TRAVEL CONTROL DEVICE OF TOWING VEHICLE

BACKGROUND ART

The present invention relates to a travel control device of a towing vehicle.

For example, Japanese Patent Application Publication No. 2022-75157 discloses a technique that detects a relative position of an aircraft maintenance doorway with respect to a maintenance vehicle such as a towing tractor and sets an approach route for the maintenance vehicle to the aircraft maintenance doorway based on the detection data.

A vehicle width of a loading trailer (trailer) changes depending on a load towed by a towing tractor (towing vehicle). In a case of a towing tractor driven by an operator, the operator drives the towing tractor on a travel path in consideration with the vehicle width of the loading trailer. On the other hand, in a case of a towing tractor travelling autonomously, the towing tractor travels according to a predetermined travel path. Here, if the vehicle width of the loading trailer changes, it is necessary for the operator to determine the vehicle width of the loading trailer and change the travel path to a travel path appropriate for the vehicle width. However, the operator may make a mistake in determining the vehicle width of the loading trailer. Additionally, the operator may not be present in the towing tractor in the case of the towing tractor travelling autonomously. Therefore, the vehicle width of the loading trailer needs to be detected automatically.

The present invention is directed to providing a travel control device of a towing vehicle that can automatically detect a vehicle width of a trailer connected to the towing vehicle.

SUMMARY

In accordance with an aspect of the present disclosure, there is provided a travel control device of a towing vehicle to which a trailer is connected including a trailer detection unit configured to detect a distance to the trailer and an orientation of the trailer relative to the towing vehicle, a vehicle width calculation unit configured to calculate a vehicle width of the trailer based on detection data of the trailer detection unit, and a control unit configured to control the towing vehicle such that the towing vehicle travels according to the vehicle width of the trailer calculated by the vehicle width calculation unit.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure, together with objects and advantages thereof, may best be understood by reference to the following description of the embodiments together with the accompanying drawings in which:

FIG. 1 is a schematic side view of a towing tractor to which a travel control device according to an embodiment of the present invention is applied, the towing tractor being in a state where a loading trailer is connected to the towing tractor;

FIG. 2 is a plan view of the towing tractor in the state where the loading trailer is connected to the towing tractor;

FIG. 3 is a block diagram illustrating a configuration of a travel control device according to a first embodiment of the present invention;

FIG. 4 is a conceptual view illustrating parameters for expressions that are used when a vehicle width calculation unit illustrated in FIG. 3 calculates a vehicle width of the loading trailer;

FIG. 5 is a conceptual view illustrating parameters for other expressions that are used when the vehicle width calculation unit illustrated in FIG. 3 calculates the vehicle width of the loading trailer;

FIG. 6 is a block diagram illustrating a configuration of a travel control device according to a second embodiment of the present invention;

FIG. 7 is a schematic side view of the towing tractor in a state where a plurality of loading trailers is connected to a towing tractor;

FIG. 8 is a block diagram illustrating a configuration of a travel control

device according to a third embodiment of the present invention;

FIG. 9 is a schematic side view of a towing tractor in a state where a load is loaded on a loading platform of a loading trailer connected to the towing tractor; and

FIG. 10A and 10B are plan views illustrating positions of obstacle sensors in FIG. 2 in modified examples.

DESCRIPTION OF EMBODIMENTS

The following will describe embodiments of the present invention in detail with reference to the accompanying drawings. It is to be noted that, in the drawings, identical or equivalent elements are denoted by the same reference numerals, and the overlapping description thereof will be omitted.

FIG. 1 is a side view of a towing tractor to which a travel control device according to an embodiment of the present invention is applied, which schematically illustrates a state where a loading trailer is connected to the towing tractor. FIG. 2 is a plan view of the towing tractor in a state where the loading trailer is connected to the towing tractor. In FIGS. 1 and 2, a travel control device 1 according to the present embodiment is mounted on a towing tractor 2.

