DESCRIPTION OF EMBODIMENTS

[0019]

Some embodiments of a coupling angle detection device for detecting a coupling angle of a towing motor vehicle, which is a combination vehicle, will be described below with reference to the drawings. A towing motor vehicle is a vehicle in which a towing vehicle (trailer head or tractor) and a towed vehicle (chassis) towed by the towing vehicle are coupled with each other by a coupling mechanism. The coupling mechanism of the towing motor vehicle is configured of a coupler provided in the towing vehicle, and a kingpin provided in the towed vehicle, and the coupling angle (the coupling angle between the towing vehicle and the towed vehicle) changes due to a change in the traveling direction of the towing motor vehicle or the like.

[0020]

(First embodiment)

(Configuration of towing motor vehicle 1A using coupling angle detection device 30A according to first embodiment)

FIG. 1 is a side view illustrating a configuration of a towing motor vehicle 1A using a coupling angle detection device 30A according to the first embodiment. The towing motor vehicle 1A includes a towing vehicle 2, a towed vehicle 3, and a coupling mechanism 4 for coupling the towing vehicle 2 and the towed vehicle 3. A plurality of target members 40-1 and 40-2 are installed at prescribed positions of the towed vehicle 3 serving as the first vehicle. These target members 40-1 and 40-2 are installed in the towed vehicle 3 such that the direction specified based on the prescribed condition from the shape information thereof fits the front-rear direction of the vehicle body of the towed vehicle 3. In the present embodiment, as illustrated in FIG. 2, two identically shaped target members 40-1 and 40-2 are installed at prescribed positions on the upper surface of the towed vehicle 3. The installation positions of the target members 40-1 and 40-2 in the towed vehicle 3 will be described later.

[0021]

The towing vehicle 2 serving as a second vehicle is provided with a driving control device 10, a sensor (ranging sensor) 20 as a shape information acquisition device, and a coupling angle detection device 30A.

[0022]

The driving control device 10 controls the driving of the towing vehicle 2. The sensor 20 is configured of, for example, a camera device or a LiDAR (light detection and ranging). The sensor 20 is installed at a prescribed position in the rear of the towing

line extraction unit 304.

[0027]

The coupling angle detection unit 306A recognizes (determines) the front-rear direction of the vehicle body of the towed vehicle 3, based on the straight line connecting an apex of each corner portion of the target members 40-1 and 40-2 estimated by the corner estimation unit 305. The coupling angle detection unit 306A holds information in advance, indicating the front-rear direction of the vehicle body of the towing vehicle 2 with respect to the installation direction of the sensor 20, and detects an angle formed by the front-rear direction of the vehicle body of the towing vehicle 2 as held above and the front-rear direction of the vehicle body of the towed vehicle 3 as recognized above, as a coupling angle of the towing motor vehicle 1A. The coupling angle detection unit 306A transmits the information on the detected coupling angle, to the driving control device 10.

[0028]

(Operation of towing motor vehicle 1A using coupling angle detection device 30A according to first embodiment)

The operation of the towing motor vehicle 1A using the coupling angle detection device 30A according to the present embodiment will be described below. In the present embodiment, the target members 40-1 and 40-2 have a rectangular shape such as a rectangular parallelepiped. The target members 40-1 and 40-2 are installed in the towed vehicle 3 such that each corner in the towing vehicle 2 overlaps a line perpendicular to the front-rear direction of the vehicle body of the towed vehicle 3 on a plane parallel to the traveling surface of the towing motor vehicle 1A.

[0029]

During traveling of the towing motor vehicle 1A, the sensor 20 measures the distance to a plurality of measurement points in the objects positioned in the upper surface area of the towed vehicle 3, that is, measures the distance to a plurality of measurement points in the objects including the target members 40-1 and 40-2 at prescribed time intervals. In the present embodiment, the sensor 20 measures the distance to a plurality of measurement points, in the target members 40-1 and 40-2 positioned on the upper surface of the towed vehicle 3 and in a projection member 3a that is a portion of the vehicle body, as illustrated in FIG. 2.

[0030]

At this time, if the target members 40-1 and 40-2 are formed of thin plate-like members, depending on the coupling angle between the towing vehicle 2 and the towed vehicle 3, the sensor 20 may not be able to detect some end portions of the target members

information P1, identification information P2, … identification information P15, to the fifteen measurement points, respectively.

[0034]

Next, regarding the measurement points extracted by filtering processing, the clustering unit 303 performs clustering processing to recognize a set of measurement points whose distance from adjacent measurement points is less than a prescribed value, as a measurement point group related to one object. Specifically, the clustering unit 303 recognizes the set of measurement points of the identification information P1 to P8 as a measurement point group related to one object, and recognizes the set of measurement points of the identification information P9 to P15 as a measurement point group related to the other object.

[0035]

The clustering unit 303 calculates the size of each object that is a measurement target, based on the measurement information regarding the measurement points in each recognized measurement point group (S4). The clustering unit 303 holds range information corresponding to the sizes of the target members 40-1 and 40-2 in advance, and recognizes that the object is the target member 40-1 or 40-2 if the calculated size of the object is within a range of the information that is held above. Here, the clustering unit 303 recognizes that the sizes of two objects that are measurement targets are within the range of the information that is held in advance, and that these two objects are the target members 40-1 and 40-2 ("YES" in S5).

