step **395**, the CPU terminates the present routine tentatively.

[0085] When the learning mode button has been operated, the CPU makes a "Yes" determination at step **335** and the process proceeds to step **340**. At Step **340**, the CPU sets the learning flag Xlrn to "1". Thereafter, the process proceeds to step **395** and the CPU terminates the present routine tentatively.

[0086] In a case where the assist flag Xast is "1" when the process proceeds to step **305**, the CPU makes a "No" determination at step **305** and the process proceeds to step **395**. At step **395**, the CPU terminates the present routine tentatively.

<Assist Screen Display Routine>

[0087] When an appropriate time point comes, the CPU starts a process from step **400** in FIG. **4**. At step **405**, the CPU determines whether or not the assist flag Xast is "1".

[0088] When the assist flag Xast is "0", the CPU makes a "No" determination at step **405**, and the process proceeds to step **495**. At step **495**, the CPU terminates the present routine tentatively.

[0089] When the assist flag Xast is "1", the CPU makes a "Yes" determination at step **405** and executes steps **410** to **420**. [0090] Step **410**: The CPU acquires the image data from the camera **22**. [0091] Step **415**: The CPU generates a 3D image based on the image data. [0092] Step **420**: The CPU determines whether or not the shift range is the parking range (P).

[0093] When the shift range is not the parking range (R), the CPU makes a "No" determination at step **420** and executes steps **425** to **435**. [0094] Step **425**: The CPU generates, based on the 3D image, a forward image of a forward direction of the vehicle VA as the travel direction image **210**. [0095] Step **430**: The CPU generates the overhead image **220** based on the 3D image. [0096] Step **435**: The CPU determines whether or not the learning flag Xlrn is "1".

[0097] When the learning flag Xlrn is "0", the CPU makes a "No" determination at step **435** and the process proceeds to step **440**. At step **440**, the CPU displays the assist screen **200** including the travel direction image **210** and the overhead image **220**, on the display **42**. Thereafter, the process proceeds to step **495** and the CPU terminates the present routine tentatively.

[0098] In a case where the learning flag Xlrn is "1" when the process proceeds to step **435**, the CPU makes a "Yes" determination at step **435** and the process proceeds to step **445**. At step **445**, the CPU embeds the assist line **230** in the travel direction image **210** and the overhead image **220**. Thereafter, at step **440**, the CPU displays the assist screen **200** including the travel direction image **210** and the overhead image **220** in which the assist lines **230** is embedded, on the display **42**. Thereafter, the process proceeds to step **495**, and the CPU terminates the present routine tentatively.

[0099] In a case where the shift range is the parking range (R) when the process proceeds to step **420**, the CPU makes a "Yes" determination at step **420**, and the process proceeds to step **450**. At step **450**, the CPU generates, based on the 3D image, a backward image of a backward direction of the vehicle VA as the travel direction image **210**. Thereafter, the process proceeds to step **430**.

[0100] In the present routine, when the learning flag Xlrn is "1", the assist line **230** is displayed on the travel direction image **210** and the overhead image **220** of the assist screen **200**. The driver manually operates the vehicle VA so that the vehicle VA travels along the assist line **230**. The operation assist apparatus **10** can improve the driver's parking skill.

<Automatic Parking Control Routine>

[0101] When an appropriate time point comes, the CPU starts a process from step **500** shown in FIG. **5**, and at step **505**, the CPU determines whether or not the assist flag Xast is "1".

[0102] If the assist flag Xast is "0", the CPU makes a "No" determination at step **505**, and the process proceeds to step **595**. At step **595**, the CPU terminates the present routine tentatively.

[0103] When the assist flag Xast is "1", the CPU makes a "Yes" determination at step **505** and the process proceeds to step **510**. At step **510**, the CPU determines whether or not the vehicle VA has arrived at the target space. For example, the CPU stores an image of an area near the target space that was acquired when the target space was specified, and then determines whether or not the vehicle VA has arrived at the target space by comparing the stored image with the image data acquired at the current time.

