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MOBILE OBJECT CONTROL DEVICE, MOBILE OBJECT CONTROL METHOD, AND STORAGE MEDIUM

Abstract

A mobile object control device for controlling a mobile object capable of moving both on a roadway and in a predetermined region different from the roadway includes a road type recognition unit configured to recognize whether the mobile object is moving on the roadway or in the predetermined region on the basis of an output of an external environment detection device configured to detect an external situation of the mobile object and a control unit configured to limit a speed of a case where the mobile object moves on the roadway to a first speed and limit a speed of a case where the mobile object moves in the predetermined region to a second speed lower than the first speed. The road type recognition unit adds a point value to a roadway score every time each of a plurality of first events indicating that the mobile object is moving on the roadway is recognized on the basis of the output of the external environment detection device and recognizes that the mobile object is moving on the roadway when the roadway score is greater than or equal to a first threshold value.

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Background/Summary

TECHNICAL FIELD

[0001] The present invention relates to a mobile object control device, a mobile object control method, and a storage medium.

BACKGROUND ART

[0002] Conventionally, practical applications have been made for mobile objects capable of moving on both a sidewalk and a roadway and it is necessary to set different upper limit speeds for the sidewalk and the roadway for such mobile objects. In this regard, documents considering a process of recognizing whether a mobile object is moving on a sidewalk or a roadway have been disclosed (Patent Documents 1 to 4).

CITATION LIST

Patent Document

Patent Document 1

[0003] Japanese Unexamined Patent Application, First Publication No. 2020-197387

Patent Document 2

[0004] Japanese Unexamined Patent Application, First Publication No. 2020-168953

Patent Document 3

[0005] Japanese Unexamined Patent Application, First Publication No. 2020-086995

Patent Document 4

[0006] Japanese Unexamined Patent Application, First Publication No. 2019-190975

SUMMARY OF INVENTION

Technical Problem

[0007] In the conventional technology, it may not be possible to appropriately recognize whether a mobile object is moving on a roadway or in a predetermined region different from the roadway.

[0008] The present invention has been made in consideration of such circumstances and an objective of the present invention is to provide a mobile object control device, a mobile object control method, and a storage medium for enabling whether a mobile object is moving on a roadway or in a predetermined region different from the roadway to be appropriately recognized.

Solution to Problem

[0009] A mobile object control device, a mobile object control method, and a storage medium according to the present invention adopt the following configurations.

[0010] (1): According to an aspect of the present invention, there is provided a mobile object control device for controlling a mobile object capable of moving both on a roadway and in a predetermined region different from the roadway, the mobile object control device including: a road type recognition unit configured to recognize whether the mobile object is moving on the roadway or in the predetermined region on the basis of an output of an external environment detection device configured to detect an external situation of the mobile object; and a control unit

configured to limit a speed of a case where the mobile object moves on the roadway to a first speed and limit a speed of a case where the mobile object moves in the predetermined region to a second speed lower than the first speed, wherein the road type recognition unit adds a point value to a roadway score every time each of a plurality of first events indicating that the mobile object is moving on the roadway is recognized on the basis of the output of the external environment detection device and recognizes that the mobile object is moving on the roadway when the roadway score is greater than or equal to a first threshold value.

[0011] (2): In the above-described aspect (1), the road type recognition unit weights a point value in accordance with a degree of confidence when each of the plurality of first events has been recognized and adds the weighted point value to the roadway score.

[0012] (3): In the above-described aspect (1), the plurality of first events include that a static obstacle other than a vehicle is not located inside an outer edge of a region where the mobile object is located.

[0013] (4): In the above-described aspect (1), the plurality of first events include that a vehicle is moving in a region where the mobile object is located.

[0014] (5): In the above-described aspect (1), the plurality of first events include that there is a road surface marking on a road surface of a region where the mobile object is located.

[0015] (6): In the above-described aspect (1), the plurality of first events include that there is a crosswalk in a region where the mobile object is located.

[0016] (7): In the above-described aspect (1), the plurality of first events include that a region where the mobile object is located is on a lower side with respect to a step.

[0017] (8): In the above-described aspect (1), the road type recognition unit recognizes that the mobile object is moving in the predetermined region regardless of the roadway score when any one of one or more second events indicating that the mobile object is moving in the predetermined region has been recognized on the basis of the output of the external environment detection device.

[0018] (9): In the above-described aspect (1), the road type recognition unit recognizes any one of one or more second events indicating that the mobile object is moving in the predetermined region on the basis of the output of the external environment detection device and recognizes that the mobile object is moving in the predetermined region when the roadway score is less than a second threshold value larger than the first threshold value.

[0019] (10): In the above-described aspect (9), the road type recognition unit recognizes any one of the one or more second events on the basis of the output of the external environment detection device and executes exception processing when the roadway score is greater than or equal to the second threshold value larger than the first threshold value.