[0036]

Next, the straight line extraction unit 304 extracts measurement point groups constituting straight lines from among the measurement points corresponding to the recognized target members 40-1 and 40-2, and groups the measurement point groups for each straight line (S6). In addition, from among the grouped measurement point groups, the straight line extraction unit 304 extracts a measurement point group whose corresponding measurement points are equal to or greater than a prescribed first threshold value. This first threshold value is a value that is set to determine the reliability of the grouped measurement point group as a straight line portion. The straight line extraction unit 304 specifies a straight line from the extracted measurement point group (S7). Here, the straight line extraction unit 304 may use, for example, the least squares method when specifying a straight line from the extracted measurement point group.

[0037]

Next, if there is a measurement point that does not belong to any of the straight

line measurement point groups on an extension line of any of the straight lines specified for the respective target members 40-1 and 40-2, the straight line extraction unit 304 extends the straight line to the measurement point. If there is another straight line on an extension line of any of the straight lines which are specified, the straight line extraction unit 304 integrates these straight lines into one straight line (S8). By performing such extension processing and integration processing, the straight line extraction unit 304 can accurately extract the straight line portions of the target members 40-1 and 40-2.

[0038]

Next, from among the extracted straight lines, the straight line extraction unit 304 extracts a straight line whose corresponding measurement points are equal to or greater than a prescribed second threshold value (S9). This second threshold value is a value that is set to determine the reliability of the specified straight line as a straight line constituting the outer shape of the target members 40-1 and 40-2.

[0039]

Next, the corner estimation unit 305 selects the right-downward-sloping line and the right-upward-sloping line for each of the target members 40-1 and 40-2, from the straight lines extracted by the straight line extraction unit 304 (S10 and S11). For example, as illustrated in FIG. 5, the corner estimation unit 305 selects the straight line Q1 specified by the measurement point groups P1 to P4 as the right-downward-sloping line, and the straight line Q2 specified by the measurement point groups P4 to P8 as the right-upward-sloping line, regarding the target member 40-1. The corner estimation unit 305 also selects the straight line Q3 specified by the measurement point groups P9 and P10 as the right-upward-sloping line, and the straight line Q4 specified by the measurement point groups P11 to P15 as the right-downward-sloping line, regarding the target member 40-2.

[0040]

Thereafter, the corner estimation unit 305 detects an L-shaped portion where the selected right-downward-sloping line and right-upward-sloping line intersect with each other, regarding each of the target members 40-1 and 40-2.

[0041]

Next, when the corner estimation unit 305 detects an L-shaped portion corresponding to each of the target members 40-1 and 40-2 ("YES" in S12), the position of the detected L-shaped portion is estimated as a corner portion of each of the target members 40-1 and 40-2 (S13). For example, as illustrated in FIG. 5, the corner estimation unit 305 estimates the corner portions of the target member 40-1 from the lines Q1 and

the same as the processing of steps S1 to S5 described in the first embodiment, a detailed description thereof will be omitted.

[0077]

When the clustering unit 303 recognizes that the sizes of two objects that are measurement targets are within the range of the information that is held in advance, and that these two objects are the target members 40-5 and 40-6 ("YES" in S65), the processing proceeds to step S66. In step S66, the circle approximation unit 309 performs circle approximation processing using, for example, the least squares method, on the measurement group corresponding to the target members 40-5 and 40-6 recognized by the clustering unit 303. The circle approximation unit 309 then detects the respective center positions of the circles of the target members 40-5 and 40-6 (S66).

[0078]

Next, the coupling angle detection unit 306D calculates (specifies) a direction perpendicular to the straight line coupling the center positions of the circles detected by the circle approximation unit 309, and recognizes (determines) the calculated direction as the front-rear direction of the vehicle body of the towed vehicle 3 (S67). The coupling angle detection unit 306D then detects an angle formed by the recognized front-rear direction of the vehicle body of the towed vehicle 3 and the front-rear direction of the vehicle body of the towing vehicle 2 that is held in advance, as the coupling angle of the towing motor vehicle 1D (S68).

[0079]

According to the fourth embodiment, the shape of two cylindrical target members 40-5 and 40-6 installed in the towed vehicle 3 is measured by the sensor 20 installed in the towing vehicle 2 of the towing motor vehicle 1D. Therefore, the coupling angle between the towing vehicle 2 and the towed vehicle 3 can be accurately detected with simpler processing than that of the first embodiment.

[0080]

(Fifth embodiment)

(Configuration of towing motor vehicle 1E using coupling angle detection device 30E according to fifth embodiment)

Since the configuration of the towing motor vehicle 1E according to the fifth embodiment is the same as that of the towing motor vehicle 1A in FIG. 1 described in the first embodiment, a detailed description of the parts having the same functions will be omitted. In the present embodiment, the shape and number of target members and the position of target members on the towed vehicle 3 are not limited. For example, target