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Parking assistance apparatus, parking assistance method, and program

Abstract

A parking assistance apparatus includes: a route calculation unit configured to calculate a movement route for moving a vehicle to a parking target position; an inclination angle calculation unit configured to calculate first inclination angle information, calculate second inclination angle information by performing a filtering process, and when there is a deviation between the first inclination angle information and the second inclination angle information, reset the first inclination angle information used in the filtering process and calculate the second inclination angle information by performing the filtering process using first inclination angle information calculated after the resetting; and a movement control unit configured to execute movement control for controlling a driving force and a braking force to move the vehicle to the parking target position along the movement route, while adjusting the driving force and the braking force according to the second inclination angle information.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS

(1) This application is based on and claims priority under 35 U.S.C. § 119 to Japanese Patent Application 2020-163494, filed on Sep. 29, 2020, the entire content of which is incorporated herein by reference.

TECHNICAL FIELD

(2) This disclosure relates to a parking assistance apparatus, a parking assistance method, and a program.

BACKGROUND DISCUSSION

(3) In related art, as a parking assistance technique, there has been known a technique in which when control for moving a vehicle to a parking target position is performed, a driving force and a braking force applied to the vehicle is adjusted according to an inclination angle with respect to the ground on which the vehicle travels.
(4) However, for example, when information on the inclination angle with respect to the ground detected in the vehicle includes noise of a high frequency component, recognition of the inclination angle is delayed since a filtering process of removing the noise is performed. In this case, there are problems that when, for example, the parking target position is immediately after a change from an uphill slope to a downhill slope, a speed of the vehicle immediately before the parking target position becomes higher than expected, and sudden braking is required to stop the vehicle at the parking target position.
(5) A need thus exists for a parking assistance apparatus, a parking assistance method, and a program which are not susceptible to the drawback mentioned above.

SUMMARY

(6) According to an aspect of this disclosure, for example, a parking assistance apparatus includes: a route calculation unit configured to calculate a movement route for moving a vehicle from a current position of the vehicle to a parking target position; an inclination angle calculation unit configured to calculate first inclination angle information, which is information indicating an inclination angle with respect to the ground on which the vehicle travels, in a chronological order, calculate second inclination angle information by performing a filtering process of removing a high frequency component equal to or higher than a predetermined threshold value on waveform information represented by arranging a plurality of pieces of the calculated first inclination angle information in a chronological order, and when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information based on a predetermined reference, reset the plurality of pieces of the first inclination angle information used in the filtering process and calculate the second inclination angle information by performing the filtering process using a plurality of pieces of the first inclination angle information calculated after the resetting; and a movement control unit configured to execute movement control for controlling a driving force and a braking force on the vehicle to move the vehicle to the parking target position along the movement route, while adjusting the driving force and the braking force according to the second inclination angle information.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The foregoing and additional features and characteristics of this disclosure will become more apparent from the following detailed description considered with the reference to the accompanying drawings, wherein:
(2) FIG. **1** is a plan view of a vehicle on which a parking assistance system according to an embodiment is mounted;
(3) FIG. **2** is a block diagram showing an overall configuration of the parking assistance system according to the embodiment;
(4) FIG. **3** is a functional block diagram illustrating functions of a parking assistance apparatus according to the embodiment;
(5) FIG. **4** is a diagram showing an example of an inclination of a road at the time of performing parking assistance according to the embodiment;
(6) FIG. **5** is a graph related to inclination angles during parking assistance according to a comparative example;
(7) FIG. **6** is a graph related to inclination angles during the parking assistance according to the

