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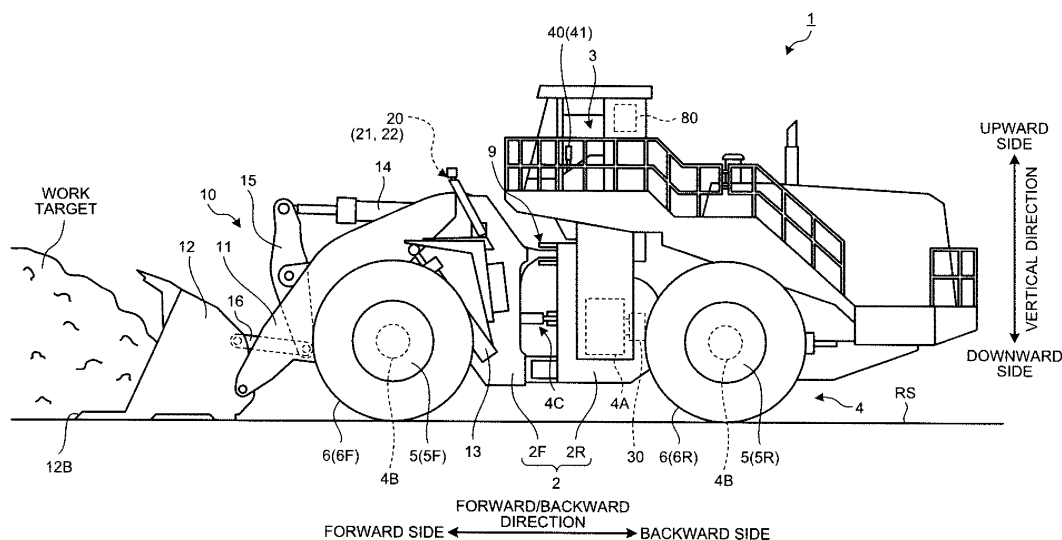
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(54) **CONTROL DEVICE OF WORKING MACHINE AND CONTROL METHOD OF WORKING MACHINE**

(57) A work machine control device includes a measurement-data acquisition unit that acquires measurement data of a measurement device that measures a work target, the measurement device being mounted on a work machine including a working equipment, an algorithm selection unit that selects a specific algorithm that

processes the measurement data depending on work of the work machine, and a calculation unit that processes the measurement data based on the algorithm selected by the algorithm selection unit to calculate a parameter regarding the work target.

FIG.1



Description

Field

[0001] The present invention relates to a work machine control device and a work machine control method. Background

[0002] Work machines are used at work sites. Patent Literature 1 discloses an example of an automatic excavator equipped with a measurement device for measuring a distance to an excavation target and a loading target.

Citation List

Patent Literature

[0003] Patent Literature 1: JP H10-088625 A

Summary

Technical Problem

[0004] In order to automate work of a work machine, it is desired to acquire a parameter regarding a work target.

[0005] An aspect of the present invention is to acquire a parameter regarding a work target.

Solution to Problem

[0006] According to an aspect of the present invention, a work machine control device comprises: a measurement-data acquisition unit configured to acquire measurement data of a measurement device configured to measure a work target, the measurement device being mounted on a work machine including a working equipment; an algorithm selection unit configured to select a specific algorithm that processes the measurement data depending on work of the work machine; and a calculation unit configured to process the measurement data based on the algorithm selected by the algorithm selection unit to calculate a parameter regarding the work target.

Advantageous Effects of Invention

[0007] According to an aspect of the present invention, it is possible to acquire a parameter regarding a work target.

Brief Description of Drawings

[0008]

FIG. 1 is a side view illustrating a work machine according to the present embodiment.

FIG. 2 is a diagram schematically illustrating an op-

eration of the work machine according to the present embodiment.

FIG. 3 is a diagram schematically illustrating an excavation work mode of the work machine according to the present embodiment.

FIG. 4 is a diagram schematically illustrating a loading work mode of the work machine according to the present embodiment.

FIG. 5 is a functional block diagram illustrating a work machine control device according to the present embodiment.

FIG. 6 is a flowchart illustrating a work machine control method according to the present embodiment.

FIG. 7 is a flowchart illustrating the work machine control method according to the present embodiment.