[0020] (11): In the above-described aspect (8) or (9), the one or more second events include that a camera included in the external environment detection device has imaged a second surface facing a sidewalk side of a guardrail.

[0021] (12): In the above-described aspect (8) or (9), the one or more second events include that there is a braille block on a road surface on which the mobile object is moving.

[0022] (13): In the above-described aspect (8) or (9), the one or more second events include that there is a static obstacle other than a vehicle within a region where the mobile object is located.

[0023] (14): In the above-described aspect (8) or (9), the one or more second events include that a region where the mobile object is located is located on an upper side with respect to a step.

[0024] (15): According to another aspect of the present invention, there is provided a mobile object control method including: recognizing, by a computer for controlling a mobile object capable of moving both on a roadway and in a predetermined region different from the roadway, whether the mobile object is moving on the roadway or in the predetermined region on the basis of an output of an external environment detection device configured to detect an external situation of the mobile object; and limiting, by the computer, a speed of a case where the mobile object moves on the roadway to a first speed and limiting a speed of a case where the mobile object moves in the

predetermined region to a second speed lower than the first speed, wherein the recognizing includes adding a point value to a roadway score every time each of a plurality of first events indicating that the mobile object is moving on the roadway is recognized on the basis of the output of the external environment detection device and recognizing that the mobile object is moving on the roadway when the roadway score is greater than or equal to a first threshold value.

[0025] (16): According to yet another aspect of the present invention, there is provided a storage medium storing a program for causing a computer for controlling a mobile object capable of moving both on a roadway and in a predetermined region different from the roadway to: recognize whether the mobile object is moving on the roadway or in the predetermined region on the basis of an output of an external environment detection device configured to detect an external situation of the mobile object; and limit a speed of a case where the mobile object moves on the roadway to a first speed and limit a speed of a case where the mobile object moves in the predetermined region to a second speed lower than the first speed, wherein the recognizing includes adding a point value to a roadway score every time each of a plurality of first events indicating that the mobile object is moving on the roadway is recognized on the basis of the output of the external environment detection device and recognizing that the mobile object is moving on the roadway when the roadway score is greater than or equal to a first threshold value.

Advantageous Effects of Invention

[0026] According to the above-described aspects (1) to (16), it is possible to appropriately recognize whether a mobile object is moving on a roadway or in a predetermined region different from the roadway.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0027] FIG. **1** is a diagram showing an example of a configuration of a mobile object and a control device according to an embodiment.

[0028] FIG. **2** is a perspective view of the mobile object viewed from above.

[0029] FIG. **3** is a diagram showing a plurality of first events.

[0030] FIG. **4** is a diagram showing a plurality of second events.

[0031] FIG. **5** is a diagram showing a second surface **207***b* facing a sidewalk side of a guardrail **207**.

[0032] FIG. **6** is a flowchart showing an example of a flow of a process executed by a road type recognition unit **120** of a first embodiment.

[0033] FIG. **7** is a flowchart showing an example of a flow of a process executed by a road type recognition unit **120** of a second embodiment.

DESCRIPTION OF EMBODIMENTS

[0034] Hereinafter, embodiments of a mobile object control device, a mobile object control method, and a program according to the present invention will be described with reference to the drawings. A mobile object moves both on a roadway and in a predetermined region different from the roadway. The mobile object may be referred to as micromobility. An electric kickboard is a type of micromobility. Moreover, the mobile object may be a vehicle that an occupant can board or may be an autonomous mobile object capable of performing unmanned autonomous movement. The autonomous mobile object is used, for example, for an application to transport cargo or the like. The predetermined region is, for example, a sidewalk. Moreover, the predetermined region may be a part or all of a roadside strip, a bicycle lane, a public open space, or the like or may include all sidewalks, roadside strips, bicycle lanes, public open spaces, and the like. In the following description, it is assumed that the predetermined region is a sidewalk. In the following description, a part described as the “sidewalk” can be read as the “predetermined region” as appropriate.