embodiment;
(8) FIG. **7** is a flowchart of a parking assistance process executed by the parking assistance apparatus according to the embodiment; and
(9) FIG. **8** is a flowchart showing details of processing of step S**4** in FIG. **7**.
DETAILED DESCRIPTION
(10) Hereinafter, embodiments disclosed here will be described. Configurations of the embodiments described below and actions, results, and effects provided by this configuration are examples. This disclosure can be implemented by configurations other than those disclosed in the following embodiment, and at least one of various effects based on the basic configuration and derived effects can be obtained.
(11) FIG. **1** is a plan view of a vehicle **10** on which a parking assistance system **20** (FIG. **2**) according to an embodiment is mounted. The vehicle **10** may be, for example, an automobile that uses an internal combustion engine (engine, not shown) as a drive source (internal combustion engine automobile), an automobile that uses an electric motor (motor, not shown) as the drive source (electric automobile, fuel cell automobile or the like), or an automobile that uses both the internal combustion engine and the electric motor as the drive source (hybrid automobile). The vehicle **10** can mount various transmission devices, and can also mount various devices (system, component, and the like) necessary for driving the internal combustion engine or the electric motor. A method, the number, a layout, and the like of the device related to driving wheels **13** in the vehicle **10** can be set in various ways.
(12) As shown in FIG. **1**, the vehicle **10** includes a vehicle body **12**, four wheels **13**, four imaging units **14***a* to **14***d*, and twelve distance measuring units **16***a* to **16***l*. Hereinafter, when it is not necessary to distinguish the imaging units **14***a* to **14***d*, the imaging units **14***a* to **14***d* are referred to as the imaging unit **14**. When it is not necessary to distinguish the distance measuring units **16***a* to **16***l*, the distance measuring units **16***a* to **16***l* are referred to as the distance measuring unit **16**.
(13) The vehicle body **12** constitutes a vehicle compartment where an occupant gets on. The vehicle body **12** accommodates or holds the wheels **13**, the imaging unit **14**, the distance measuring unit **16**, and the like.
(14) The four wheels **13** are provided on the front, rear, left, and right sides of the vehicle body **12**. For example, the two front wheels **13** function as turning wheels, and the two rear wheels **13** function as driving wheels.
(15) The imaging unit **14** is, for example, a digital camera including an imaging element such as a charge coupled device (CCD) or a CMOS image sensor (CIS). The imaging unit **14** outputs data of moving images including a plurality of frame images generated at a predetermined frame rate or a still image as data of a captured image.
(16) The distance measuring unit **16** is, for example, a sonar that is provided at an outer peripheral portion of the vehicle **10**, transmits a sound wave or the like including an ultrasonic wave as a detection wave, and captures the detection wave reflected by an object such as another vehicle present around the vehicle **10**. The distance measuring unit **16** may be a radar, a millimeter wave radar, or the like that outputs a detection wave such as laser light.
(17) FIG. **2** is a block diagram showing an overall configuration of the parking assistance system **20** according to the embodiment. The parking assistance system **20** is mounted on the vehicle **10** and assists driving of the vehicle **10** by automatic driving (including partial automatic driving) according to an object around the vehicle **10**.
(18) As shown in FIG. **2**, the parking assistance system **20** includes the imaging unit **14**, the distance measuring unit **16**, a braking system **22**, an acceleration system **24**, a steering system **26**, a transmission system **28**, a vehicle speed sensor **30**, an acceleration sensor **31**, a monitor device **32**, a parking assistance apparatus **34**, and an in-vehicle network **36**.
(19) The braking system **22** controls deceleration of the vehicle **10**. The braking system **22** includes a braking unit **40**, a braking control unit **42**, and a braking unit sensor **44**.

(20) The braking unit **40** is a device that includes, for example, a brake, a brake pedal, and the like, and causes the deceleration of the vehicle **10**.
(21) The braking control unit **42** is, for example, a computer such as a microcomputer including a hardware processor such as a central processing unit (CPU). The braking control unit **42** controls the braking unit **40** to control the deceleration of the vehicle **10** based on an instruction from the parking assistance apparatus **34**.
(22) The braking unit sensor **44** is, for example, a position sensor, and detects a position of the braking unit **40** when the braking unit **40** is a brake pedal. The braking unit sensor **44** outputs the detected position of the braking unit **40** to the in-vehicle network **36**.
(23) The acceleration system **24** controls acceleration of the vehicle **10**. The acceleration system **24** includes an acceleration unit **46**, an acceleration control unit **48**, and an acceleration unit sensor **50**.
(24) The acceleration unit **46** is a device that includes, for example, an accelerator pedal, and causes the acceleration of the vehicle **10**.
(25) The acceleration control unit **48** is, for example, a computer such as a microcomputer including a hardware processor such as a CPU. The acceleration control unit **48** controls the acceleration unit **46** to control the acceleration of the vehicle **10** based on an instruction from the parking assistance apparatus **34**.
(26) The acceleration unit sensor **50** is, for example, a position sensor, and detects a position of the acceleration unit **46** when the acceleration unit **46** is an accelerator pedal. The acceleration unit sensor **50** outputs the detected position of the acceleration unit **46** to the in-vehicle network **36**.
(27) The steering system **26** controls a traveling direction of the vehicle **10**. The steering system **26** includes a steering unit **52**, a steering control unit **54**, and a steering unit sensor **56**.
(28) The steering unit **52** is a device that includes, for example, a handle or a steering wheel, and turns the turning wheels of the vehicle **10** to steer the traveling direction of the vehicle **10**.
(29) The steering control unit **54** is, for example, a computer such as a microcomputer including a hardware processor such as a CPU. The steering control unit **54** controls the steering unit **52** to control the traveling direction of the vehicle **10** based on an instruction from the parking assistance apparatus **34**.
(30) The steering unit sensor **56** is, for example, an angle sensor including a Hall element or the like, and detects a steering angle that is a rotation angle of the steering unit **52**. The steering unit sensor **56** outputs the detected steering angle of the steering unit **52** to the in-vehicle network **36**.
(31) The transmission system **28** controls a transmission ratio of the vehicle **10**. The transmission system **28** includes a transmission unit **58**, a transmission control unit **60**, and a transmission unit sensor **62**.
(32) The transmission unit **58** is a device that includes, for example, a shift lever, and changes the transmission ratio of the vehicle **10**.
(33) The transmission control unit **60** is, for example, a computer such as a microcomputer including a hardware processor such as a CPU. The transmission control unit **60** controls the transmission unit **58** to control the transmission ratio of the vehicle **10** based on an instruction from the parking assistance apparatus **34**.
(34) The transmission unit sensor **62** is, for example, a position sensor, and detects a position of the transmission unit **58** when the transmission unit **58** is a shift lever. The transmission unit sensor **62** outputs the detected position of the transmission unit **58** to the in-vehicle network **36**.
(35) The vehicle speed sensor **30** is, for example, a sensor that includes a Hall element provided near the wheel **13** of the vehicle **10** and detects a rotation amount of the wheel **13** or the number of rotations per unit time. The vehicle speed sensor **30** outputs a wheel speed pulse number indicating the detected rotation amount or the number of rotations to the in-vehicle network **36** as a sensor value for calculating a vehicle speed. The parking assistance apparatus **34** can calculate a speed (vehicle speed), a movement amount, and the like of the vehicle **10** based on the sensor value acquired from the vehicle speed sensor **30**.