[0104] When the vehicle VA has not arrived at the target space, the CPU makes a "No" determination at step **510** and the process proceeds to step **515**. At Step **515**, the CPU determines whether or not the learning flag Xlrn is "0".

[0105] When the learning flag Xlrn is "0", the CPU makes a "Yes" determination at step **515** and executes steps **520** to **530**. [0106] Step **520**: The CPU again sets the target route from the current position of the vehicle VA to the target space. [0107] Step **525**: The CPU acquires the target steering angle θtgt for the vehicle VA to travel along the target route based on a deviation amount from the target route, the current direction of the vehicle VA, and the current steering angle θ.

[0108] Step **530**: The CPU controls the steering motor **34** such that the steering angle θ matches the target steering angle θtgt.

[0109] Thereafter, the process proceeds to step **595**, and the CPU terminates the present routine tentatively.

[0110] Steps **525** and **530** are a control for controlling the steered angle control to make the vehicle VA travel along the target route, and may be referred to as the "automatic parking control".

[0111] In a case where the vehicle VA has arrived at the target space when the process proceeds to step **510**, the CPU makes a "Yes" determination at step **510** and the process proceeds to step **535**. At step **535**, the CPU sets the assist flag Xast and the learning flag Xlrn to "0". As a result, the parking assist control ends.

[0112] When the vehicle VA has arrived at the target space, the CPU may activate the PKB actuator **38** to maintain the vehicle VA in the stopped state, and may also control the shift actuator **40** to change the shift range to the parking range (P).

[0113] Even if the learning flag Xlrn is "1" ("No" at step **515**), the CPU may again set the target route.

[0114] According to the present embodiment, when the learning flag Xlrn is "1", the automatic parking control is not executed, so the driver needs to park the vehicle VA manually. In this case, the assist line **230** is displayed on the travel direction image **210** and the overhead image **220** of the assist screen **200**. The driver manually operates the vehicle VA such that the vehicle VA travels along the assist line **230**. Therefore, the present embodiment can improve the driver's parking skill.

First Modification Example

[0115] In the present modification example, when the ECU **20** executes the parking assist control in the learning mode, the ECU **20** also executes a guidance control. In the guidance control, the ECU **20** displays, on the assist screen **200**, a confirmation message relating to an area to which the driver should pay attention according to a travel situation of the vehicle VA, and an operation message relating to the manual operation that the driver should perform according to the travel situation of the vehicle VA.

[0116] For example, the ECU **20** divides the parking route shown in FIG. **2** into the following four areas, and displays the confirmation message and the operation message according to the area where the vehicle VA is located.

[0117] First area: An area from a point at which the parking assist control starts to a change point TP

[0118] The transition point TP is a point at which the vehicle VA reverses the travel direction (in other words, a point at which the travel direction of the vehicle VA changes from forward to backward.).

[0119] Second area: The change point TP

[0120] Third area: An area from the change point TP to a point at which a rear wheel of vehicle VA passes a space edge SE

[0121] The space edge SE is a left front edge of the target space when the driver steers the steering wheel to the left and the vehicle VA travels backward. The space edge SE is the right front edge of the target space when the driver steers the steering wheel to the right and the vehicle VA travels backward. In an example shown in FIG. **2**, the space edge SE is the left front edge of the target space.

[0122] Fourth area: An area from a point at which the rear wheel passes the space edge SE to a point at which parking is complete.

[0123] When the ECU **20** executes the parking assist control in the learning mode, the ECU **20** specifies which area a reference point is located in. The reference point is the midpoint between a left rear wheel and a right rear wheel of the vehicle VA.

<First Area>

[0124] As shown in FIG. **6**, when the vehicle VA is located in the first area, the ECU **20** displays a first confirmation message and a first operation message in a confirmation message display area **240** and an operation message display area **250**, respectively.

[0125] As shown in FIG. **7**, the first confirmation message is a message to check a right front area. The first operation message is a message to steer the steering wheel to the right.

<Second Area>

[0126] As shown in FIG. **6**, when the vehicle VA is located in the second area, the ECU **20** displays a second confirmation message and a second operation message in the confirmation message display area **240** and the operation message display area **250**, respectively.