The towing tractor 2 is an industrial vehicle used in an airport, for example. The towing tractor 2 is a towing vehicle that tows a loading trailer 3 (trailer). The loading trailer 3 is connected to a rear end of the towing tractor 2 with a coupler 4.

The towing tractor 2 includes a vehicle body 5 and four wheels 6. The loading trailer 3 includes a loading platform 7 on which a load M (see FIG. 9) is loaded and four wheels 8. A vehicle width W of the loading trailer 3 is greater than a vehicle width W0 of the towing tractor 2. The vehicle width W of the loading trailer 3 is a dimension of the loading platform 7 in a width direction. The vehicle width W0 of the towing tractor 2 is a dimension of the vehicle body 5 in a width direction. At an airport, a plurality of types of (for example, three types of)

the loading trailers 3 with different vehicle widths W are used.

FIG. 3 is a block diagram illustrating a configuration of a travel control device according to a first embodiment of the present invention. In FIG. 3, the travel control device 1 of the first embodiment is a device that controls the towing tractor 2 so that the towing tractor 2 to which the loading trailer 3 is connected travels autonomously.

The travel control device 1 includes a self-position estimation sensor 11, a map storage unit 12, obstacle sensors 13, 14, 15, a vehicle information storage unit 16, a drive unit 17, an alarm unit 18, and a controller 20.

The self-position estimation sensor 11 is used for estimation of a self-position of the towing tractor 2. The self-position estimation sensor 11 is a sensor that detects an object existing around the towing tractor 2. For example, a light detection and ranging (LIDAR), or a laser sensor such as a laser range finder may be used as the self-position estimation sensor 11.

The self-position estimation sensor 11 detects a distance from the self-position estimation sensor 11 to an object existing around the towing tractor 2 by irradiating a periphery of the towing tractor 2 with a laser light and receiving the reflection light of the laser light.

The map storage unit 12 stores map data of a location where the towing tractor 2 travels (the airport in this case). Buildings, pillars, walls, and the like in the location are included in the map data.

For example, a laser sensor similar to the self-position estimation sensor 11 may be used for the obstacle sensors 13, 14, 15. For example, an obstacle may be a worker, or other vehicles existing around the towing tractor 2.

The obstacle sensor 13 is mounted to a front end of the towing tractor 2

(see FIG. 2). The obstacle sensor 13 is a sensor that detects an obstacle existing in a region including an area in front of the towing tractor 2. The obstacle sensor 13 detects an obstacle by irradiating the region including the area in front of the towing tractor 2 with a laser light and receiving the reflection light of the laser light.

The obstacle sensor 14 is mounted to a left end of a rear part of the towing tractor 2 (see FIG. 2). The obstacle sensor 14 is a sensor that detects an obstacle existing in a region including an area on the left and the rear left of the towing tractor 2. The obstacle sensor 14 detects an obstacle by irradiating the region including an area on the left and the rear left of the towing tractor 2 with a laser light and receiving the reflection light of the laser light.

The obstacle sensor 15 is mounted to a right end of a rear part of the towing tractor 2 (see FIG. 2). The obstacle sensor 15 is a sensor that detects an obstacle existing in a region including an area on the right and the rear right of the towing tractor 2. The obstacle sensor 15 detects an obstacle by irradiating the region including an area on the right and the rear right of the towing tractor 2 with a laser light and receiving the reflection light of the laser light. In the following description, the obstacle sensor 14 and the obstacle sensor 15 may be referred to as the left obstacle sensor 14 and the right obstacle sensor 15, respectively.

The obstacle sensors 14, 15 also detect the loading trailer 3 connected to the towing tractor 2. The obstacle sensors 14, 15 cooperate to form a trailer detection unit that detect a distance to the loading trailer 3 and an orientation of the loading trailer 3 relative to the towing tractor 2.