(36) The acceleration sensor **31** is, for example, an electrostatic capacitance three-axis acceleration sensor, and detects acceleration caused by gravity acceleration, the acceleration or the deceleration of the vehicle **10**, or the like. The acceleration sensor **31** outputs an acceleration signal indicating a detection result. The parking assistance apparatus **34** can calculate an inclination angle with respect to the ground on which the vehicle **10** travels based on, for example, the acceleration signal acquired from the acceleration sensor **31**.
(37) The monitor device **32** is provided on a dashboard or the like in the vehicle compartment of the vehicle **10**. The monitor device **32** includes a display unit **64**, a sound output unit **66**, and an operation input unit **68**.
(38) The display unit **64** displays an image based on image data transmitted from the parking assistance apparatus **34**. The display unit **64** is, for example, a display device such as a liquid crystal display (LCD) or an organic electroluminescent display (OELD). The display unit **64** displays, for example, an image indicating reception of an operation instruction for instructing switching between the automatic driving and manual driving.
(39) The sound output unit **66** outputs a sound based on sound data transmitted from the parking assistance apparatus **34**. The sound output unit **66** is, for example, a speaker. The sound output unit **66** outputs, for example, a sound related to the operation instruction for instructing the switching between the automatic driving and the manual driving.
(40) The operation input unit **68** receives an input from an occupant. The operation input unit **68** is, for example, a touch panel. The operation input unit **68** is provided on a display screen of the display unit **64**. The operation input unit **68** is configured to transmit the image displayed by the display unit **64**. Accordingly, the operation input unit **68** allows the occupant to visually recognize the image displayed on the display screen of the display unit **64**. The operation input unit **68** receives an instruction input by the occupant touching a position corresponding to the image displayed on the display screen of the display unit **64**, and transmits the instruction to the parking assistance apparatus **34**. The operation input unit **68** is not limited to a touch panel, and may be a push button type hard switch, or other type of hard switch.
(41) The parking assistance apparatus **34** is a computer including a microcomputer such as an electronic control unit (ECU), and performs parking assistance of the vehicle **10**.
(42) The parking assistance apparatus **34** includes a CPU **34***a*, a read only memory (ROM) **34***b*, a random access memory (RAM) **34***c*, a display control unit **34***d*, a sound control unit **34***e*, and a solid state drive (SSD) **34***f*. The CPU **34***a*, the ROM **34***b*, and the RAM **34***c* may be integrated in a same package.
(43) The CPU **34***a* is an example of a hardware processor, reads a program stored in a nonvolatile storage device such as the ROM **34***b*, and executes various calculation processing and control according to the program. For example, the CPU **34***a* executes the parking assistance by the automatic driving of the vehicle **10**.
(44) The ROM **34***b* stores programs, parameters necessary for executing each program, and the like. The RAM **34***c* temporarily stores various data used in the calculation in the CPU **34***a*. Among the calculation processing in the parking assistance apparatus **34**, the display control unit **34***d* mainly executes image processing of an image captured by the imaging unit **14**, data conversion of a display image to be displayed on the display unit **64**, and the like. Among the calculation processing in the parking assistance apparatus **34**, the sound control unit **34***e* mainly executes processing of a sound to be output to the sound output unit **66**. The SSD **34***f* is a rewritable nonvolatile storage device, and maintains data even when the parking assistance apparatus **34** is powered off.
(45) The in-vehicle network **36** includes, for example, a controller area network (CAN), and a local interconnect network (LIN). The in-vehicle network **36** connects the acceleration system **24**, the braking system **22**, the steering system **26**, the transmission system **28**, the distance measuring unit **16**, the vehicle speed sensor **30**, the acceleration sensor **31**, the operation input unit **68** of the