FIG. 8 is a diagram schematically illustrating the work machine control method according to the present embodiment.

FIG. 9 is a flowchart illustrating the work machine control method according to the present embodiment.

FIG. 10 is a diagram schematically illustrating the work machine control method according to the present embodiment.

FIG. 11 is a diagram schematically illustrating the work machine control method according to the present embodiment.

FIG. 12 is a block diagram illustrating an example of a computer system.

Description of Embodiment

[0009] Hereinafter, an embodiment of the present invention is described with reference to the drawings, but the present invention is not limited thereto. The constituent elements of the embodiment described below can be appropriately combined. In addition, some constituent elements cannot be used.

[Wheel loader]

[0010] FIG. 1 is a side view illustrating an example of a work machine 1 according to the present embodiment.

The work machine 1 performs predetermined work on a work target at a work site. In the present embodiment, the work machine 1 is assumed to be a wheel loader 1, which is one of articulate work machines. The predetermined work includes excavation work and loading work.

The work target includes an excavation target and a loading target. The wheel loader 1 performs excavation work for excavating an excavation target and loading work for loading an excavated object excavated by the excavation work on a loading target. The loading work is a concept including discharging work for discharging the excavated object to a discharging target. The excavation target is, for example, at least one of natural ground, a rock pile, coal, and a wall surface. The natural ground is a mountain

formed of earth and sand, and the rock pile is a mountain formed of rock or stone. The loading target is, for example, at least one of a transport vehicle, a predetermined area of a work site, a hopper, a belt conveyor, and a crusher.

[0011] As illustrated in FIG. 1, a wheel loader 1 includes a vehicle body 2, a cab 3 provided with a driver's seat, a traveling device 4 supporting the vehicle body 2, a working equipment 10 supported by the vehicle body 2, a transmission device 30, a three-dimensional measurement device 20 that measures a work target in front of the vehicle body 2, and a control device 80.

[0012] The vehicle body 2 includes a front vehicle body 2F and a rear vehicle body 2R. The front vehicle body 2F and the rear vehicle body 2R are coupled via a joint mechanism 9 so as to be bendable.

[0013] The cab 3 is supported by the vehicle body 2. At least a part of the wheel loader 1 is operated by a driver on the cab 3.

[0014] The traveling device 4 supports the vehicle body 2. The traveling device 4 includes wheels 5. The wheels 5 are rotated by driving force generated by an engine mounted on the vehicle body 2. The wheels 5 are mounted with tires 6. The wheels 5 include two front wheels 5F mounted on the front vehicle body 2F and two rear wheels 5R mounted on the rear vehicle body 2R. The tires 6 include front tires 6F mounted on the front wheels 5F and rear tires 6R mounted on the rear wheels 5R. The traveling device 4 is capable of traveling on the ground RS.

[0015] In the following description, the direction parallel to the rotation axis of the front wheels 5F is appropriately referred to as a vehicle width direction, the direction orthogonal to the ground contact surfaces of the front tires 6F in contact with the ground RS is appropriately referred to as a vertical direction, and the direction orthogonal to both the vehicle width direction and the vertical direction is appropriately referred to as a front-rear direction. When the vehicle body 2 of the wheel loader 1 travels straight, the rotation axis of the front wheels 5F and the rotation axis of the rear wheels 5R are parallel to each other.

[0016] In addition, in the following description, a position or a direction close to the center of the vehicle body 2 in the vehicle width direction is appropriately referred to as an inside or an inward side of the vehicle width direction, and a position or a direction far from the center of the vehicle body 2 is appropriately referred to as an outside or an outward side of the vehicle width direction. In addition, in the vehicle width direction, one side with respect to the driver's seat of the cab 3 is appropriately referred to as a right side or a rightward side, and the opposite side or the opposite direction of the right side or the rightward side is appropriately referred to as a left side or a leftward side. In addition, in the front-rear direction, a position or a direction close to the working equipment 10 with respect to the driver's seat of the cab 3 is appropriately referred to as a front side or a forward side,

and the opposite side or the opposite direction of the front side or the forward side is appropriately referred to as a rear side or a backward side. In addition, a position or a direction close to the ground contact surfaces of the front tires 6F in the vertical direction is appropriately referred to as a lower side or a downward side, and the opposite side or the opposite direction of the lower side or the downward side is appropriately referred to as an upper side or an upward side.