[0035] FIG. **1** is a diagram showing an example of a configuration of the mobile object **1** and the control device **100** according to the embodiment. The mobile object **1** includes, for example, an external environment detection device **10**, a mobile object sensor **12**, a manipulation element **14**, an internal camera **16**, a positioning device **18**, a mode changeover switch **22**, a moving mechanism **30**, a drive device **40**, an external notification device **50**, a storage device **70**, and a control device **100**. Also, some constituent elements not essential for implementing the functions of the present invention may be omitted.
[0036] The external environment detection device **10** includes various types of devices in which a movement direction of the mobile object **1** is designated as a detection range. The external environment detection device **10** includes an external camera, a radar device, a light detection and ranging (LIDAR) sensor, a sensor fusion device, and the like. The external environment detection device **10** outputs information indicating a detection result (an image, a position of a physical object, or the like) to the control device **100**.
[0037] The mobile object sensor **12** includes, for example, a speed sensor, an acceleration sensor, a yaw rate (angular velocity) sensor, an orientation sensor, a manipulation quantity detection sensor attached to the manipulation element **14**, and the like. The manipulation element **14** includes, for example, a manipulation element for issuing an acceleration/deceleration instruction (for example, an accelerator pedal or a brake pedal) and a manipulation element for issuing a steering instruction (for example, a steering wheel). In this case, the mobile object sensor **12** may include an accelerator opening degree sensor, a brake depression amount sensor, a steering torque sensor, and the like. The mobile object **1** may include a type of manipulation element other than the above manipulation elements (for example, a non-annular rotation manipulation element, a joystick, a button, or the like) as the manipulation element **14**.
[0038] The internal camera **16** images at least a head of the occupant of the mobile object **1** from the front. The internal camera **16** is a digital camera that uses an imaging element such as a charge-coupled device (CCD) or a complementary metal oxide semiconductor (CMOS). The internal camera **16** outputs a captured image to the control device **100**.
[0039] The positioning device **18** is a device for measuring a position of the mobile object **1**. The positioning device **18** is, for example, a global navigation satellite system (GNSS) receiver, and identifies the position of the mobile object **1** on the basis of a signal received from a GNSS satellite and outputs the identified position as position information. Also, the position information of the mobile object **1** may be estimated from a position of a Wi-Fi base station to which a communication device to be described below is connected.
[0040] The mode changeover switch **22** is a switch to be manipulated by the occupant. The mode changeover switch **22** may be a mechanical switch or a graphical user interface (GUI) switch set on the touch panel. The mode changeover switch **22** receives a manipulation for switching a driving mode to any one of, for example, mode A that is an assist mode in which one of the steering manipulation and acceleration/deceleration control is performed by the occupant and the other is performed automatically and that may be mode A-**1** in which the steering manipulation is performed by the occupant and the acceleration/deceleration control is performed automatically or mode A-**2** in which an acceleration/deceleration manipulation is performed by the occupant and the steering control is performed automatically, mode B that is a manual driving mode in which the steering manipulation and the acceleration/deceleration manipulation are performed by the occupant, and mode C that is an automated driving mode in which the steering control and the acceleration/deceleration control are performed automatically.
[0041] The moving mechanism **30** is a mechanism for moving the mobile object **1** on the road. The moving mechanism **30** is, for example, a wheel group that includes a steered wheel and a driven wheel. Moreover, the moving mechanism **30** may be a leg unit for multi-legged walking.
[0042] The drive device **40** outputs a force to the moving mechanism **30** so that the mobile object **1** can be moved. For example, the drive device **40** includes a motor that drives the driven wheel, a

battery that stores electric power to be supplied to the motor, a steering device that adjusts the steering angle of the steered wheel, and the like. The drive device **40** may include an internal combustion engine, a fuel cell, or the like as a driving force output means or an electric power generation means. Moreover, the drive device **40** may further include a braking device using a friction force or air resistance.

[0043] The external notification device **50** is, for example, a lamp, a display device, a speaker, or the like provided on an outer plate portion of the mobile object **1** and configured to provide a notification of information to the outside of the mobile object **1**. The external notification device **50** performs different operations in a state in which the mobile object **1** is moving on the sidewalk and a state in which the mobile object **1** is moving on the roadway. For example, the external notification device **50** is controlled so that light of the lamp is emitted when the mobile object **1** is moving on the sidewalk and light of the lamp is not emitted when the mobile object **1** is moving on the roadway. The color of the light emitted by this lamp is preferably a color specified by law. The external notification device **50** may be controlled so that the light of the lamp is emitted in green when the mobile object **1** is moving on the sidewalk and the light of the lamp is emitted in blue when the mobile object **1** is moving on the roadway. When the external notification device **50** is a display device, the external notification device **50** displays text or a graphic indicating “moving on the sidewalk” when the mobile object **1** is moving on the sidewalk.

[0044] FIG. **2** is a perspective view of the mobile object **1** viewed from above. In FIG. **2**, FW denotes the steered wheel, RW denotes the driven wheel, SD denotes the steering device, MT denotes the motor, and BT denotes the battery. The steering device SD, the motor MT, and the battery BT are included in the drive device **40**. Moreover, AP denotes the accelerator pedal, BP denotes the brake pedal, WH denotes the steering wheel, SP denotes the speaker, and MC denotes a microphone. The mobile object **1** shown in FIG. **2** is a single-seater mobile object and an occupant P is seated in the driver's seat DS and wearing a seat belt SB. An arrow D**1** indicates a movement direction (a speed vector) of the mobile object **1**. The external environment detection device **10** is provided near a front end of the mobile object **1**, the internal camera **16** is provided at a position where the head of the occupant P can be imaged from the front of the occupant P, and the mode changeover switch **22** is provided on a boss portion of the steering wheel WH. Moreover, the external notification device **50** serving as a display device is provided near the front end of the mobile object **1**.