monitor device **32**, and the parking assistance apparatus **34** so as to be able to transmit and receive information to and from each other.

(46) FIG. **3** is a functional block diagram illustrating functions of the parking assistance apparatus **34**. As shown in FIG. **3**, the parking assistance apparatus **34** includes an acquisition unit **71**, a detection unit **72**, an operation reception unit **73**, a parking assistance unit **74**, and an inclination angle storage unit **75**. The parking assistance unit **74** includes a target position calculation unit **74***a*, a route calculation unit **74***b*, an inclination angle calculation unit **74***c*, and a movement control unit **74***d*.

(47) The acquisition unit **71**, the detection unit **72**, the operation reception unit **73**, and the parking assistance unit **74** are implemented by the CPU **34***a* reading and executing a program (parking program) stored in a storage device such as the ROM **34***b*. Some or all of the acquisition unit **71**, the detection unit **72**, the operation reception unit **73**, and the parking assistance unit **74** may be formed of hardware such as a circuit including an application specific integrated circuit (ASIC). The inclination angle storage unit **75** is implemented by, for example, a storage unit such as the RAM **34***c*.

(48) The acquisition unit **71** acquires sensor values from various sensors and acquires captured image data from the imaging unit **14**.

(49) The detection unit **72** detects obstacles, parking areas, and the like around the vehicle **10** based on surrounding information (sensor values, captured image data, and the like) acquired by the acquisition unit **71**.

(50) The operation reception unit **73** acquires (receives) a signal from the operation input unit **68** according to an operation performed on the operation input unit **68**.

(51) The parking assistance unit **74** calculates a parking target position and a movement route by the automatic driving of the vehicle **10** implemented by controlling all or a part of the systems **22**, **24**, **26**, and **28**, and moves the vehicle **10** to the parking target position along the movement route. That is, the parking assistance unit **74** assists parking of the vehicle **10**.

(52) The target position calculation unit **74***a* calculates (determines) a movement target position, in other words, the parking target position, of the vehicle **10** as a guide or a target position for guiding the vehicle **10** by a known method or the like, based on a detection result of the detection unit **72**, for example. The parking target position may be an end of the movement route or may be in the middle of the movement route. The parking target position may be set as, for example, a point, a line, a frame, a region, or the like.

(53) The route calculation unit **74***b* calculates the movement route for moving the vehicle **10** from a current position of the vehicle **10** to the parking target position by a known method or the like.

(54) For example, the inclination angle calculation unit **74***c* calculates first inclination angle information, which is information indicating an inclination angle with respect to the ground on which the vehicle **10** travels, in a chronological order based on the acceleration signal acquired from the acceleration sensor **31**. In addition, the inclination angle calculation unit **74***c* calculates second inclination angle information by performing a filtering process (for example, a low-pass filter (LPF) process, an averaging filtering process, or the like) that removes a high frequency component equal to or higher than a predetermined threshold value on waveform information represented by arranging a plurality of pieces of calculated first inclination angle information in a chronological order.

(55) In addition, the inclination angle calculation unit **74***c* determines whether there is a deviation between the first inclination angle information and the second inclination angle information based on a predetermined reference. The determination of the deviation may be performed based on, for example, whether a difference between instantaneous values of the first inclination angle information and the second inclination angle information is equal to or greater than a predetermined difference threshold value, but this disclosure is not limited thereto. When the inclination angle calculation unit **74***c* determines that there is a deviation, the inclination angle

calculation unit **74***c* resets (deletes) the plurality of pieces of the first inclination angle information used in the filtering process, and performs the filtering process by using a plurality of pieces of the first inclination angle information calculated after the resetting to calculate the second inclination angle information.

(56) When a time period in which the inclination angle calculation unit **74***c* determines that there is a deviation between the first inclination angle information and the second inclination angle information based on the predetermined reference continues for a predetermined time period or longer, the inclination angle calculation unit **74***c* may reset the plurality of pieces of the first inclination angle information used in the filtering process.