As a distance to the loading trailer 3, the obstacle sensors 14, 15 detect distances from the obstacle sensors 14, 15, respectively, to a front end 3a of the loading trailer 3. Specifically, the distance from the obstacle sensor 14 to the front end 3a of the loading trailer 3 corresponds to a distance from the obstacle sensor 14 to the left corner of the front end 3a, and the distance from the obstacle sensor 15 to the front end 3a of the loading trailer 3 corresponds to a distance from the

obstacle sensor 15 to the right corner of the front end 3a.

As the orientation of the loading trailer 3 relative to the towing tractor 2, the obstacle sensors 14, 15 detect an angle between a line that connects the obstacle sensor 14 and the left corner of the front end 3a and a line that passes through the obstacle sensor 14 and extends in the front-rear direction of the towing tractor 2, and an angle between a line that connects the obstacle sensor 15 and the right corner of the front end 3a and a line that passes the obstacle sensor 15 and extends in the front-rear direction of the towing tractor 2.

The vehicle information storage unit 16 stores information related to the towing tractor 2. The information related to the towing tractor 2 includes information related to the positions of the obstacle sensors 14, 15, and the like. The positions of the obstacle sensors 14, 15 are expressed in two-dimensional coordinates (XY coordinates), which will be described later.

The drive unit 17 includes, for example, a travel motor (not illustrated) that rotates the wheels 6 of the towing tractor 2, and a steering motor (not illustrated) that steers the wheels 6.

The alarm unit 18 issues an alarm by sounding an alarm, or displaying an alarm when an obstacle detection unit 27, which will be described later, of the controller 20 detects an obstacle in the vicinity of the towing tractor 2.

The controller 20 includes a central processing unit (CPU), a random access memory (RAM), a read-only memory (ROM), and an input/output interface, and the like. The controller 20 includes a self-position estimation unit 21, a vehicle width calculation unit 22, a travel path setting unit 23, a travel route generation unit 24, a travel control unit 25, a detection range setting unit 26, and the obstacle detection unit 27. Functions of these units are performed, for example, when a start of autonomous travel is instructed by an operation switch (not illustrated) after the loading trailer 3 is connected to the towing tractor 2.

The self-position estimation unit 21 estimates the self-position of the towing tractor 2 based on detection data of the self-position estimation sensor 11, and map data stored in the map storage unit 12. Specifically, the self-position estimation unit 21 estimates the self-position of the towing tractor 2 by matching the detection data of the self-position estimation sensor 11 and the map data with a method such as simultaneous localization and mapping (SLAM). The SLAM is a self-position estimation technique that uses sensor data and map data to estimate a self-position.

The vehicle width calculation unit 22 calculates the vehicle width W of the loading trailer 3 based on the detection data of the obstacle sensors 14, 15 and the information related to the towing tractor 2 stored in the vehicle information storage unit 16. Specifically, the vehicle width calculation unit 22 calculates the vehicle width W of the loading trailer 3 as follows.

As illustrated in FIG. 4, the vehicle width W of the loading trailer 3 may be expressed by an equation below with a position of a specific part of the towing tractor 2 set as an origin point O, a position of a front left corner CL of the loading trailer 3 set as (X3, Y3), and a position of a front right corner CR of the loading trailer 3 set as (X4, Y4). The origin point O is positioned on a center line G of the towing tractor 2 in the vehicle width direction. The center line G extends in the front-rear direction of the towing tractor 2. Specifically, the origin point O is a point where the center line G intersects an axis S through which an axle of the left and right rear wheels 6 pass.

$$W = ((X4 - X3)^2 + (Y4 - Y3)^2)^{1/2} \quad \ldots(A)$$

Equations below are obtained with the position of the left obstacle sensor 14 set as (X1, Y1) and the position of the right obstacle sensor 15 set as (X2, Y2). The positions of the obstacle sensors 14, 15 are registered in the vehicle information storage unit 16 in advance.