[0017] The front vehicle body 2F is disposed on the front side of the rear vehicle body 2R. The front wheels 5F and the front tires 6F are disposed on the front side of the rear wheels 5R and the rear tires 6R. The front wheels 5F and the front tires 6F are disposed on both sides of the vehicle body 2 in the vehicle width direction. The rear wheels 5R and the rear tires 6R are disposed on both sides of the vehicle body 2 in the vehicle width direction. The front vehicle body 2F bends left and right with respect to the rear vehicle body 2R.

[0018] The traveling device 4 includes a driving device 4A, a braking device 4B, and a steering device 4C. The driving device 4A generates driving force for accelerating the wheel loader 1. The driving device 4A includes an internal combustion engine, such as a diesel engine. The driving force generated by the driving device 4A is transmitted to the wheels 5 via the transmission device 30 to rotate the wheels 5. The braking device 4B generates braking force for decelerating or stopping the wheel loader 1. The steering device 4C is capable of adjusting the traveling direction of the wheel loader 1. The traveling direction of the wheel loader 1 includes the facing direction of the front vehicle body 2F. The steering device 4C bends the front vehicle body 2F with a hydraulic cylinder to adjust the traveling direction of the wheel loader 1.

[0019] In the present embodiment, the traveling device 4 is operated by a driver on the cab 3. The working equipment 10 is controlled by the control device 80. A traveling operation device 40 that operates the traveling device 4 is disposed on the cab 3. The driver operates the traveling operation device 40 to operate the traveling device 4. The traveling operation device 40 includes an accelerator pedal, a brake pedal, a steering lever, and a shift lever 41 for switching moving forward and backward. By operating the accelerator pedal, the traveling speed of the wheel loader 1 is increased. By operating the brake pedal, the traveling speed of the wheel loader 1 is reduced or traveling is stopped. By operating the steering lever, the wheel loader 1 is turned. By operating the shift lever 41, moving forward/backward of the wheel loader 1 is switched.

[0020] The transmission device 30 transmits the driving force generated by the driving device 4A to the wheels 5.

[0021] The working equipment 10 includes a boom 11 rotatably coupled to the front vehicle body 2F, a bucket 12 rotatably coupled to the boom 11, a bell crank 15, and a link 16.

[0022] The boom 11 is operated by power generated

by a boom cylinder 13. The boom cylinder 13 expands and retracts, and the boom 11 is thereby raised or lowered.

[0023] The bucket 12 is a working member including a distal end 12B with a cutting edge. The bucket 12 is disposed on the front side of the front wheels 5F. The bucket 12 is coupled to the distal end of the boom 11. The bucket 12 is operated by power generated by a bucket cylinder 14. The bucket cylinder 14 expands and retracts, and the bucket 12 thereby performs a dumping operation or a tilt operation.

[0024] The bucket 12 performs the dumping operation, and the excavated object scooped up by the bucket 12 is thereby discharged from the bucket 12. The bucket 12 performs the tilt operation, and the bucket 12 thereby scoops the excavated object.

[Three-dimensional measurement device]

[0025] The three-dimensional measurement device 20 is mounted on the wheel loader 1. The three-dimensional measurement device 20 measures a work target in front of the front vehicle body 2F. The work target includes an excavation target of the working equipment 10 and a loading target on which an excavated object excavated by the working equipment 10 is loaded. The three-dimensional measurement device 20 measures a relative position from the three-dimensional measurement device 20 to each of a plurality of measurement points on the surface of the work target to measure the three-dimensional shape of the work target. The control device 80 calculates, based on the measured three-dimensional shape of the work target, a parameter regarding the work target. As to be described later, the parameter regarding the work target includes at least one of the distance to the excavation target, the distance to the loading target, the angle of repose of the excavation target, and the height of the loading target.

[0026] The three-dimensional measurement device 20 includes a laser radar 21, which is one of laser measurement devices, and a stereo camera 22, which is one of photographic measurement devices.