(57) In order to move the vehicle **10** to the parking target position along the movement route, the movement control unit **74***d* controls all or a part of the systems **22**, **24**, **26**, and **28** to execute movement control for controlling a driving force and a braking force on the vehicle **10**. When the movement control unit **74***d* executes the movement control, the movement control unit **74***d* adjusts the driving force and the braking force according to the second inclination angle information. For example, when the second inclination angle information indicates an uphill slope, the movement control unit **74***d* increases the driving force according to the second inclination angle information. For example, when the second inclination angle information indicates a downhill slope, the movement control unit **74***d* increases the braking force according to the second inclination angle information.

(58) When the inclination angle calculation unit **74***c* resets the plurality of pieces of the first inclination angle information used in the filtering process, the movement control unit **74***d* may execute the movement control by using the first inclination angle information instead of the second inclination angle information until the inclination angle calculation unit **74***c* starts calculating the second inclination angle information after the resetting.

(59) Next, how the inclination angle information changes during the parking assistance will be described with reference to FIGS. **4** to **6**. FIG. **4** is a diagram showing an example of an inclination of a road at the time of performing the parking assistance according to the embodiment. FIG. **5** is a graph related to inclination angles during the parking assistance according to a comparative example. FIG. **6** is a graph related to inclination angles during the parking assistance according to the embodiment.

(60) As shown in FIG. **4**, when the vehicle travels in a right direction on a paper surface, a region between points P**1** and P**2** is an uphill slope, and a region between points P**2** and P**3** is a downhill slope. Here, it is assumed that a vehicle position of C**1** is a parking assistance start point, and a vehicle position of C**4** is a parking assistance end point (that is, the parking target position).

(61) When the vehicle position changes to C**1**, C**2**, C**3**, and C**4**, the inclination angles are recognized as shown in FIG. **5** in the comparative example (related art). Data L**1** is data of the inclination angles calculated based on the acceleration signal from the acceleration sensor. Since the data L**1** includes noise of a high frequency component, the filtering process for removing the noise is performed. Data L**2** is data of the inclination angles after the filtering process is performed. Data L**3** is a true value of the inclination angle.

(62) As can be seen from a comparison between the data L**2** and the data L**3**, when a road on which the vehicle travels changes from the uphill slope to the downhill slope (near the point P**2**), the inclination angles (data L**2**) after the filtering process is performed delay with respect to the true values of the inclination angle (data L**3**). As a result, a speed of the vehicle immediately before the vehicle arrives the parking target position (C**4**) becomes higher than expected, and sudden braking is required to stop the vehicle at the parking target position, and thus, there is room for improvement.

(63) According to the method of the embodiment disclosed here, the inclination angles are recognized as shown in FIG. **6**. The data L**1** and L**2** are the same as those in FIG. **5**. In the method of the embodiment disclosed here, the inclination angle that is indicated by the data L**2** in FIG. **5** is

obtained up to a point P**4**, but the inclination angle calculation unit **74***c* determines that there is a deviation between the data L**2** and the data L**1** at the point P**4**. Then, the inclination angle calculation unit **74***c* resets (deletes) the latest data L**1** used in the filtering process, and performs the filtering process by using the data L**1** calculated after the resetting to calculate data L**4**.
(64) As can be seen from a comparison between the data L**4** and the data L**2**, the data L**4** is significantly earlier than the data L**2**, returns from the deviation, and follows the true value (data L**3**).
(65) Next, a parking assistance process executed by the parking assistance apparatus **34** according to the embodiment will be described with reference to FIG. **7**. FIG. **7** is a flowchart of the parking assistance process executed by the parking assistance apparatus **34** according to the embodiment.
(66) In step S**1**, when the operation reception unit **73** receives a parking assistance instruction or the like from an occupant via the operation input unit **68**, the target position calculation unit **74***a* calculates the parking target position based on the detection result from the detection unit **72** in step S**2**.
(67) Next, in step S**3**, the route calculation unit **74***b* calculates the movement route for moving the vehicle **10** from the current position of the vehicle **10** to the parking target position.
(68) Next, in step S**4**, the movement control unit **76***c* executes the movement control for moving the vehicle **10** to the parking target position along the movement route.
(69) Here, FIG. **8** is a flowchart showing details of the processing of step S**4** in FIG. **7**. In step S**41**, the inclination angle calculation unit **74***c* calculates the first inclination angle information (data L**1** in FIG. **6**), which is the information indicating the inclination angle with respect to the ground on which the vehicle **10** travels, in a chronological order based on the acceleration signal acquired from the acceleration sensor **31**.
(70) Next, in step S**42**, the inclination angle calculation unit **74***c* calculates the second inclination angle information (data L**2** in FIG. **6**) by performing the filtering process that removes the high frequency component equal to or higher than the predetermined threshold value on the waveform information represented by arranging a plurality of pieces of the first inclination angle information calculated in step S**41** in a chronological order.
(71) Next, in step S**43**, the inclination angle calculation unit **74***c* determines whether there is a deviation between the first inclination angle information and the second inclination angle information based on the predetermined reference. If Yes, the process proceeds to step S**44**. If No, the process proceeds to step S**45**.
(72) In step S**44**, the inclination angle calculation unit **74***c* resets the plurality of pieces of the first inclination angle information used in the filtering process.
(73) In step S**45**, in order to move the vehicle **10** to the parking target position along the movement route, the movement control unit **74***d* executes the movement control for controlling the driving force and the braking force on the vehicle **10**, while adjusting the driving force and the braking force according to the second inclination angle information. For example, when the second inclination angle information indicates an uphill slope, the movement control unit **74***d* increases the driving force according to the second inclination angle information. For example, when the second inclination angle information indicates a downhill slope, the movement control unit **74***d* increases the braking force according to the second inclination angle information.
(74) When the inclination angle calculation unit **74***c* resets the plurality of pieces of the first inclination angle information used in the filtering process, the movement control unit **74***d* may execute the movement control by using the first inclination angle information instead of the second inclination angle information until the inclination angle calculation unit **74***c* starts calculating the second inclination angle information after the resetting.
(75) Next, in step S**46**, the movement control unit **74***d* determines whether the vehicle **10** has reached the parking target position. If Yes, the process of step S**4** ends. If No, the process returns to step S**41**.