$$X3 = X1 - L1 \cdot \sin\theta1$$

$$Y3 = Y1 - L1 \cdot \cos\theta1$$

$$X4 = X2 + L2 \cdot \sin\theta2$$

$$Y4 = Y2 - L2 \cdot \cos\theta2$$

A distance L1 represents a distance from the left obstacle sensor 14 to the front left corner CL of the loading trailer 3. A distance L2 represents a distance from the right obstacle sensor 15 to the front right corner CR of the loading trailer 3. An angle θ1 represents an angle between a line P1 that connects the left obstacle sensor 14 and the front left corner CL of the loading trailer 3 and a line Q1 that passes through the left obstacle sensor 14 and extends in the front-rear direction of the towing tractor 2. An angle θ2 represents an angle between a line P2 that connects the right obstacle sensor 15 and the front right corner CR of the loading trailer 3 and a line Q2 that passes through the right obstacle sensor 15 and extends in the front-rear direction of the towing tractor 2.

The distance L1 and the angle θ1 are obtained from the detection data of the obstacle sensor 14. The distance L2 and the angle θ2 are obtained from the detection data of the obstacle sensor 15. The distance L1 and the distance L2 correspond to the distances from the obstacle sensor 14 to the loading trailer 3 and the distance from the obstacle sensor 15 to the loading trailer 3, respectively. The angle θ1 and the angle θ2 correspond to the orientation of the loading trailer 3 relative to the towing tractor 2.

Referring to FIG. 3, the travel path setting unit 23 sets the travel path corresponding to the vehicle width W of the loading trailer 3 calculated by the vehicle width calculation unit 22. The travel path is a path where the towing tractor 2 travels while travelling in a curve. The travel path setting unit 23 sets the travel path that becomes a wider curve as the vehicle width W of the loading trailer 3 is greater.

The relationship between the vehicle width W of the loading trailer 3 and the travel path of the towing tractor 2 is predetermined, for example, as the map data. The travel path setting unit 23 selects the travel path corresponding to the vehicle width W of the loading trailer 3.

The travel route generation unit 24 generates a travel route including the travel path set by the travel path setting unit 23. The travel route is a route on which the towing tractor 2 travels from a point where the loading trailer 3 is connected to the towing tractor 2 to a destination.

The travel control unit 25 controls the drive unit 17 such that the towing tractor 2 travels along the travel route generated by the travel route generation unit 24 based on the self-position of the towing tractor 2 estimated by the self-position estimation unit 21. Additionally, the travel control unit 25 controls the drive unit 17 such that the towing tractor 2 decelerates or stops when the obstacle detection unit 27, which will be described later, detects an obstacle existing in the vicinity of the towing tractor 2.

The travel path setting unit 23, the travel route generation unit 24, the travel control unit 25 form a control unit that controls the towing tractor 2 such that the towing tractor 2 travels according to the vehicle width W of the loading trailer 3 calculated by the vehicle width calculation unit 22. The control unit sets the travel path corresponding to the vehicle width W of the loading trailer 3, and controls the towing tractor 2 such that the towing tractor 2 travels in accordance with the travel path.

The detection range setting unit 26 sets an obstacle detection range, which will be described later, corresponding to the vehicle width W of the loading trailer 3. The detection range setting unit 26 increases the obstacle detection range as the vehicle width W of the loading trailer 3 is greater.

The relationship between the vehicle width W of the loading trailer 3 and

the obstacle detection range is predetermined, for example, as the map data. The detection range setting unit 26 sets the obstacle detection range corresponding to the vehicle width W of the loading trailer 3.

The obstacle detection unit 27 detects whether or not an obstacle exists in the obstacle detection range set by the detection range setting unit 26, based on the detection data of the obstacle sensors 13, 14, 15. The obstacle detection range is a designated range to detect whether or not an obstacle exists in the vicinity of the towing tractor 2. When the obstacle detection unit 27 detects that an obstacle exists in the obstacle detection range, the obstacle detection unit 27 causes the alarm unit 18 to issue an alarm and the travel control unit 25 to decelerate or stop the towing tractor 2.