[0045] Returning to FIG. **1**, the storage device **70** is, for example, a non-transitory storage device such as a hard disk drive (HDD), a flash memory, or a random-access memory (RAM). The storage device **70** stores map information **72**, a program **74** to be executed by the control device **100**, and the like. Although the storage device **70** is shown outside a frame of the control device **100** in FIG. **1**, the storage device **70** may be included in the control device **100**. Moreover, the storage device **70** may be provided on a server (not shown).

First Embodiment

[Control Device]

[0046] The control device **100** includes, for example, a road type recognition unit **120**, a physical object recognition unit **130**, and a control unit **140**. These constituent elements are implemented, for example, by a hardware processor such as a central processing unit (CPU) executing a program (software) **74**. Also, some or all of these constituent elements may be implemented by hardware (including a circuit unit; circuitry) such as a large-scale integration (LSI) circuit, an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or a graphics processing unit (GPU) or may be implemented by software and hardware in cooperation. The program may be pre-stored in the storage device **70** or may be stored in a removable storage medium (a non-transitory storage medium) such as a DVD or a CD-ROM and installed in the storage device **70** when the storage medium is mounted in a drive device.

[0047] The road type recognition unit **120** recognizes whether the mobile object **1** is moving on the

roadway or the sidewalk. For example, the road type recognition unit **120** recognizes whether the mobile object **1** is moving on the roadway or the sidewalk by analyzing an image captured by the external camera of the external environment detection device **10**. Also, the output of a radar device, a LIDAR sensor, a sensor fusion device, or the like may be used in an auxiliary way.

[0048] The road type recognition unit **120** adds a point value to a roadway score Sr every time each of the plurality of first events indicating that the mobile object **1** is moving on the roadway is recognized in the image captured by the external camera, and recognizes that the mobile object **1** is moving on the roadway when the roadway score Sr is greater than or equal to a first threshold value. In this case, the road type recognition unit **120** weights a point value in accordance with a degree of confidence when each of the plurality of first events has been recognized and adds the weighted point value to the roadway score Sr. Point values corresponding to the first events are denoted by P**1** to Pn (n is a natural number and is equal to the number of events assumed as the first event). The point values P**1** to Pn may be the same value or may be different values according to types of first events. Moreover, it is assumed that the weight corresponding to the degree of confidence of a recognition process is al to an. The degree of confidence of the recognition process is incidentally output in the process of recognizing the first event (including, for example, a discrimination process using a trained model by machine learning). The roadway score Sr is expressed by Eq. (1).

[00001] Sr = $1 \times P1 + 1 + P2 +$ .Math. $+ n \times$ Pn (1)

[0049] (If the corresponding first event k is not recognized, Pk=0 (k=1 to n))

[0050] Here, when the road type recognition unit **120** has recognized any one of a plurality of second events indicating that the mobile object **1** is moving on the sidewalk in the image captured by the external camera, it is recognized that the mobile object **1** is moving on the sidewalk regardless of the roadway score Sr.

[0051] More specifically, first, the road type recognition unit **120** classifies and labels pixels within a frame of the image according to semantic segmentation and assumes a plurality of virtual division regions and their boundary lines. The road type recognition unit **120** performs at least a process of classifying the region of the image captured by the external camera into a region where the mobile object **1** is located (hereinafter referred to as a host region) and a region where the mobile object **1** is not located adjacent to the region (hereinafter referred to as an adjacent region).

[0052] FIG. **3** is a diagram showing a plurality of first events. Although FIGS. **3** and **4** are represented by bird's-eye views viewed from above for description, a process of the road type recognition unit **120** may be performed on an image plane. As shown in FIG. **3**, the first events include, for example, two or more events among event (A) in which there is no static obstacle **204** other than a vehicle **203** in a host region **200** (i.e., inside the outer edge of the region where the mobile object **1** is located), event (B) in which the vehicle **203** is moving in the host region **200**, event (C) in which there is a road surface marking **205** on a road surface of the host region **200**, event (D) in which there is a crosswalk **206** in the host region **200**, and event (E) in which the host region **200** is located on a lower side with respect to a step **202**. Static obstacles are, for example, standing signboards, mailboxes, telephone poles, garbage bins, and the like, which are not classified as mobile objects or traffic participants. Because the static obstacles are rarely placed on the roadway in general, the road type recognition unit **120** increases a value of the roadway score when there is no static obstacle **204** in its host region **200**. Moreover, because a region where the vehicle **203** is moving is a roadway with a high probability, the road type recognition unit **120** increases the value of the roadway score when the vehicle **203** is moving in the host region **200**. Moreover, because the road surface marking **205** is generally drawn on the roadway, the road type recognition unit **120** increases the value of the roadway score when the road surface marking **205** is located in the host region **200**. Moreover, because the crosswalk **206** is generally drawn on the roadway, the road type recognition unit **120** increases the value of the roadway score when the

crosswalk **206** is located in the host region **200**. Moreover, because the sidewalk is generally located on the upper side of the step with respect to the roadway, the road type recognition unit **120** increases the value of the roadway score when the host region **200** is located on the lower side with respect to the step **202**.