[0127] As shown in FIG. **7**, the second confirmation message is a message to check a left rear area. The second operation message is a message to change the shift range to the parking range.

<Third Area>

[0128] As shown in FIG. **6**, when the vehicle VA is located in the third area, the ECU **20** displays the second confirmation message and a third operation message in the confirmation message display area **240** and the operation message display area **250**, respectively.

[0129] As shown in FIG. **7**, the third operation message is a message to travel the vehicle VA backward while maintaining the steering wheel in the neutral position.

<Fourth Area>

[0130] As shown in FIG. **6**, when the vehicle VA is located in the fourth area, the ECU **20** displays a third confirmation message and a fourth operation message in the confirmation message display area **240** and the operation message display area **250**, respectively.

[0131] As shown in FIG. **7**, the third confirmation message is a message to check a left rear area and a right rear area. The fourth operation message is a message to steer the steering wheel to the left until the vehicle VA is parallel to the parking space.

[0132] In the present modification example, the confirmation message and the operation message are displayed on the display **42**, but the confirmation message and the operation message may also be output as audio messages from the speaker **44**. The control that outputs the confirmation message and the operation message is called a "guidance control". In the guidance control, at least one of the confirmation message and the operation message may be output.

[0133] As explained above, when the parking assist control is executed in the learning mode, the operation message (an operation guidance) and the confirmation message (a confirmation guidance) are output according to the area in which the vehicle VA is traveling. The driver performs "an operation for parking" specified by the operation message while looking at "an area to which the driver should pay attention" specified by the confirmation message. According to the present modification example, the driver can understand the operation that should be performed according to the travel condition of the vehicle VA and the area to which the driver should pay attention according to the travel condition of the vehicle VA, so the driver's parking skill can be improved.

Second Modification Example

[0134] In the present modification example, when an excessive condition is satisfied, the ECU **20** executes a steering assist control that notifies the driver that the excessive condition is established. The excessive condition is satisfied when the steering wheel is operated such that the steering angle θ is greater than the target steering angle θ_{tgt} (in other words, the steering wheel is operated beyond the target steering angle θ_{tgt}), and a magnitude of a difference ($\Delta\theta$) between the steering angle θ and the target steering angle θ_{tgt} is equal to or greater than a threshold. For example, in the steering assist control, the ECU **20** controls the steering motor **34** so as to inhibit the steering wheel from being operated to (in) a direction where the steering angle θ exceeds (becomes greater than) the target steering angle θ_{tgt}. In other words, the ECU **20** interferes a steering operation to a direction where the steering angle θ exceeds the target steering angle θ_{tgt}.

[0135] In the present modification example, when the CPU of the ECU **20** makes a "No" determination at step **515** shown in FIG. **5** (in other words, when the learning flag Xlrn is "1"), the CPU executes steps **805** to **825** shown in FIG. **8**. [0136] Step **805**: The CPU sets the target route. Step **805** is the same as step **520** shown in FIG. **5**, so a detailed explanation of step **805** is omitted.

[0137] Step **810**: The CPU acquires the target steering angle θ_{tgt}. Step **810** is the same as step **525**

shown in FIG. **5**, so a detailed explanation of step **810** is omitted. [0138] Step **815**: The CPU acquires the steering angle θ based on the detected value of the steering angle sensor **26**. [0139] Step **820**: The CPU acquires a difference Δθ by subtracting the target steering angle θtgt from the steering angle θ. [0140] Step **825**: The CPU determines whether or not the target steering angle θtgt is the negative value.

[0141] When the target steering angle θtgt is the negative value, the CPU makes a "Yes" determination at step **825** and the process proceeds to step **828**. At step **828**, the CPU determines whether or not the steering angle θ is smaller than the target steering angle θtgt.

[0142] When the steering angle θ is smaller than the target steering angle θtgt, the CPU makes a "Yes" determination at step **828** and the process proceeds to step **830**. At step **830**, the CPU determines whether or not a magnitude of the difference Δθ (|Δθ|) is greater than or equal to a "predetermined threshold θ1th".