The above-described travel control device 1 causes the towing tractor 2 to travel autonomously to a destination after the towing tractor 2 moves rearward to the loading trailer 3 and the loading trailer 3 is connected to the towing tractor 2 with the coupler 4. The towing tractor 2 and the loading trailer 3 are connected manually by an operator. It is noted that the connection between the towing tractor 2 and the loading trailer 3 may be automated.

After the loading trailer 3 is connected to the towing tractor 2, firstly, the vehicle width W of the loading trailer 3 is calculated based on the detection data of the obstacle sensors 14, 15. Then, the travel path corresponding to the vehicle width W of the loading trailer 3 is set, the travel route of the towing tractor 2 including the travel path having been set is generated, and the obstacle detection range corresponding to the vehicle width W of the loading trailer 3 is set.

The towing tractor 2 travels toward the destination along the travel route while estimating the self-position with the self-position estimation sensor 11. At this time, when an obstacle is detected in the vicinity of the towing tractor 2 by the obstacle sensors 13, 14, 15, the alarm unit 18 issues an alarm and the towing tractor 2 is forcibly decelerated or stopped.

As has been described, in the present embodiment, the obstacle sensors 14, 15 detect the distance to the loading trailer 3 and the orientation of the loading trailer 3 relative to the towing tractor 2. Then, the vehicle width W of the loading trailer 3 is calculated based on the detection data of the obstacle sensors 14, 15, and the towing tractor 2 is controlled to travel according to the vehicle width W of the loading trailer 3. In this way, the vehicle width W of the loading trailer 3 is calculated by detecting the distance to the loading trailer 3 and the orientation of the loading trailer 3 relative to the towing tractor 2. Accordingly, the vehicle width W of the loading trailer 3 connected to the towing tractor 2 is automatically detected. As a result, a mistake in determining the vehicle width W of the loading trailer 3, for example, by the operator, may be eliminated.

In the present embodiment, the travel path corresponding to the vehicle width W of the loading trailer 3 is set, and the towing tractor 2 is controlled such that the towing tractor 2 travels according to the travel path. Thus, the travel path suitable for the vehicle width W of the loading trailer 3 is set. As a result, for example, even when the towing tractor 2 having the loading trailer 3 connected travels in a curve, the towing tractor 2 travels smoothly regardless of the vehicle width W of the loading trailer 3.

In the present embodiment, the distance to the loading trailer 3 and the orientation of the loading trailer 3 relative to the towing tractor 2 are detected by using the obstacle sensors 14, 15 existing in the towing tractor 2. Thus, a need for the towing tractor 2 to be equipped with a dedicated sensor for detecting the distance to the loading trailer 3 and the orientation of the loading trailer 3 relative to the towing tractor 2 may be eliminated. Accordingly, an increase in the cost may be suppressed.

In the present embodiment, the obstacle detection range corresponding to the vehicle width W of the loading trailer 3 is set. Thus, the obstacle detection range changes depending on the vehicle width W of the loading trailer 3. As a

result, even when the vehicle width W of the loading trailer 3 changes, an obstacle existing in the vicinity of the towing tractor 2 may be detected accurately.

In the present embodiment, the vehicle width W of the loading trailer 3 may be calculated using simple equations by detecting the distance L1 from the left obstacle sensor 14 to the left corner of the front end 3a (the front left corner CL) of the loading trailer 3, the distance L2 from the right obstacle sensor 15 to the right corner of the front end 3a (the front right corner CR) of the loading trailer 3, the angle θ1 between the line P1 that connects the left obstacle sensor 14 and the front left corner CL of the loading trailer 3 and the line Q1 that passes through the left obstacle sensor 14 and extends in the front-rear direction of the towing tractor 2, and the angle θ2 between the line P2 that connects the right obstacle sensor 15 and the front right corner CR of the loading trailer 3 and the line Q2 that passes through the right obstacle sensor 15 and extends in the front-rear direction of the towing tractor 2.