[Operation]

[0027] FIG. 2 is a diagram schematically illustrating an operation of the wheel loader 1 according to the present embodiment. The wheel loader 1 works in a plurality of work modes. The work modes include an excavation work mode in which the bucket 12 of the working equipment 10 excavates an excavation target, and a loading work mode in which the excavated object scooped by the bucket 12 in the excavation work mode is loaded onto a loading target. The excavation target is, for example, natural ground DS on the ground RS. The loading target is, for example, a vessel BE (dump body) of a transport vehicle LS capable of traveling on the ground. The transport vehicle LS is, for example, a dump truck.

[0028] In the excavation work mode, the wheel loader 1 moves forward toward the natural ground DS to excavate the natural ground DS with the bucket 12, while no excavated object is held in the bucket 12. The driver of the wheel loader 1 operates the traveling operation device 40 to move the wheel loader 1 forward to approach the natural ground DS, as indicated by the arrow M1 in FIG. 2. The three-dimensional measurement device 20 mounted on the wheel loader 1 measures the three-dimensional shape of the natural ground DS. The control device 80 calculates, based on the measurement data of the three-dimensional measurement device 20, the distance from the wheel loader 1 to the natural ground DS as a parameter regarding the natural ground DS and controls the working equipment 10 so that the bucket 12 excavates the natural ground DS. That is, the control device 80 controls the working equipment 10 so that the distal end 12B and the bottom surface of the bucket 12 are brought into contact with the ground RS, while the wheel loader 1 is moving forward to approach the natural ground DS.

[0029] After the bucket 12 plunges into the natural ground DS, excavates the natural ground DS, and scoops the excavated object, the wheel loader 1 moves backward to be separated from the natural ground DS, while the excavated object is held in the bucket 12. The driver of the wheel loader 1 operates the traveling operation device 40 to move the wheel loader 1 backward to be separated from the natural ground DS, as indicated by the arrow M2 in FIG. 2.

[0030] Next, the loading work mode is performed. In the loading work mode, the wheel loader 1 moves forward toward the transport vehicle LS to load the excavated object excavated by the bucket 12, while the excavated object is held in the bucket 12. The driver of the wheel loader 1 operates the traveling operation device 40 in order for the wheel loader 1 to approach the transport vehicle LS by turning and moving forward the wheel loader 1, as indicated by the arrow M3 in FIG. 2. The three-dimensional measurement device 20 mounted on the wheel loader 1 measures the three-dimensional shape of the transport vehicle LS. The control device 80 calculates, based on the measurement data of the three-dimensional measurement device 20, the distance from the wheel loader 1 to the transport vehicle LS as a parameter regarding the transport vehicle LS and controls the working equipment 10 so that the excavated object held in the bucket 12 is loaded onto the vessel BE of the transport vehicle LS. That is, the control device 80 controls the working equipment 10 so that the boom 11 is raised, while the wheel loader 1 is moving forward to approach the transport vehicle LS. After the boom 11 is raised to position the bucket 12 above the vessel BE, the control device 80 controls the working equipment 10 so that the bucket 12 performs the tilt operation. The excavated object is thereby discharged from the bucket 12 and loaded on the vessel BE.

[0031] After the excavated object is discharged from

the bucket 12 and loaded on the vessel BE, the wheel loader 1 moves backward to be separated from the transport vehicle LS, while no excavated object is held in the bucket 12. The driver operates the traveling operation device 40 to move the wheel loader 1 backward to be separated from the transport vehicle LS, as indicated by the arrow M4 in FIG. 2.

[0032] The driver and the control device 80 repeat the above operation until the vessel BE is filled with the excavated objects.

[0033] FIG. 3 is a diagram schematically illustrating the excavation work mode of the wheel loader 1 according to the present embodiment. The driver of the wheel loader 1 operates the traveling operation device 40 to move the wheel loader 1 forward to approach the natural ground DS.

[0034] As illustrated in FIG. 3(A), the three-dimensional measurement device 20 mounted on the wheel loader 1 measures the three-dimensional shape of the natural ground DS. The control device 80 determines, based on the measurement data of the three-dimensional measurement device 20, the position of a boundary DP between the ground RS and the natural ground DS.

[0035] As illustrated in FIG. 3(B), the control device 80 calculates, based on the measurement data of the three-dimensional measurement device 20, the distance between the distal end 12B of the bucket 12 and the boundary DP as a parameter regarding the natural ground DS, while the wheel loader 1 is moving forward to approach the natural ground DS. Based on the measurement data of the three-dimensional measurement device 20, the control device 80 lowers the boom 11 and controls the angle of the bucket 12 so that the distal end 12B of the bucket 12 approaches the boundary DP.