[0143] When the magnitude of the difference Δθ (|Δθ|) is equal to or greater than the threshold θ1th, the CPU determines that the above excessive condition is satisfied. In this case, the CPU makes a "Yes" determination at step **830**, and the process proceeds to step **835**. At step **835**, the CPU controls the steering motor **34** such that it becomes difficult for the driver to steer the steering wheel to a direction (to the left) that exceeds the target steering angle θtgt (in other words, such that the steering operation to the left becomes heavier.). As a result, the CPU interferes (weighs) the steering operation to the left. In more detail, the steering motor **34** provides a torque to rotate the steering wheel to the right. Thereafter, the process proceeds to step **895**, and the CPU terminates the present routine tentatively.

[0144] On the other hand, when the magnitude of the difference Δθ (|Δθ|) is smaller than the threshold θ1th, the CPU determines that the above excessive condition is not satisfied. In this case, the CPU makes a "No" determination at step **830**, and the process proceeds to step **895**. At Step **895**, the CPU terminates the present routine tentatively.

[0145] In a case where the target steering angle θtgt is equal to or greater than "0" when the process proceeds to step **825**, the CPU makes a "No" determination at step **825** and the process proceeds to step **838**. At step **838**, the CPU determines whether or not the steering angle θ is greater than the target steering angle θtgt.

[0146] When the steering angle θ is greater than the target steering angle θtgt, the CPU makes a "Yes" determination at step **838** and the process proceeds to step **840**. At step **840**, the CPU determines whether or not the magnitude of the difference **40** (|Δθ|) is equal to or greater than the threshold θ1th.

[0147] When the magnitude of the difference Δθ (|Δθ|) is equal to or greater than the threshold θ1th, the CPU determines that the above excessive condition is satisfied. In this case, the CPU makes a "Yes" determination at step **840**, and the process proceeds to step **845**. At step **845**, the CPU controls the steering motor **34** such that the steering operation to the right becomes heavier. As a result, the CPU interferes (weighs) the steering operation to the right. Thereafter, the process proceeds to step **895**, and the CPU terminates the present routine tentatively.

[0148] On the other hand, when the magnitude of the difference Δθ (|Δθ|) is smaller than the threshold θ1th, the CPU determines that the above excessive condition is not satisfied. In this case, the CPU makes a "No" determination at step **840**, and the process proceeds to step **895**. At step **895**, the CPU terminates the present routine tentatively.

[0149] In a case where the steering angle θ is equal to or greater than the target steering angle θtgt when the process proceeds to step **828**, the CPU makes a "No" determination at step **828** and the process proceeds to step **850**. At step **850**, the CPU determines whether or not the magnitude of the difference Δθ (|Δθ|) is equal to or greater than a predetermined threshold θ2th.

[0150] When the magnitude of the difference (|Δθ|) is greater than or equal to the threshold θ2th, the CPU determines an insufficient condition is satisfied. The insufficient condition is satisfied when that the steering wheel is being operated without exceeding the target steering angle θtgt and

that the magnitude of the difference ($\Delta\theta$) between the steering angle θ and the target steering angle θtgt is equal to or greater than the threshold. In this case, the CPU makes a "Yes" determination at step **850** and the process proceeds to step **855**. At step **855**, the CPU controls the steering motor **34** such that it becomes easy for the driver to steer the steering wheel in a direction (to the left) that exceeds the target steering angle θtgt (in other words, such that the steering operation to the left becomes lighter.). In more detail, the steering motor **34** provides a torque to rotate the steering wheel to the left. Thereafter, the process proceeds to step **895**, and the CPU terminates the present routine tentatively.

[0151] When the magnitude of the difference ($|\Delta\theta|$) is smaller than the threshold θ2th, the CPU determines that the insufficient condition is not satisfied. In this case, the CPU makes a "No" determination at step **850**, and the process proceeds to step **895**. At step **895**, the CPU terminates the present routine tentatively.