In addition, in the present embodiment, even when the loading trailer 3 is connected to the towing tractor 2 in a state where the loading trailer 3 is tilted relative to the towing tractor 2, the vehicle width W of the loading trailer 3 is calculated by detecting the distances to the loading trailer 3 and the orientation of the loading trailer 3 relative to the towing tractor 2.

It is noted that when the loading trailer 3 is connected straight to the towing tractor 2, not being tilted relative to the towing tractor 2, as illustrated in FIG. 5, the vehicle width W of the loading trailer 3 may be calculated by the following equation, instead of the equation (A).

$$W = L1 \cdot \sin\theta1 + Y1 + Y2 + L2 \cdot \sin\theta2 \ldots (B)$$

A distance Y1 represents a distance from the left obstacle sensor 14 to the center line G of the towing tractor 2 in the vehicle width direction. A distance Y2 represents a distance from the right obstacle sensor 15 to the center line G of

the towing tractor 2 in the vehicle width direction. The distances Y1 and Y2 are stored in advance in the vehicle information storage unit 16.

When it is detected that the loading trailer 3 is connected straight to the towing tractor 2 based on the detection data of the obstacle sensors 14, 15, a calculation time may be reduced by calculating the vehicle width W of the loading trailer 3 using the expression (B).

FIG. 6 is a block diagram illustrating a configuration of a travel control device according to a second embodiment of the present invention. As illustrated in FIG. 6, the travel control device 1A of the second embodiment includes a controller 20A, in place of the controller 20 of the first embodiment.

The controller 20A includes the self-position estimation unit 21, the vehicle width calculation unit 22, a trailer number detection unit 28, a travel path setting unit 23A, the travel route generation unit 24, the travel control unit 25, the detection range setting unit 26, and the obstacle detection unit 27.

As illustrated in FIG. 7, the trailer number detection unit 28 detects the number of the loading trailers 3 towed by the towing tractor 2 based on the detection data of the obstacle sensors 14, 15. The trailer number detection unit 28 may be configured to detect the number of the loading trailer 3 towed by the towing tractor 2 based on the detection data of only one of the obstacle sensors 14, 15.

In FIG. 7, the towing tractor 2 tows three loading trailers 3 connected in series. In this case, the loading trailer 3 in the rear is connected to a rear end of the loading trailer 3 in the front with the coupler 4. The obstacle sensors 14, 15 are mounted to upper ends of both side ends of the rear part of the towing tractor 2. This allows laser lights L emitted from the obstacle sensors 14, 15 to easily reach the rear of the towing tractor 2. As a result, the number of the loading trailers 3 towed by the towing tractor 2 is more easily detected.

The travel path setting unit 23A sets the travel path corresponding to the vehicle width W of the loading trailer 3 calculated by the vehicle width calculation unit 22, and the number of the loading trailers 3 detected by the trailer number detection unit 28. The travel path setting unit 23A sets the travel path such that the travel path is the shortest distance corresponding to the number of the loading trailers 3 by setting the travel path that becomes a wider curve as the vehicle width W increases and as the number of the loading trailers 3 increases. The relationship between the vehicle width W of the loading trailer 3 and the number of the loading trailers 3 and the travel path of the towing tractor 2 is predetermined, for example, as the map data. The travel path setting unit 23A selects the travel path corresponding to the vehicle width W of the loading trailer 3 and the number of the loading trailers 3.

The travel path setting unit 23A, the travel route generation unit 24, and the travel control unit 25 form a control unit that controls the travelling of the towing tractor 2 according to the vehicle width W of the loading trailer 3 calculated by the vehicle width calculation unit 22. The control unit sets the travel path corresponding to the vehicle width W of the loading trailer 3 calculated by the vehicle width calculation unit 22, and the number of the loading trailers 3 detected by the trailer number detection unit 28.