[0036] As illustrated in FIG. 3(C), the wheel loader 1 further moves forward, and the distal end 12B of the bucket 12 is thereby inserted from the boundary DP into the natural ground DS. The natural ground DS is thereby excavated by the bucket 12, and the bucket 12 can scoop the excavated object.

[0037] FIG. 4 is a diagram schematically illustrating the loading work mode of the wheel loader 1 according to the present embodiment. The driver of the wheel loader 1 operates the traveling operation device to move the wheel loader 1 forward to approach the transport vehicle LS. As illustrated in FIG. 4(A), the three-dimensional measurement device 20 mounted on the wheel loader 1 measures the three-dimensional shape of the front side surface of the transport vehicle LS. The control device 80 detects, based on the measurement data of the three-dimensional measurement device 20, the distance between the distal end 12B of the bucket 12 and the transport vehicle LS and the height of the upper end of the vessel BE as parameters regarding the natural ground DS. The height of the upper end of the vessel BE is the distance from the ground RS to the approximately-horizontal upper end of the side surface when the vessel BE is viewed from the side as illustrated in FIG. 10 to be

described later.

[0038] As illustrated in FIG. 4(B), based on the measurement data of the three-dimensional measurement device 20, the control device 80 controls the angle of the bucket 12 and raises the boom 11 so that the bucket 12 is positioned above the upper end of the vessel BE and that the excavated object held in the bucket 12 is not fallen from the bucket 12, while the wheel loader 1 is moving forward to approach the transport vehicle LS.

[0039] As illustrated in FIG. 4(C), after the boom 11 is raised to position the bucket 12 above the vessel BE, the control device 80 controls the working equipment 10 so that the bucket 12 performs the tilt operation. The excavated object is thereby discharged from the bucket 12 and loaded on the vessel BE.

[Control device]

[0040] FIG. 5 is a functional block diagram illustrating the control device 80 of the wheel loader 1 according to the present embodiment. The control device 80 includes a computer system.

[0041] The control device 80 is connected to the working equipment 10, the three-dimensional measurement device 20, an excavated-object determination sensor 51, a rotation sensor 52, and the traveling operation device 40.

[0042] The control device 80 includes a measurement-data acquisition unit 81, a storage unit 82, an excavated-object determination unit 83, a forward/backward-movement determination unit 84, an algorithm selection unit 85, a calculation unit 86, and a working-equipment control unit 87.

[0043] The measurement-data acquisition unit 81 acquires measurement data of the three-dimensional measurement device 20.

[0044] The storage unit 82 stores a plurality of algorithms for processing the measurement data acquired by the measurement-data acquisition unit 81. The algorithms are a procedure, a flowchart, a method, or a program for outputting predetermined data using the measurement data acquired by the measurement-data acquisition unit 81. Depending on the algorithms, the procedure, the method, or the program may be different, or the number pieces of or types of output data may be different. The storage unit 82 stores a first algorithm for processing the measurement data regarding the natural ground DS measured by the stereo camera 22 and a second algorithm for processing the measurement data regarding the transport vehicle LS measured by the stereo camera 22. The storage unit 82 further stores an algorithm for processing the measurement data regarding the natural ground DS measured by the laser radar 21 and an algorithm for processing the measurement data regarding the transport vehicle LS measured by the laser radar 21. The algorithm for processing the measurement data regarding the natural ground DS measured by the laser radar 21 is an example of the first algorithm, and the algorithm

for processing the measurement data regarding the transport vehicle LS measured by the laser radar 21 is an example of the second algorithm.

[0045] The excavated-object determination unit 83 determines whether the bucket 12 is holding an excavated object. The excavated-object determination sensor 51 outputs the detection data to the control device 80. The excavated-object determination sensor 51 includes at least one of a weight sensor, a boom cylinder pressure sensor, a boom angle sensor, and a bucket angle sensor. The weight sensor is capable of detecting at least one of the weight of the bucket 12, the presence or absence of an excavated object in the bucket 12, and the weight of the excavated object held in the bucket 12. The boom cylinder pressure sensor is capable of detecting the pressure of hydraulic oil in the internal space of the boom cylinder 13. The boom angle sensor is capable of detecting the rotation angle of the boom 11 in a vehicle body coordinate system. The bucket angle sensor is capable of detecting the rotation angle of the bucket 12 in the vehicle body coordinate system. The excavated-object determination unit 83 determines, based on the detection data of the excavated-object determination sensor 51, whether the bucket 12 is holding an excavated object. The excavated-object determination unit 83 is capable of determining, based on a detection signal of at least one of the weight sensor, the boom cylinder pressure sensor, the boom angle sensor, and the bucket angle sensor, whether the bucket 12 is holding an excavated object.