[0152] In a case where the steering angle θ is equal to or smaller than the target steering angle θtgt when the process proceeds to step **838** and, the CPU makes a "No" determination at step **838** and the process proceeds to step **860**. At step **860**, the CPU determines whether or not the magnitude of the difference $\Delta\theta$ ($|\Delta\theta|$) is equal to or greater than the threshold θ2th.

[0153] When the magnitude of the difference $\Delta\theta$ ($|\Delta\theta|$) is equal to or greater than the threshold θ2th, the CPU determines that the insufficient condition is satisfied. In this case, the CPU makes a "Yes" determination at step **860**, and the process proceeds to step **855**. At Step **855**, the CPU controls the steering motor **34** such that the steering operation to the right becomes lighter. Thereafter, the process proceeds to step **895**, and the CPU terminates the present routine tentatively.

[0154] When the magnitude of the difference $\Delta\theta$ ($|\Delta\theta|$) is smaller than the threshold θ2th, the CPU determines that insufficient condition is not satisfied. In this case, the CPU makes a "No" determination at step **860**, and the process proceeds to step **895**. At step **895**, the CPU terminates the present routine tentatively.

[0155] According to the present modification example, when the excessive condition is satisfied, the steering operation to the direction that exceeds the target steering angle θtgt becomes heavier. Therefore, the driver can quickly know that the excessive condition is satisfied (i.e. that the driver turns the steering wheel too much). When the insufficient condition is satisfied, the steering operation to the direction that brings the steering angle θ closer to the target steering angle θtgt become lighter. Therefore, the driver can quickly know that the insufficient condition is satisfied (i.e. that the driver turns the steering wheel too little).

[0156] The parking assist control according to the present modification example notifies the driver that either the excessive condition or the insufficient condition is satisfied by controlling the steering motor **34** to change weight of the steering operation of the steering wheel, either the excessive condition or the insufficient condition is satisfied. However, the parking assist is not limited to this. For example, when either the excessive condition or the insufficient condition is satisfied, the parking assist control may display an animation on the assist screen **200** showing the steering operation of the steering wheel to match the target steering angle θtgt.

Third Modification Example

[0157] The learning mode according to the present modification example includes a full-auto learning mode, an assist learning mode, and a manual learning mode. The ECU **20** allows the driver to select which learning mode to use for the parking assist control after the learning mode button is operated on the initial screen.

[0158] As shown in FIG. **9**, in the full-auto learning mode, the ECU **20** displays the assist line **230**, and executes an automatic steering control and the guidance control. The driver selects the full-auto learning mode when the driver wants to learn the assist lines **230**, the operation message and confirmation messages without performing any manual operation to park the vehicle VA. In the full-auto learning mode, the automatic steering control is executed, so the driver does not need to operate the steering wheel. Therefore, the steering assist control is not executed in the full-auto

learning mode.

[0159] In the assist learning mode, the ECU **20** displays the assist line **230** and does not execute the automatic steering control. In the assist learning mode, the ECU **20** executes at least one of the guidance control and the steering assist control. The driver can select whether to execute either the guidance control or the steering assist control, or to execute both the guidance control and the steering assist control. The driver selects the assist learning mode when the driver performs the manual operation to park the vehicle VA and the driver needs to parking assist.

[0160] In the manual learning mode, the ECU **20** displays the assist line **230** and does not execute the automatic steering control, the guidance control, and the steering assist control. The driver selects the manual learning mode when the driver does not need any parking assist other than the assist line **230**.

[0161] The assist for the driver in the full-auto learning mode is the strongest. The assist for the driver in the assist learning mode is the next strongest. The assist for the driver in the manual learning mode is the weakest.

[0162] In the parking assist control, a mode in which the automatic steering control is executed is called as "a first mode", and a mode in which the automatic steering control is not executed is called as a "second mode". In the above embodiment, the learning mode is explained as the "second mode", but the full-auto learning mode of the present modification example is not included in the second mode.

[0163] According to the present modification example, the driver can select the learning mode that suits the driver's parking skill.