In this embodiment, the travel path suitable for the vehicle width W of the loading trailer 3 and the number of the loading trailers 3 is set by detecting the number of the loading trailers 3 towed by the towing tractor 2. As a result, for example, even when the towing tractor 2 having the loading trailers 3 connected travels in a curve, the towing tractor 2 travels smoothly regardless of the vehicle width W of the loading trailer 3 and the number of the loading trailers 3. As a result, a transport efficiency of the towing tractor 2 may be increased.

FIG. 8 is a block diagram illustrating a configuration of a travel control device according to a third embodiment. In FIG. 8, a travel control device 1B

according to the third embodiment includes a controller 20B in place of the controller 20 of the first embodiment.

The controller 20B includes the self-position estimation unit 21, the vehicle width calculation unit 22, the travel path setting unit 23, a height detection unit 29, a travel route generation unit 24B, the travel control unit 25, the detection range setting unit 26, and the obstacle detection unit 27.

As illustrated in FIG. 9, the height detection unit 29 detects a height of the load M loaded on the loading platform 7 of the loading trailer 3 that is towed by the towing tractor 2, based on the detection data of the obstacle sensors 14, 15. The height detection unit 29 detects the height of the loading trailer 3 towed by the towing tractor 2. The height of the loading trailer 3 corresponds to the maximum height of the loading trailer 3 including the load M. The height detection unit 29 may be configured to detect the height of the loading trailer 3 based on the detection data of only one of the obstacle sensors 14, 15.

Similarly to the above-described second embodiment, the obstacle sensors 14, 15 are mounted to the upper ends of both side ends of the rear part of the towing tractor 2. This allows laser lights L emitted from the obstacle sensors 14, 15 to easily reach the upper end of the load M. As a result, the height of the loading trailer 3 is more easily detected.

The travel route generation unit 24B generates a travel route including the travel path set by the travel path setting unit 23 based on the height of the loading trailer 3 detected by the height detection unit 29. The travel route generation unit 24B generates, for example, the shortest route to the destination where the loading trailer 3 on which the load M is loaded can pass, as the travel route.

The travel path setting unit 23, the travel route generation unit 24B, and the travel control unit 25 form a control unit that controls the towing tractor 2 such that the towing tractor 2 travels according to the vehicle width W of the loading

trailer 3 calculated by the vehicle width calculation unit 22. The control unit generates the travel route including the travel path based on the height of the loading trailer 3 detected by the height detection unit 29, and controls the towing tractor 2 such that the towing tractor 2 travels along the travel route.

This embodiment allows the towing tractor 2 having the loading trailer 3 connected to travel along the travel route where the loading trailer 3 can pass without a height restriction by detecting the height of the loading trailer 3 towed by the towing tractor 2.

The present invention is not limited to the above-described embodiments. For example, although the obstacle sensors 14, 15 are disposed on the side ends of the rear part of the towing tractor 2 in the above-described embodiments, the positions of the obstacle sensors 14, 15 are not limited thereto as long as the obstacle sensors 14, 15 can detect an obstacle existing in the region including the area on the sides and the rear of the towing tractor 2.

For example, as illustrated in FIG. 10A, the obstacle sensors 14, 15 may be disposed on the side ends of the front part of the towing tractor 2. In this case, since the obstacle sensors 14, 15 can detect an obstacle exists in the area in front of the towing tractor 2, the obstacle sensor 13 may be omitted.

For example, as illustrated in FIG. 10B, the obstacle sensors 14, 15 may be disposed on the rear corners of the towing tractor 2. Furthermore, although the illustration is omitted, only one obstacle sensor may be provided at the rear end of the towing tractor 2 as long as the front left corner CL and the front right corner CR (see FIG. 4) of the loading trailer 3 connected to the towing tractor 2 can be detected.