[0053] FIG. **4** is a diagram showing a plurality of second events. In FIG. **4**, a relationship between a host region **200** and an adjacent region **201** is reversed according to a position of the mobile object **1**. As shown in FIG. **4**, the second events include, for example, one or more events among event (a) in which a second surface **207***b* facing the sidewalk side between two surfaces of a guardrail **207** has been imaged by the external camera, event (b) in which a braille block **208** is located on the road surface of the host region **200**, event (c) in which there is a static obstacle **204** other than the vehicle **203** in the host region **200**, event (d) in which the host region **200** is located on the upper side with respect to the step **202**. The guardrail **207** includes a first surface **207***a* facing the roadway side and a second surface **207***b* facing the sidewalk side and is installed on the road to match its direction. When the second surface **207***b* is imaged by the external camera, it is inferred that the mobile object **1** is moving on the sidewalk with a high probability. Moreover, in general, braille blocks are laid only on sidewalks. The static obstacle **204** and the step **202** are as described in the first event.

[0054] FIG. **5** is a diagram showing the second surface **207***b* facing the sidewalk side of the guardrail **207**. As shown in FIG. **5**, it is characterized that the second surface **207***b* has supports **207***c* on a front side compared to the first surface and is formed so that it is bent in the order of recess.fwdarw.projection.fwdarw.recess in a downward direction from the upper end. For example, the second surface **207***b* can be trained by a trained model and discriminated by image analysis.

[0055] In this way, it is possible to appropriately recognize whether the mobile object **1** is moving on the roadway or in a predetermined region different from the roadway by designating the first event as a factor for increasing the roadway score Sr and recognizing that the mobile object **1** is moving on the roadway when the roadway score Sr is greater than or equal to a first threshold value Th**1** and the second event is not recognized. As will be described below, the mobile object **1** is permitted to move at a higher speed when the mobile object **1** moves on the roadway than when the mobile object **1** moves on the sidewalk. Therefore, conditions for recognizing that the mobile object **1** is moving on the roadway are preferably set conservatively compared with conditions for recognizing that the mobile object **1** is moving on the sidewalk in consideration of safety aspects. In this regard, according to the embodiment, the validity of a recognition result can be ensured by designating the first event as a condition for increasing a point value instead of a condition for immediately recognizing the region as a roadway and designating the second event as a condition for immediately recognizing the region as a sidewalk.

[0056] The road type recognition unit **120** may collate position information of the mobile object **1** with the map information **72** and recognize whether the mobile object **1** is moving on the roadway or the sidewalk. In this case, the map information needs to be accurate enough to distinguish the sidewalk and the roadway from position coordinates. Moreover, when the “predetermined region” is not only a sidewalk, the road type recognition unit **120** also performs similar processes for roadside strips, bicycle lanes, public open spaces, and the like.

[0057] FIG. **6** is a flowchart showing an example of a flow of a process executed by the road type recognition unit **120** of the first embodiment. First, the road type recognition unit **120** acquires information for recognition, such as an image of the external camera (step S**300**).

[0058] Subsequently, the road type recognition unit **120** performs the processing of steps S**302** and S**304** for each of first events k (k=1 to n). The argument k is identification information of the first event. The road type recognition unit **120** determines whether or not first event k has been recognized (step S**302**) and a product of a coefficient αk and a point value Pk is added to the roadway score Sr when first event k has been recognized (step S**304**).

[0059] Subsequently, the road type recognition unit **120** determines whether or not second event j

