DESCRIPTION

BRAKING CONTROL DEVICE FOR INDUSTRIAL VEHICLE

TECHNICAL FIELD

[0001] The present invention relates to a braking control device for an industrial vehicle.

BACKGROUND ART

[0002] In recent years, attempts have been made to configure industrial vehicles such as towing tractors or forklifts as electric vehicles capable of autonomously traveling in a limited area, for example. An industrial vehicle as above includes a braking member that is formed of a traveling motor generating a regenerative braking force and a mechanical brake generating a mechanical braking force, so that braking is performed by regeneration obtained by the traveling motor during a travel on a downhill slope, for example, with autonomous driving.

[0003] As a braking control device for an industrial vehicle, a technique described in Patent Literature 1 is known, for example. The braking control device for the industrial vehicle described in Patent Literature 1 controls an inverter control device so as to limit a regenerative torque command value of a traveling motor based on terminal voltage of a battery in which the regenerative electric power obtained by the traveling motor is charged.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Patent Application Publication No. 2012-200048

FIG. 2 is a block diagram illustrating a functional configuration of a braking control device for the industrial vehicle in FIG. 1. A braking control device 100 for the industrial vehicle includes the controller 10 that supervises the braking control and the autonomous driving control of the industrial vehicle 1. The controller 10 is an electronic control unit including a CPU, a ROM, a RAM, and the like. In the controller 10, for example, various functions are realized by loading a program recorded on the ROM onto the RAM and executing the program loaded on the RAM by the CPU. The controller 10 may detect a voltage of the battery B. The controller 10 may be formed of a plurality of electronic units.

[0032] The controller 10 is connected to a GNSS receiver 21, a peripheral situation sensor 22, a traveling information sensor 23, and a map database 24.

[0033] The GNSS receiver 21 measures a position of the industrial vehicle 1 (for example, a latitude and a longitude of the industrial vehicle 1) on a map by receiving signals from three or more GNSS satellites. The GNSS receiver 21 transmits the measured position information of the industrial vehicle 1 to the controller 10.

[0034] The peripheral situation sensor 22 is an in-vehicle detector that detects a situation around the vehicle. The peripheral situation sensor 22 includes a camera and a LiDAR (light detection and ranging). Imaging information of the camera is used for road surface pattern recognition and matching, for example. Obstacle information detected by the LiDAR is used for danger avoidance of the industrial vehicle 1, for example. The peripheral situation sensor 22 transmits information relating to a peripheral situation of the industrial vehicle 1 to the controller 10.

[0035] The traveling information sensor 23 is a detector that detects a traveling state of the industrial vehicle 1. The traveling information sensor 23 includes a vehicle speed sensor, an acceleration sensor, and a yaw rate sensor (gyroscope sensor). The vehicle speed sensor is a detector that detects a speed of the

Specifically, the braking force control unit 15 calculates the regenerative braking force based on a change rate of the rotational speed of each of the left traveling motor 6 and the right traveling motor 7 detected by the speed sensor. The braking force control unit 15 calculates a target rotational speed at which a requested deceleration (a negative acceleration of the industrial vehicle 1) is achieved and calculates the regenerative braking force such that the change rate of the detected rotational speed reaches the target rotational speed (for example, the rotational speed decreases by a predetermined amount after an elapse of predetermined seconds). Thus, when the mechanical braking force coexists with the regenerative braking force, the target rotational speed corresponding to the deceleration from which the amount of the deceleration caused by the mechanical braking force has been subtracted is calculated. Therefore, the distribution of the regenerative braking force becomes smaller as the distribution of the mechanical braking force becomes greater, and the distribution of the regenerative braking force becomes greater as the distribution of the mechanical braking force becomes smaller.

[0046] The braking force control unit 15 determines whether a first condition or a second condition is satisfied based on the position information of the industrial vehicle 1 and the gradient information of the road on which the industrial vehicle 1 is traveling, for example. The first condition indicates that a first predetermined period of time has elapsed since the industrial vehicle 1 started traveling downhill. The second condition indicates that the industrial vehicle 1 is traveling downhill on a downhill slope having a predetermined gradient or more. The first condition and the second condition are conditions for determining whether the distribution of the regenerative braking force and the mechanical braking force is changed. The first condition and the second condition are determined in real time based on the gradient information of the road on which the industrial vehicle 1 is traveling, and hence may be considered to be conditions for suppressing the regenerative braking without necessarily generating the traveling plan in advance in consideration of the influence of the downhill slope existing in the traveling route with the autonomous driving.

approach based on the comparison of the predetermined gradient with the gradient information. Therefore, a state where traveling downhill has ended may be determined using an approach based on the gradient information acquired based on the map database 24.

[0057] In the example of FIG. 3, the braking force control unit 15 determines that the release condition is satisfied at time t3. The battery voltage at the time t3 corresponds to battery voltage V2 smaller than the battery voltage V1. The braking force control unit 15 determines that the release condition is satisfied at the time t3, ends the control of the braking member 8 in accordance with the first distribution R1, and changes to the control of the braking member 8 in accordance with the second distribution R2, for example.

[0058] When the braking force control unit 15 changes the distribution of the regenerative braking force and the mechanical braking force, the braking force control unit 15 may consecutively increase the distribution of the mechanical braking force in the distribution R2 which is applied before the distribution change to that in the distribution R1 which is applied after the distribution change, as in a period from the time t1 to time t2 of FIG. 3. Similarly, the braking force control unit 15 may consecutively decrease the distribution of the mechanical braking force in the distribution R1 which is applied before the distribution change to that in the distribution R2 which is applied after the distribution change, as in a period from the time t3 to time t4 of FIG. 3. As a result, the regenerative braking force of the braking member 8 easily follows the change of the mechanical braking force. This can stabilize the braking force generated in the entire braking member 8 as compared with a case where the distribution is rapidly changed.

[0059] [One Example of Arithmetic Processing by Controller 10]

Next, one example of arithmetic processing by the controller 10 will be described. FIG. 4 is a flowchart illustrating a processing example of the braking control device for the industrial vehicle in FIG. 1. The processing illustrated in

controlled so as to increase the distribution of the mechanical braking force using the required braking force as the entire braking force. Thus, the braking may be suitably performed depending on the weight of the cargo.

[0073] In the braking control device 100 for the industrial vehicle, the braking force control unit 15 determines whether the release condition indicating that the second predetermined period of time has elapsed after satisfaction of the first condition or traveling downhill has ended after satisfaction of the second condition is satisfied. When the release condition is satisfied during the control of the braking member 8 in accordance with the first distribution, the braking force control unit 15 ends the control of the braking member 8 in accordance with the first distribution. As a result, the control of the braking member 8 in accordance with the first distribution may be ended based on a predetermined period of time after satisfaction of the first condition or the gradient after satisfaction of the second condition.

[0074] In the braking control device 100 for the industrial vehicle, the braking force control unit 15 determines whether the first condition or the second condition is satisfied, based on the regenerative current of the left traveling motor 6 and the right traveling motor 7. As a result, whether the first condition or the second condition is satisfied may be determined by determination in which the industrial vehicle 1 is traveling downhill when the regenerative current of the left traveling motor 6 and the right traveling motor 7 becomes equal to or more than a predetermined current threshold value, for example.

[0075] [Modified Example]

An embodiment according to the present invention has been described above, but the present invention is not limited to the above-described embodiment.

[0076] In the above-described embodiment, although an electric towing tractor as in FIG. 1 is exemplified as the industrial vehicle 1, the industrial vehicle 1 is not limited to the electric towing tractor and may be an electric forklift or a hybrid