(76) As described above, according to the parking assistance apparatus **34** of the first embodiment, when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information, the plurality of pieces of the first inclination angle information used in the filtering process are reset, so that the second inclination angle information calculated thereafter can follow the true value more quickly. That is, it is possible to improve accuracy of recognition of the inclination angle with respect to the ground at the time of the parking assistance.
(77) Therefore, for example, even when the parking target position is immediately after a change from an uphill slope to a downhill slope, it is possible to significantly reduce a possibility or degree that the vehicle becomes faster than expected immediately before arriving the parking target position, and it is possible to prevent a situation in which the sudden braking is required to stop the vehicle at the parking target position.
(78) In addition, for example, by performing the resetting when a time period in which it is determined that there is a deviation continues for the predetermined time period or longer, it is possible to more reliably prevent error resetting.
(79) In addition, for example, the movement control can be continuously executed by using the first inclination angle information instead of the second inclination angle information until calculation of the second inclination angle information is started after the resetting.
(80) Modification
(81) Next, a modification of the parking assistance apparatus **34** will be described. When the inclination angle calculation unit **74***c* resets the plurality of pieces of the first inclination angle information used in the filtering process, immediately after the resetting, the movement control unit **74***d* executes the movement control by using predetermined inclination angle information obtained based on the plurality of pieces of the first inclination angle information calculated immediately before the resetting.
(82) Referring to FIG. **6**, even when the data L**2** deviates from the data L**3** (true value) around the points P**4** and P**2**, for example, an intermediate value between an upper peak value and a lower peak value in the data L**1** is the true value. Therefore, immediately after the resetting, based on the plurality of pieces of the first inclination angle information calculated immediately before the resetting, the movement control unit **74***d* can acquire, for example, the intermediate value between the upper peak value and the lower peak value in the data L**1** as the predetermined inclination angle information, and use the intermediate value for the movement control.
(83) As described above, according to the parking assistance apparatus **34** of the modification, by using, immediately after the resetting, the predetermined inclination angle information (inclination angle information closer to the true value) obtained based on the plurality of pieces of the first inclination angle information acquired immediately before the resetting, it is possible to execute more appropriate movement control.
(84) The predetermined inclination angle information is not limited to the intermediate value between the upper peak value and the lower peak value in the data L**1** as described above, and for example, other values such as a value obtained by averaging the data L**1** in a predetermined time period may be adopted.
(85) The program for executing the above-described processes executed by the parking assistance apparatus **34** may be stored in a computer-readable storage medium such as a CD-ROM, a CD-R, a memory card, a digital versatile disk (DVD), or a flexible disk (FD) as a file in an installable format or an executable format and provided as a computer program product. Further, the program may be stored in a computer connected to a network such as the Internet and provided by being downloaded via the network. The program may be provided or distributed via a network such as the Internet.
(86) According to an aspect of this disclosure, for example, a parking assistance apparatus includes: a route calculation unit configured to calculate a movement route for moving a vehicle from a