has been recognized for each of second events j (j=1 to m) (step S**306**). The argument j is identification information of the second event and m is a natural number.
[0060] When a positive determination result has been obtained even once in the determination processing of step S**306** performed up to m times, the road type recognition unit **120** recognizes that the mobile object **1** is moving on the sidewalk (step S**312**).
[0061] When a negative determination result has been obtained in all of the determination processing of step S**306**, the road type recognition unit **120** determines whether or not the roadway score Sr is greater than or equal to the first threshold value Th**1** (step S**308**). When it is determined that the roadway score Sr is greater than or equal to the first threshold value Th**1**, the road type recognition unit **120** recognizes that the mobile object **1** is moving on the roadway (step S**310**). When the roadway score Sr is less than the first threshold value Th**1**, strictly speaking, it is not recognized with a sufficient degree of confidence whether the mobile object **1** is moving on the roadway or the sidewalk, but the road type recognition unit **120** recognizes that the mobile object **1** is moving on the sidewalk in consideration of safety aspects (step S**312**).
[0062] The physical object recognition unit **130** recognizes a physical object located near the mobile object **1** on the basis of an output of the external environment detection device **10**. Physical objects include some or all of mobile objects such as a vehicle, a bicycle, and a pedestrian, course boundaries such as a road marking, a step, a guardrail, a road shoulder, a median strip, structures installed on the road such as a road sign and a signboard, and an obstacle such as a falling object located (having fallen) on the course. For example, the physical object recognition unit **130** acquires information such as the presence, position, and type of another mobile object when an image captured by the external camera of the external environment detection device **10** is input to a trained model that has been trained to output information such as the presence, position, and type of a physical object if the image captured by the external camera is input. A type of the other mobile object can also be estimated on the basis of a size in the image and/or the intensity of reflected waves received by the radar device of the external environment detection device **10**. Moreover, the physical object recognition unit **130** acquires, for example, the speed of another mobile object detected by the radar device using a Doppler shift or the like.
[0063] The control unit **140** controls, for example, the drive device **40** in accordance with a set driving mode. Also, the mobile object **1** may execute only some of the following driving modes, but the control unit **140** sets different speed limit values when the mobile object **1** moves on the roadway and when the mobile object **1** moves on the sidewalk in any case. In this case, the mode changeover switch **22** may be omitted.
[0064] In mode A-**1**, the control unit **140** controls the motor MT of the drive device **40** so that a distance from a physical object located in front of the mobile object **1** is maintained at a certain distance or more when the mobile object **1** moves on the roadway and the mobile object **1** moves at a first speed V**1** (e.g., a speed of 10 [km/h] or more and less than several tens of kilometers per hour [km/h]) when a distance from a physical object located in front of the mobile object **1** is sufficiently long with reference to information about a course and a physical object based on the output of the physical object recognition unit **130**. The control unit **140** controls the motor MT of the drive device **40** so that a distance from a physical object located in front of the mobile object **1** is maintained at a certain distance or more when the mobile object **1** moves on the sidewalk and the mobile object **1** moves at the second speed V**2** (for example, a speed of less than 10 [km/h]) when a distance from a physical object located in front of the mobile object **1** is sufficiently long. This function is similar to an adaptive cruise control (ACC) function of a vehicle in which the first speed V**1** or the second speed V**2** is designated as the set speed and the technology used in ACC can be used. Moreover, in mode A-**1**, the control unit **140** controls the steering device SD so that a steering angle of the steered wheel is changed on the basis of a manipulation quantity of the manipulation element **14** such as the steering wheel. This function is similar to that of a power steering device and the technology used in the power steering device can be used. Also, electronic control is not

performed in relation to steering and the mobile object **1** may include a steering device in which the manipulation element **14** and the steering mechanism are mechanically connected.

[0065] In mode A-**2**, the control unit **140** controls the steering device SD of the drive device **40** so that a target trajectory along which the mobile object **1** can move while avoiding a physical object within the course is generated with reference to information about the course and the physical object based on the output of the physical object recognition unit **130** and the mobile object **1** moves along the target trajectory. In relation to acceleration/deceleration, the control unit **140** controls the motor MT of the drive device **40** on the basis of the speed of the mobile object **1** and the manipulation quantity of the accelerator pedal or the brake pedal. The control unit **140** controls the motor MT of the drive device **40** in a state in which the first speed V**1** is designated as the upper limit speed (wherein this control indicates that the mobile object **1** is not accelerated even if there is a further acceleration instruction when the mobile object **1** reaches the upper limit speed in the case of mode A-**2**) when the mobile object **1** is moving on the roadway and controls the drive device **40** in a state in which the second speed V**2** is designated as the upper limit speed when the mobile object **1** is moving on the sidewalk.

[0066] In mode B, the control unit **140** controls the motor MT of the drive device **40** on the basis of the speed of the mobile object **1** and the manipulation quantity of the accelerator pedal or brake pedal. The control unit **140** controls the motor MT of the drive device **40** in a state in which the first speed V**1** is designated as the upper limit speed (wherein this control indicates that the mobile object **1** is not accelerated even if there is a further acceleration instruction when the mobile object **1** reaches the upper limit speed in the case of mode B) when the mobile object **1** is moving on the roadway and controls the motor MT of the drive device **40** in a state in which the second speed V**2** is designated as the upper limit speed when the mobile object **1** is moving on the sidewalk. In relation to steering, mode B is similar to mode A-**1**.

[0067] In mode C, the control unit **140** controls the drive device **40** so that a target trajectory along which the mobile object **1** can move while avoiding a physical object within the course is generated with reference to information about the course and the physical object based on the output of the physical object recognition unit **130** and the mobile object **1** moves along the target trajectory. Even in mode C, the control unit **140** controls the drive device **40** in a state in which the first speed V**1** is designated as the upper limit speed when the mobile object **1** is moving on the roadway and controls the drive device **40** in a state in which the second speed V**2** is designated as the upper limit speed when the mobile object **1** is moving on the sidewalk.