Although the distances L1, L2 from the obstacle sensors 14, 15 to the front left corner CL and the front right corner CR of the loading trailer 3, respectively, are detected as the distances to the loading trailer 3 (see FIG. 4) in the above-

described embodiments, the configuration is not limited thereto. For example, the shortest distances from the obstacle sensors 14, 15 to the front end 3a of the loading trailer 3 may be detected as the distances to the loading trailer 3.

Although the distances to the loading trailer 3 and the orientation of the loading trailer 3 relative to the towing tractor 2 are detected by using the obstacle sensors 14, 15 in the above-described embodiments, a dedicated sensor for detecting the distance to the loading trailer 3 and the orientation of the loading trailer 3 relative to the towing tractor 2 may be provided, separately from the obstacle sensors 14, 15. In this case, a laser sensor similar to the obstacle sensors 14, 15 or an image sensor such as a camera may be used for the dedicated sensor

Although the widths W of all of a plurality types of the loading trailers 3 are greater than the vehicle width W0 of the towing tractor 2 in the above-described embodiments, the configuration is not limited thereto. The loading trailer 3 having the vehicle width W the same as the vehicle width W0 of the towing tractor 2 or the loading trailer 3 having the vehicle width W smaller than the vehicle width W0 of the towing tractor 2 may be used.

Although the travel control device that controls travelling of the towing tractor 2 having the loading trailer 3 connected has been described in the embodiments, the present invention is applicable to a towing vehicle, other than the towing tractor 2, to which trailers having different types of the vehicle widths W are connected.

What is claimed is:

1. A travel control device of a towing vehicle to which a trailer is connected, the travel control device comprising:

a trailer detection unit configured to detect a distance to the trailer and an orientation of the trailer relative to the towing vehicle;

a vehicle width calculation unit configured to calculate a vehicle width of the trailer based on detection data of the trailer detection unit; and

a control unit configured to control the towing vehicle such that the towing vehicle travels according to the vehicle width of the trailer calculated by the vehicle width calculation unit.

2. The travel control device of the towing vehicle according to claim 1, wherein the control unit sets a travel path corresponding to the vehicle width of the trailer, and controls the towing vehicle such that the towing vehicle travels according to the travel path.

3. The travel control device of the towing vehicle according to claim 2, wherein

the travel control device further includes a trailer number detection unit configured to detect the number of the trailers towed by the towing vehicle based on the detection data of the trailer detection unit, and

the control unit sets the travel path corresponding to the vehicle width of the towing vehicle calculated by the vehicle width calculation unit and the number of the trailers detected by the trailer number detection unit.

4. The travel control device of the towing vehicle according to claim 2, wherein

the travel control device further includes a height detection unit configured to detect a height of the trailer towed by the towing vehicle based on the detection data of the trailer detection unit, and

the control unit generates a travel route including the travel path based on

the height of the trailer detected by the height detection unit, and controls the towing vehicle such that the towing travels along the travel route.

5. The travel control device of the towing vehicle according to claim 1, wherein the trailer detection unit is an obstacle sensor that detects an obstacle existing in a region including an area on sides and a rear of the towing vehicle.

6. The travel control device of the towing vehicle according to claim 5, wherein

the travel control device further includes

a detection range setting unit configured to set an obstacle detection range corresponding to the vehicle width of the trailer, and

an obstacle detection unit configured to detect whether the obstacle exists in the obstacle detection range set by the detection range setting unit based on the detection data of the obstacle sensor.

7. The travel control device of the towing vehicle according to claim 1, wherein the trailer detection unit detects distances from the trailer detection unit to left and right corners of a front end of the trailer as the distance to the trailer, and angles between lines that connect the trailer detection unit and the left and right corners of the front end of the trailer, and a line that passes through the trailer detection unit and extends in a front-rear direction of the towing vehicle, as the orientation of the trailer relative to the towing vehicle.