Fourth Modification Example

[0164] In the present modification example, the manual learning mode of the third modification example can only be selected when a predetermined release condition is satisfied. When the parking assistant control is being executed in the assist learning mode, the ECU **20** acquires a route deviation amount and a completion deviation amount. The route deviation amount represents an amount of deviation from the target route. The completion deviation amount represents an amount of deviation in a direction orientation of the vehicle VA with respect to the target space when parking is complete, and an amount of deviation in the position of the vehicle VA with respect to the target space when parking is complete. In a case where a pass condition is satisfied when parking is complete in the assist learning mode, the ECU **20** registers that the pass condition is satisfied. The pass condition is satisfied when the route deviation amount is equal to or smaller than a threshold amount Tth and the completion deviation amount is equal to or smaller than a threshold amount Dth.

[0165] When the number of times the pass condition is satisfies in the assist learning mode is equal to or greater than a threshold, the ECU **20** determines that the release condition is satisfied and enables the manual learning mode to be selected. The manual learning mode can only be executed when the parking skill have improved in the assist learning mode. This can also be used as an incentive for the driver to use the learning mode.

[0166] In the present modification example, the CPU of the ECU **20** executes a routine shown in FIG. **10** instead of the routine shown in FIG. **5**. In FIG. **10**, the same processes as in FIG. **5** are given the same symbols, and their explanations are omitted.

[0167] When an appropriate time comes, the CPU starts a process from step **1000** in FIG. **10**. If the assist flag Xast is "1" ("Yes" at step **505** in FIG. **10**) and the vehicle VA has not yet arrived at the target space ("No" at step **510** in FIG. **10**), the process proceeds to step **1005**.

[0168] At step **1005**, the CPU determines whether or not the learning flag Xlrn is "0" or the full-auto learning mode has been selected.

[0169] When the learning flag Xlrn is "0" or the full auto learning mode has been selected, the CPU makes a "Yes" determination at step **1005** and the process proceeds to step **520**. On the other hand, when the learning flag Xlrn is "1" and the full-auto learning mode has not been selected, the

CPU makes a "No" determination at step **1005** and the process proceeds to step **1010**.

[0170] At step **1010**, the CPU determines whether or not the assist learning mode has been selected. When the assist learning mode has been selected, the CPU makes a "Yes" determination at step **1010** and executes steps **1015** and **1020**. [0171] Step **1015**: The CPU sets the target route. [0172] Step **1020**: The CPU acquires the route deviation amount.

[0173] Thereafter, the process proceeds to step **1095**, and the CPU terminates the present routine tentatively.

[0174] When the assist learning mode has not been selected (i.e. when the manual learning mode has been selected), the CPU makes a "No" determination at step **1010** and the process proceeds to step **1095**. At step **1095**, the CPU terminates the present routine tentatively.

[0175] In a case where the vehicle VA arrives at the target space when the process proceeds to step **510** shown in FIG. **10**, the CPU makes a "Yes" determination at step **510** and executes step **535**. Thereafter, the process proceeds to step **1025**.

[0176] At step **1025**, the CPU determines whether or not the assist learning mode has been selected. When the assist learning mode has been selected, the CPU makes a "Yes" determination at step **1025** and executes steps **1030** and **1035**. [0177] Step **1030**: The CPU acquires the completion deviation amount. [0178] Step **1035**: The CPU determines whether or not a total value of the route deviation amount in the present assist learning mode is equal to or smaller than the threshold amount Tth.

[0179] When the total value is equal to or smaller than the threshold amount Tth, the CPU makes a "Yes" determination at step **1035** and the process proceeds to step **1040**. At Step **1040**, the CPU determines whether or not the completion deviation amount is equal to or smaller than the threshold amount Dth.

[0180] When the completion deviation amount is equal to or smaller than the threshold Dth, the CPU determines that the pass condition is satisfied. In this case, the CPU makes a "Yes" determination at Step **1040**, and the process proceeds to step **1045**. At step **1045**, the CPU registers that the pass condition is satisfied. Thereafter, the process proceeds to step **1095**, and the CPU terminates the present routine tentatively.