current position of the vehicle to a parking target position; an inclination angle calculation unit configured to calculate first inclination angle information, which is information indicating an inclination angle with respect to the ground on which the vehicle travels, in a chronological order, calculate second inclination angle information by performing a filtering process of removing a high frequency component equal to or higher than a predetermined threshold value on waveform information represented by arranging a plurality of pieces of the calculated first inclination angle information in a chronological order, and when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information based on a predetermined reference, reset the plurality of pieces of the first inclination angle information used in the filtering process and calculate the second inclination angle information by performing the filtering process using a plurality of pieces of the first inclination angle information calculated after the resetting; and a movement control unit configured to execute movement control for controlling a driving force and a braking force on the vehicle to move the vehicle to the parking target position along the movement route, while adjusting the driving force and the braking force according to the second inclination angle information.

(87) According to the above-described parking assistance apparatus, for example, when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information, the plurality of pieces of the first inclination angle information used in the filtering process are reset, so that the second inclination angle information calculated thereafter can follow the true value more quickly. That is, it is possible to improve accuracy of recognition of the inclination angle with respect to the ground at the time of the parking assistance.

(88) In the above-described parking assistance apparatus, for example, when a time period in which it is determined that there is a deviation between the first inclination angle information and the second inclination angle information based on the predetermined reference continues for a predetermined time period or longer, the inclination angle calculation unit resets the plurality of pieces of the first inclination angle information used in the filtering process.

(89) According to the above-described parking assistance apparatus, for example, by performing the resetting when a time period in which it is determined that there is a deviation continues for the predetermined time period or longer, it is possible to more reliably prevent error resetting.

(90) In the above-described parking assistance apparatus, for example, when the inclination angle calculation unit resets the plurality of pieces of the first inclination angle information used in the filtering process, the movement control unit executes the movement control by using the first inclination angle information instead of the second inclination angle information until the inclination angle calculation unit starts calculating the second inclination angle information after the resetting.

(91) According to the above-described parking assistance apparatus, for example, the movement control can be continuously executed by using the first inclination angle information instead of the second inclination angle information until the second inclination angle information starts to be calculated after the resetting.

(92) In the above-described parking assistance apparatus, for example, when the inclination angle calculation unit resets the plurality of pieces of first inclination angle information used in the filtering process, immediately after the resetting, the movement control unit executes the movement control by using predetermined inclination angle information obtained based on the plurality of pieces of the first inclination angle information calculated by the inclination angle calculation unit immediately before the resetting.

(93) According to the above-described parking assistance apparatus, for example, by obtaining, immediately after the resetting, the predetermined inclination angle information based on the plurality of pieces of the first inclination angle information calculated immediately before the resetting and using the predetermined inclination angle information, it is possible to execute more appropriate movement control.

(94) According to an aspect of this disclosure, a parking assistance method includes: a route calculation step of calculating a movement route for moving a vehicle from a current position of the vehicle to a parking target position; an inclination angle calculation step of calculating first inclination angle information, which is information indicating an inclination angle with respect to the ground on which the vehicle travels, in a chronological order, calculating second inclination angle information by performing a filtering process of removing a high frequency component equal to or higher than a predetermined threshold value on waveform information represented by arranging a plurality of pieces of the calculated first inclination angle information in a chronological order, and when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information based on a predetermined reference, resetting the plurality of pieces of the first inclination angle information used in the filtering process and calculating the second inclination angle information by performing the filtering process using a plurality of pieces of the first inclination angle information calculated after the resetting; and a movement control step of executing movement control for controlling a driving force and a braking force on the vehicle to move the vehicle to the parking target position along the movement route, while adjusting the driving force and the braking force according to the second inclination angle information.

(95) According to the above-described parking assistance method, for example, when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information, the plurality of pieces of the first inclination angle information used in the filtering process are reset, so that the second inclination angle information calculated thereafter can follow the true value more quickly.

(96) According to an aspect of this disclosure, a program that causes a computer to function as: a route calculation unit configured to calculate a movement route for moving a vehicle from a current position of the vehicle to a parking target position; an inclination angle calculation unit configured to calculate first inclination angle information, which is information indicating an inclination angle with respect to the ground on which the vehicle travels, in a chronological order, calculate second inclination angle information by performing a filtering process of removing a high frequency component equal to or higher than a predetermined threshold value on waveform information represented by arranging a plurality of pieces of the calculated first inclination angle information in a chronological order, and when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information based on a predetermined reference, reset the plurality of pieces of the first inclination angle information used in the filtering process and calculate the second inclination angle information by performing the filtering process using a plurality of pieces of the first inclination angle information calculated after the resetting; and a movement control unit configured to execute movement control for controlling a driving force and a braking force on the vehicle to move the vehicle to the parking target position along the movement route, while adjusting the driving force and the braking force according to the second inclination angle information.

