vehicle is limited to 5 km/h or less, or 10 km/h or less, etc., so the running speed can be treated as known (or, an influence to a turning radius caused by the running speed can be ignored).

[0016]

Note that, even also during running on public roads, there is a case where a running route may be predetermined and a running speed may be treated as a known parameter (or its influence can be ignored) when transporting a large loaded cargo at night with traffic control and traffic management. A large loaded cargo includes, for example, a train car, part of an aircraft or a rocket, and part of a bridge. Such a large loaded cargo often tends to become unstable when loaded on a trailer (vehicle), and thereby the detection of a loading anomaly according to the present embodiment is effective. And, even also in such a case where a running route is known and a running speed can be treated as a known parameter (or its influence on turning characteristics can be ignored), the detection of a loading anomaly can be done similarly to the above-mentioned in-site running (which may include running by autonomous driving).

[0017]

In addition, it is assumed here that the in-site running is done by autonomous driving. Since not only a running speed but also a running route can be specified in the site, it is easier to introduce autonomous driving than on public roads. Furthermore, since it is easier to create a detailed three-dimensional map (or even a two-dimensional map) of a running route in the site, it is easier to introduce autonomous driving. Furthermore, since roads in the site are not public roads and they may be exempt from the Road Traffic Law, it is easier to introduce autonomous driving. The detection method and apparatus of a loading anomaly of the present disclosure are very useful for such an autonomous driving in a site.

[0018]

Fig. 2 shows a configurational diagram of a detection of a loading anomaly according to the present embodiment. As described above, the vehicle 1 is configured of the tractor 11 and the trailer 10, and the trailer 10 is loaded with a container as the cargo 12. The driving type of the vehicle 1 can take any type, such as an internal combustion engine vehicle (ICV), an electric vehicle (BEV/FCEV), or a hybrid electric vehicle (HEV). Cargos are usually loaded in the container so that the center of gravity of whole of them is on a front-back center line of the vehicle 1. However, if a cargo shift occurs inside the container, the center of gravity of the cargos may shift. The detection apparatus of a loafing anomaly is equipped with sensors that detect

control (a steering control value). The steering control value is the steering angle request value or the steering angle control value, or alternatively both of them.

[0025]

The accelerator pedal stroke sensor 5 is a sensor that detects an operated stroke of the accelerator pedal (a driving force request value). Similar to the steering angle sensor 4 described above, when an accelerator-by-wire system or the VSC system is used, there may be a case where (the driving force request value) = (the driving force control value) doesn't satisfied. There is a case, when a hybrid system is adopted, where the driving force may be generated by an internal combustion engine and a motor in response to the driving force request value, and the driving force control value may be set separately for each. If an autonomous driving system, instead of a driver, controls driving of the vehicle 1, the driver does not operate the accelerator pedal, so no driving force request value exists and the autonomous driving system determines the driving force control value to drive the vehicle 1. However, similarly here, since the driving force control value is calculated based on the driving force request value when the driving force request value exists, the driving force control value can be obtained from the driving force request value.

[0026]

The brake pedal stroke sensor 6 is a sensor that detects an operated stroke of the brake pedal (a braking force request value). Similar to the steering angle sensor 4 and the accelerator pedal stroke sensor 5 described above, when a brake-by-wire system, the ABS system or the VSC system is used, there may be a case where (the braking force request value) = (the braking force control value) is not satisfied. In an Electric Vehicle (EV), there is a case, when a hybrid system is adopted, where the braking force may be generated by a braking by a fluid pressure brake (an oil pressure brake or an air brake) and a braking by a regenerative power generation brake with respect to the braking force request value. In such a case, the braking force control value may be set separately for each braking. If an autonomous driving system, instead of a driver, controls driving of the vehicle 1, the driver does not operate the brake pedal. In such a case, no braking force request value exists and the autonomous driving system determines the braking force control value to run the vehicle 1. However, similarly here, since the braking force control value is calculated based on the braking force request value when the braking force request value exists, the braking force control value can be obtained from the braking force request value.

[0027]

## CLAIMS

**[Claim 1]**

A detection method of a loading anomaly on a vehicle (1), the method comprising:

constructing relationship between a steering control value of the vehicle (1) and a proper turning radius (r0) for the steering control value as a control map, preliminarily;

calculating an actual turning radius (r1, r2) of the vehicle (1) by using a self-location detection function of the vehicle (1);

calculating a difference between the proper turning radius (r0) and the actual turning radius (r1, r2) by using the control map; and

determining that a loading anomaly of a cargo (12) loaded on the vehicle (1) has occurred when the difference lies outside a predetermined first reference range.