[0181] When the assist learning mode has not been selected ("No" at step **1025**), when the total value is greater than the threshold amount Tth ("No" at step **1035**), and when the completion deviation amount is greater than the threshold amount Dth ("No" at step **1040**), the process proceeds to step **1095**, and the CPU terminates the present routine tentatively.

[0182] The assist learning mode may include a first assist learning mode and a second assist learning mode. The assistance for the driver in the second assist learning mode is weaker than the assistance for the driver in the first assist learning mode. As an example, in the first assist learning mode, both the guidance control and the steering assist control are executed, and in the second assist learning mode, either the guidance control or the steering assist control is executed. When the number of times the pass condition is satisfies in the first assist learning mode is equal to or greater than the threshold, the release condition of the second assist learning mode is satisfied. In this case, the second assist learning mode can be selected.

Fifth Modification Example

[0183] In the present modification example, when a parking assist mode is being executed in the learning mode, the ECU **20** acquires the route deviation amount and the completion deviation amount. When parking is complete, the ECU **20** evaluates the manual operation in the learning mode based on the route deviation amount and the completion deviation amount, and displays the evaluation result on the display **42**. Hereby, the driver can know an objective evaluation result of the manual operation for parking.

[0184] In the present modification example, the CPU of the ECU **20** executes a routine shown in FIG. **11** instead of the routine shown in FIG. **5**. In FIG. **11**, the same processes as in FIGS. **5** and **10** are given the same symbols, and their explanations are omitted.

[0185] When an appropriate time comes, the CPU starts a process from step **1100** in FIG. **11**.

[0186] When the assist flag Xast is "1" ("Yes" at step **505** "shown in FIG. **11**), the vehicle VA has not yet arrived at the target space ("No" at step **510** shown in FIG. **11**), and the learning flag Xlrn is "0" ("Yes" at step **515** shown in FIG. **11**), the CPU executes the automatic parking control (i.e., the CPU executes steps **520** to **530** shown in FIG. **11**). Thereafter, the process proceeds to step **1195**, and the CPU terminates the present routine tentatively.

[0187] In a case where the learning flag Xlrn is "1" ("No" at step **515** as shown in FIG. **11**) when the process proceeds to step **515** as shown in FIG. **11**, the CPU executes steps **1015** and **1020** as shown in FIG. **11**. Thereafter, the process proceeds to step **1195**, and the CPU terminates the present routine tentatively.

[0188] In a case where the vehicle VA has arrived at the target space when the process proceeds to step **510** ("Yes" at step **510** shown in FIG. **11**), the process proceeds to step **1105**. At step **1105**, the CPU determines whether or not the learning flag Xlrn is "1".

[0189] When the learning flag Xlrn is "0", the CPU makes a "No" determination at step **1105**. Thereafter, the process proceeds to step **1195**, and the CPU terminates the present routine tentatively.

[0190] When the learning flag Xlrn is "1", the CPU makes a "Yes" determination at step **1105** and executes steps **1030**, **1110** to **1120**, and **535** as shown in FIG. **11**. [0191] Step **1110**: The CPU acquires a parking score based on the total value of the route deviation amount and the completion deviation amount. In detail, the parking score is acquired so that the smaller the total value of the route deviation amount, the higher the parking score, and the smaller the completion deviation amount, the higher the parking score. [0192] Step **1115**: The CPU acquires a comment based on the total value of the route deviation amount and the completion deviation amount. For example, when there is an area where the route deviation amount is greater than the threshold, the CPU acquires the confirmation message and the operation message corresponding to that area as the comment. Furthermore, the CPU may also acquire a hint/tip for reducing the route deviation amount corresponding to that area as the comment. When the completion deviation amount is greater than the threshold, the CPU acquires a hint/tip for reducing the completion deviation amount as the comment. [0193] Step **1120**: The CPU displays the parking score and the comment on display **42**. [0194] Thereafter, the process proceeds to step **1195**, and the CPU terminates the present routine tentatively.