(97) According to the above-described program, for example, when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information, the plurality of pieces of the first inclination angle information used in the filtering process are reset, so that the second inclination angle information calculated thereafter can follow the true value more quickly.

(98) While embodiments and modifications disclosed here have been described, these embodiments and modifications have been presented by way of example only, and are not intended to limit the scope of this disclosure. Indeed, these novel embodiments and modifications described herein may be embodied in a variety of other forms. Furthermore, various omissions, substitutions and changes may be made without departing from the spirit of this disclosure. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope

and spirit of this disclosure.
(99) The principles, preferred embodiment and mode of operation of the present invention have been described in the foregoing specification. However, the invention which is intended to be protected is not to be construed as limited to the particular embodiments disclosed. Further, the embodiments described herein are to be regarded as illustrative rather than restrictive. Variations and changes may be made by others, and equivalents employed, without departing from the spirit of the present invention. Accordingly, it is expressly intended that all such variations, changes and equivalents which fall within the spirit and scope of the present invention as defined in the claims, be embraced thereby.

Claims

1. A parking assistance apparatus comprising: an inclination angle calculation unit configured to calculate first inclination angle information, which is information indicating an inclination angle with respect to the ground on which the vehicle travels, in a chronological order, calculate second inclination angle information by performing a filtering process of removing a high frequency component equal to or higher than a predetermined threshold value on waveform information represented by arranging a plurality of pieces of the calculated first inclination angle information in a chronological order, and when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information based on a predetermined reference, reset the plurality of pieces of the first inclination angle information used in the filtering process and calculate the second inclination angle information by performing the filtering process using a plurality of pieces of the first inclination angle information calculated after the resetting; and a movement control unit configured to execute movement control for controlling a driving force and a braking force on the vehicle to move the vehicle to predetermined parking target position along a predetermined movement route, while adjusting the driving force and the braking force according to the second inclination angle information.
2. The parking assistance apparatus according to claim 1, wherein when a time period in which it is determined that there is a deviation between the first inclination angle information and the second inclination angle information based on the predetermined reference continues for a predetermined time period or longer, the inclination angle calculation unit resets the plurality of pieces of the first inclination angle information used in the filtering process.
3. The parking assistance apparatus according to claim 1, wherein when the inclination angle calculation unit resets the plurality of pieces of the first inclination angle information used in the filtering process, the movement control unit executes the movement control by using the first inclination angle information instead of the second inclination angle information until the inclination angle calculation unit starts calculating the second inclination angle information after the resetting.
4. The parking assistance apparatus according to claim 1, wherein when the inclination angle calculation unit resets the plurality of pieces of the first inclination angle information used in the filtering process, immediately after the resetting, the movement control unit executes the movement control by using predetermined inclination angle information obtained based on the plurality of pieces of the first inclination angle information calculated by the inclination angle calculation unit immediately before the resetting.
5. A parking assistance method comprising: an inclination angle calculation step of calculating first inclination angle information, which is information indicating an inclination angle with respect to the ground on which the vehicle travels, in a chronological order, calculating second inclination angle information by performing a filtering process of removing a high frequency component equal to or higher than a predetermined threshold value on waveform information represented by arranging a plurality of pieces of the calculated first inclination angle information in a

chronological order, and when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information based on a predetermined reference, resetting the plurality of pieces of the first inclination angle information used in the filtering process and calculating the second inclination angle information by performing the filtering process using a plurality of pieces of the first inclination angle information calculated after the resetting; and a movement control step of executing movement control for controlling a driving force and a braking force on the vehicle to move the vehicle to a predetermined parking target position along a predetermined movement route, while adjusting the driving force and the braking force according to the second inclination angle information.

6. A non-transitory computer readable medium storing a program that causes a computer to function as: an inclination angle calculation unit configured to calculate first inclination angle information, which is information indicating an inclination angle with respect to the ground on which the vehicle travels, in a chronological order, calculate second inclination angle information by performing a filtering process of removing a high frequency component equal to or higher than a predetermined threshold value on waveform information represented by arranging a plurality of pieces of the calculated first inclination angle information in a chronological order, and when it is determined that there is a deviation between the first inclination angle information and the second inclination angle information based on a predetermined reference, reset the plurality of pieces of the first inclination angle information used in the filtering process and calculate the second inclination angle information by performing the filtering process using a plurality of pieces of the first inclination angle information calculated after the resetting; and a movement control unit configured to execute movement control for controlling a driving force and a braking force on the vehicle to move the vehicle to a predetermined parking target position along a predetermined movement route, while adjusting the driving force and the braking force according to the second inclination angle information.