[0068] According to the above-described first embodiment, it is possible to appropriately recognize whether a mobile object is moving on the roadway or in a predetermined region different from the roadway.

Second Embodiment

[0069] Hereinafter, a second embodiment will be described. In the first embodiment, it is recognized that the mobile object **1** is moving on the sidewalk when a second event has been recognized. However, in the second embodiment, exception processing is performed when the second event is recognized and a roadway score Sr is greater than or equal to a second threshold value Th**2** (Th**1**<Th**2**).

[0070] When the second event is recognized and the roadway score Sr is greater than or equal to the second threshold value Th**2**, this is a case where one or more second events have been recognized regardless of the fact that it is determined that there is a high probability that the mobile object **1** is moving on the roadway because the roadway score Sr has reached a large value. In this case, the second event is likely to have been recognized due to the fact that the recognition of the second event has been misrecognition, a static obstacle has been accidentally placed on the roadway, or the roadway has been located on the upper side of the step due to an irregular road structure.

[0071] Therefore, in this case, a road type recognition unit **120** of the second embodiment performs

the following exception processing without immediately determining that the mobile object **1** is moving on the sidewalk.

[0072] For example, the exception processing is processing (1) in which a previous recognition result continues for a certain period of time if the recognition result indicates that "the mobile object **1** is moving on the roadway" and it is recognized that the mobile object **1** is moving on the sidewalk if the previous recognition result indicates that "the mobile object **1** is moving on the sidewalk." Also, when a state in which "the second event is recognized and the roadway score Sr is greater than or equal to the second threshold value Th**2**" still continues after a certain period of time, the road type recognition unit **120** may recognize that the mobile object **1** is moving on the sidewalk.

[0073] Moreover, the exception processing may be processing (2) for outputting information for asking the occupant P of the mobile object **1** about a type in which the mobile object **1** is moving on the roadway or the sidewalk and recognizing whether the mobile object **1** is moving on the roadway or the sidewalk on the basis of a response of the occupant P. In this case, the response of the occupant P may be performed, for example, via a road type input switch (not shown) provided on the mobile object **1**, or by voice.

[0074] FIG. **7** is a flowchart showing an example of a flow of a process executed by the road type recognition unit **120** of the second embodiment. Because details of the processing of steps S**300** to S**312** in this flowchart are similar to those of the processing of the flowchart shown in FIG. **6**, redundant description will be omitted.

[0075] When it is determined that second event j has been recognized in the determination processing of step S**306**, the road type recognition unit **120** determines whether or not the roadway score Sr is equal to or greater than the second threshold value (step S**314**). When it is determined that the roadway score Sr is less than the second threshold value, the road type recognition unit **120** recognizes that the mobile object **1** is moving on the sidewalk (step S**312**). On the other hand, when it is determined that the roadway score Sr is greater than or equal to the second threshold value, the road type recognition unit **120** performs the above-described exception processing (step S**316**).

[0076] According to the above-described second embodiment, even though it is determined that there is a high probability that the mobile object **1** is moving on the roadway, it is possible to further improve the validity of a recognition result by executing the exception processing so that it is not immediately recognized that the mobile object **1** is moving on the sidewalk when one or more second events are recognized. Also, in the second embodiment, a sidewalk score Ss is calculated according to the number of times the second event is recognized, and when the sidewalk score Ss is large, the exception processing may not be performed even if the roadway score Sr is greater than or equal to the second threshold value Th**2**.

[0077] The embodiment described above can be represented as follows.

[0078] A mobile object control device including: [0079] a storage medium storing computer-readable instructions; and [0080] a processor connected to the storage medium, the processor executing the computer-readable instructions to: [0081] recognize whether a mobile object capable of moving both on a roadway and in a predetermined region different from the roadway is moving on the roadway or in the predetermined region on the basis of an output of an external environment detection device configured to detect an external situation of the mobile object; and [0082] limit a speed of a case where the mobile object moves on the roadway to a first speed and limit a speed of a case where the mobile object moves in the predetermined region to a second speed lower than the first speed, [0083] wherein the recognizing includes adding a point value to a roadway score every time each of a plurality of first events indicating that the mobile object is moving on the roadway is recognized on the basis of the output of the external environment detection device and recognizing that the mobile object is moving on the roadway when the roadway score is greater than or equal to a first threshold value.

[0084] Although modes for carrying out the present invention have been described above using

embodiments, the present invention is not limited to the embodiments and various modifications and substitutions can also be made without departing from the scope and spirit of the present invention.