[0195] In the above embodiment, the example of the operation assist control is the parking assist control. The present embodiment can be applied to the operation assist control for assisting the driver's operation when the vehicle travels to the target space. Furthermore, the automatic parking control is one type of the automatic driving control for automatically travels the vehicle to the target space. As an example, the present embodiment can also be applied to the automatic driving control for traveling the vehicle out of the parking space.

[0196] The operation assist apparatus **10** may be applied to (or installed in/on) an engine vehicle, a hybrid electric vehicle (HEV), a plug-in hybrid electric vehicle (PHEV), a fuel cell electric vehicle (FCEV), and a battery electric vehicle (BEV).

Claims

1. An operation assist apparatus configured to execute an operation assist control for assisting an operation of a driver when a vehicle travels to a target space, wherein, the operation assist control includes a first mode and a second mode, wherein, whether the operation assist control is executed in the first mode or the second mode is selected, wherein, the operation assist apparatus is configured to: acquire a target route to the target space when the operation assist control is executed; execute an automatic driving control for automatically controlling at least a steered angle of the vehicle such that the vehicle travels along the target route when the first mode is selected;

and control a travel state of the vehicle according to a manual operation of the driver without executing the automatic driving control and display the target route on a display of the vehicle, when the second mode is selected.

2. The operation assist apparatus according to claim 1, wherein, the operation assist apparatus is configured to be able to execute a guidance control for outputting at least one of an operation guidance relating to the manual operation that the driver should perform and a confirmation guidance relating to an area to which the driver should pay attention, when the operation assist control is executed.

3. The operation assist apparatus according to claim 1, wherein, the operation assist apparatus is configured to a steering assist control for notifying the driver that an excessive condition is satisfied when the excessive condition is satisfied, wherein, the excessive condition is satisfied when a steering wheel of the vehicle is operated such that a steering angle of the steering wheel is greater than a target steering angle for the vehicle to travel along the target route and a magnitude of a difference between the steering angle and the target steering angle is equal to or greater than a predetermined threshold.

4. The operation assist apparatus according to claim 3, wherein, the operation assist apparatus is configured to inhibit the steering wheel from being operated to a direction where the steering angle exceeds the target steering angle, when the excessive condition is satisfied.

5. The operation assist apparatus according to claim 1, wherein, the second mode includes a third mode and a fourth mode, wherein, the operation assist apparatus is configured to provide weaker assist to the driver when the fourth condition is selected than when the third condition is selected.

6. The operation assist apparatus according to claim 5, wherein, the fourth mode is can be selected when a predetermined release condition is satisfied, wherein, the operation assist apparatus is configured to: acquire a route deviation amount representing an amount of deviation from the target route and a completion deviation amount representing an amount of deviation from the target space when parking is complete in the target space, when the third mode is selected; determine whether or not a pass condition is satisfied each time at which parking is complete in the target space in the third mode, wherein, the pass condition is satisfied when the route deviation amount is equal to or smaller than a predetermined first threshold amount and the completion deviation amount is equal to smaller than a predetermined second threshold amount; and determine that the release condition is satisfied when the number of times that the pass condition is satisfied is equal to or greater than a predetermined threshold.

7. The operation assist apparatus according to claim 5, wherein, the operation assist apparatus is configured to: be able to execute a guidance control and a steering assist control for when the second mode is selected, wherein, the guidance control is a control for outputting at least one of an operation guidance relating to the manual operation that the driver should perform and a confirmation guidance relating to an area to which the driver should pay attention, wherein, the steering assist control for notifying the driver that an excessive condition is satisfied when the excessive condition is satisfied, wherein, the excessive condition is satisfied when a steering wheel of the vehicle is operated such that a steering angle of the steering wheel is greater than a target steering angle for the vehicle to travel along the target route and a magnitude of a difference between the steering angle and the target steering angle is equal to or greater than a predetermined threshold; execute at least one of the guidance control and the steering assist control when the third mode is selected; and execute neither the guidance control nor the steering assist control when the fourth mode is selected.

8. The operation assist apparatus according to claim 1, wherein, the operation assist apparatus is configured to: evaluate the manual operation until the vehicle arrives at the target space when parking is complete in the target space in the second mode; and output a result of evaluating.