**[Claim 2]**

The detection method of a loading anomaly on a vehicle (1) according to claim 1,

wherein the loading anomaly is determined to have occurred when a state in which the difference lies outside the first reference range continues for a predetermined time.

**[Claim 3]**

The detection method of a loading anomaly on a vehicle (1) according to claim 1 or 2, further comprising:

controlling the vehicle (1), when the loading anomaly is determined to have occurred, so as to [1] stop the vehicle (1) automatically, [2] control the vehicle (1) in a low-speed mode where an upper speed limit is set, or [3] control the vehicle to eliminate the difference between the proper turning radius (r0) and the actual turning radius (r1, r2).

**[Claim 4]**

The detection method of a loading anomaly on a vehicle (1) according to any one of claims 1 to 3,

wherein the control map is constructed while treating a running speed of the vehicle (1) as a parameter, and

wherein the difference is calculated by using also the running speed of the vehicle (1) that is detected.

**[Claim 5]**

The detection method of a loading anomaly on a vehicle (1) according to any one of claims 1 to 4,

wherein the control map is constructed during actual running of the vehicle (1).

**[Claim 6]**

The detection method of a loading anomaly on a vehicle (1) according to any one of claims 1 to 5,

wherein a second reference range that encompasses the first reference range is set; and

wherein the loading anomaly is determined to have occurred and a chassis abnormality is also determined to have occurred when the difference lies outside the second reference range.

**[Claim 7]**

A detection apparatus of a loading anomaly on a vehicle (1), the apparatus comprising:

a self-location detector (2, 7, 8) that detects a self-location of the vehicle (1);

a steering detection sensor (4) that detects an actual steering control value of the vehicle (1);

a memory (2) that stores relationship between a steering control value of the vehicle (1) and a proper turning radius (r0) for the steering control value as a control map; and

a controller (2) that judges a loading anomaly of a cargo (12) loaded on the vehicle (1),

wherein the controller (2) is configured to

calculate an actual turning radius (r0) of the vehicle (1) based on detection results of the self-location detector (2, 7, 8),

calculate a difference between the proper turning radius (r0) and the actual turning radius (r1, r2) by using the control map, and

determine that the loading anomaly has occurred when the difference lies outside a predetermined first reference range.

**[Claim 8]**

The detection apparatus of a loading anomaly on a vehicle (1) according to claim 7,

wherein the controller (2) is configured to determine that the loading anomaly has occurred when a state in which the difference lies outside the first reference range continues for a predetermined time.

**[Claim 9]**

The detection apparatus of a loading anomaly on a vehicle (1) according to claim 7 or 8,

wherein the controller (2) is configured to control the vehicle (1), when the loading anomaly is determined to have occurred, so as to [1] stop the vehicle (1) automatically, [2] control the vehicle (1) in a low-speed mode where an upper speed limit is set, or [3] control the vehicle (1) to eliminate the difference between the proper turning radius (r0) and the actual turning radius (r1, r2).

**[Claim 10]**

The detection apparatus of a loading anomaly on a vehicle (1) according to any one of claims 7 to 9, further comprising:

a speed sensor (3) that detects a running speed of the vehicle (1),

wherein the control map is constructed while treating a running speed of the vehicle (1) as a parameter and then stored in the memory (2), and

wherein the controller (2) is configured to calculate the difference by using also the running speed detected by the speed sensor (3).

**[Claim 11]**

The detection apparatus of a loading anomaly on a vehicle (1) according to any one of claims 7 to 9,

wherein the controller (2) constructs the control map by using detection results of the self-location detector (2, 7, 8) and the steering detection sensor (4) during actual running of the vehicle (1).

**[Claim 12]**

The detection apparatus of a loading anomaly on a vehicle (1) according to claim 10,

wherein the controller (2) constructs the control map by using detection results of the speed sensor (3), the self-location detector (2, 7, 8) and the steering detection sensor (4) during actual running of the vehicle (1).

**[Claim 13]**

The detection apparatus of a loading anomaly on a vehicle (1) according to any one of claims 7 to 12,

wherein the controller (2) determines that the loading anomaly has occurred and a chassis abnormality also has occurred when the difference lies outside a second reference range that encompasses the first reference range.