REFERENCE SIGNS LIST

[0085] **10** External environment detection device [0086] **12** Mobile object sensor [0087] **14** Manipulation element [0088] **16** Internal camera [0089] **18** Positioning device [0090] **22** Mode changeover switch [0091] **30** Moving mechanism [0092] **40** Drive device [0093] **50** External notification device [0094] **70** Storage device [0095] **100** Control device [0096] **120** Road type recognition unit [0097] **130** Physical object recognition unit [0098] **140** Control unit

Claims

1. A mobile object control device for controlling a mobile object capable of moving both on a roadway and in a predetermined region different from the roadway, the mobile object control device comprising: a road type recognition unit configured to recognize whether the mobile object is moving on the roadway or in the predetermined region on the basis of an output of an external environment detection device configured to detect an external situation of the mobile object; and a control unit configured to limit a speed of a case where the mobile object moves on the roadway to a first speed and limit a speed of a case where the mobile object moves in the predetermined region to a second speed lower than the first speed, wherein the road type recognition unit adds a point value to a roadway score every time each of a plurality of first events indicating that the mobile object is moving on the roadway is recognized on the basis of the output of the external environment detection device and recognizes that the mobile object is moving on the roadway when the roadway score is greater than or equal to a first threshold value.

2. The mobile object control device according to claim 1, wherein the road type recognition unit weights a point value in accordance with a degree of confidence when each of the plurality of first events has been recognized and adds the weighted point value to the roadway score.

3. The mobile object control device according to claim 1, wherein the plurality of first events include that a static obstacle other than a vehicle is not located inside an outer edge of a region where the mobile object is located.

4. The mobile object control device according to claim 1, wherein the plurality of first events include that a vehicle is moving in a region where the mobile object is located.

5. The mobile object control device according to claim 1, wherein the plurality of first events include that there is a road surface marking on a road surface of a region where the mobile object is located.

6. The mobile object control device according to claim 1, wherein the plurality of first events include that there is a crosswalk in a region where the mobile object is located.

7. The mobile object control device according to claim 1, wherein the plurality of first events include that a region where the mobile object is located is on a lower side with respect to a step.

8. The mobile object control device according to claim 1, wherein the road type recognition unit recognizes that the mobile object is moving in the predetermined region regardless of the roadway score when any one of one or more second events indicating that the mobile object is moving in the predetermined region has been recognized on the basis of the output of the external environment detection device.

9. The mobile object control device according to claim 1, wherein the road type recognition unit recognizes any one of one or more second events indicating that the mobile object is moving in the predetermined region on the basis of the output of the external environment detection device and recognizes that the mobile object is moving in the predetermined region when the roadway score is less than a second threshold value larger than the first threshold value.

10. The mobile object control device according to claim 9, wherein the road type recognition unit

recognizes any one of the one or more second events on the basis of the output of the external environment detection device and executes exception processing when the roadway score is greater than or equal to the second threshold value larger than the first threshold value.

11. The mobile object control device according to claim 8, wherein the one or more second events include that a camera included in the external environment detection device has imaged a second surface facing a sidewalk side of a guardrail.

12. The mobile object control device according to claim 8, wherein the one or more second events include that there is a braille block on a road surface on which the mobile object is moving.

13. The mobile object control device according to claim 8, wherein the one or more second events include that there is a static obstacle other than a vehicle within a region where the mobile object is located.

14. The mobile object control device according to claim 8, wherein the one or more second events include that a region where the mobile object is located is located on an upper side with respect to a step.

15. A mobile object control method comprising: recognizing, by a computer for controlling a mobile object capable of moving both on a roadway and in a predetermined region different from the roadway, whether the mobile object is moving on the roadway or in the predetermined region on the basis of an output of an external environment detection device configured to detect an external situation of the mobile object; and limiting, by the computer, a speed of a case where the mobile object moves on the roadway to a first speed and limiting a speed of a case where the mobile object moves in the predetermined region to a second speed lower than the first speed, wherein the recognizing includes adding a point value to a roadway score every time each of a plurality of first events indicating that the mobile object is moving on the roadway is recognized on the basis of the output of the external environment detection device and recognizing that the mobile object is moving on the roadway when the roadway score is greater than or equal to a first threshold value.

16. A non-transitory storage medium storing a program for causing a computer for controlling a mobile object capable of moving both on a roadway and in a predetermined region different from the roadway to: recognize whether the mobile object is moving on the roadway or in the predetermined region on the basis of an output of an external environment detection device configured to detect an external situation of the mobile object; and limit a speed of a case where the mobile object moves on the roadway to a first speed and limit a speed of a case where the mobile object moves in the predetermined region to a second speed lower than the first speed, wherein the recognizing includes adding a point value to a roadway score every time each of a plurality of first events indicating that the mobile object is moving on the roadway is recognized on the basis of the output of the external environment detection device and recognizing that the mobile object is moving on the roadway when the roadway score is greater than or equal to a first threshold value.