[0046] The forward/backward-movement determination unit 84 determines, based on the detection data of the rotation sensor 52, whether the wheel loader 1 is moving forward. The rotation sensor 52 detects the rotation speed and the rotation direction of the wheels 5. The forward/backward-movement determination unit 84 may determine, based on an operation signal of the shift lever 41 of the traveling operation device 40, whether the wheel loader 1 is moving forward.

[0047] The algorithm selection unit 85 selects, depending on the work of the wheel loader 1, a specific algorithm for processing the measurement data acquired by the measurement-data acquisition unit 81 from the algorithms stored in the storage unit 82. The work of the wheel loader 1 includes at least one of a work mode of the wheel loader 1 and a work target of the wheel loader 1.

[0048] In the present embodiment, the algorithm selection unit 85 determines the work mode of the wheel loader 1 based on the determination data of the excavated-object determination unit 83 and the determination data of the forward/backward-movement determination unit 84 and selects, depending on the work mode of the wheel loader 1, a specific algorithm for processing the measurement data acquired by the measurement-data acquisition unit 81 from the algorithms stored in the storage unit 82.

[0049] In the excavation work mode, the wheel loader 1 moves forward toward the natural ground DS, while no

excavated object is held in the bucket 12. In the loading work mode, the wheel loader 1 moves forward toward the transport vehicle LS, while the excavated object is held in the bucket 12. When determining, based on the determination data of the excavated-object determination unit 83 and the determination data of the forward/backward-movement determination unit 84, that the wheel loader 1 is moving forward toward the natural ground DS to excavate the natural ground DS with the bucket 12, the algorithm selection unit 85 selects the first algorithm from the algorithms stored in the storage unit 82. In addition, when determining that the wheel loader 1 is moving forward toward the transport vehicle LS to load the excavated object excavated by the bucket 12, the algorithm selection unit 85 selects the second algorithm from the algorithms stored in the storage unit 82.

[0050] The algorithm selection unit 85 may select, based on the determination data of the excavated-object determination unit 83 and the determination data of the forward/backward-movement determination unit 84, the specific algorithm from the algorithms without determining the work mode of the wheel loader 1. The algorithm selection unit 85 may determine the work mode or select the specific algorithm based on at least the determination data of the excavated-object determination unit 83.

[0051] The calculation unit 86 processes the measurement data based on the algorithm selected by the algorithm selection unit 85 to calculate the parameter regarding the work target. When the first algorithm for calculating the parameter regarding the natural ground DS is selected, the calculation unit 86 calculates the distance from the wheel loader 1 to the natural ground DS as the parameter regarding the natural ground DS. The calculation unit 86 processes the measurement data acquired by the measurement-data acquisition unit 81 based on the first algorithm selected by the algorithm selection unit 85 to calculate the distance from the wheel loader 1 to the natural ground DS. When the second algorithm for calculating the parameter regarding the transport vehicle LS is selected, the calculation unit 86 calculates the distance from the wheel loader 1 to the transport vehicle LS as the parameter regarding the transport vehicle LS. The calculation unit 86 processes the measurement data acquired by the measurement-data acquisition unit 81 based on the second algorithm selected by the algorithm selection unit 85 to calculate the distance from the wheel loader 1 to the transport vehicle LS.

[0052] The calculation unit 86 may calculate, in addition to the distance from the wheel loader 1 to the natural ground DS, the angle of repose of the natural ground DS as the parameter regarding the natural ground DS. In the present embodiment, the parameter regarding the natural ground DS includes at least one of the distance from the wheel loader 1 to the natural ground DS, the angle of repose of the natural ground DS, the quality of the rock and soil of the natural ground DS, the grain size of the rock and soil forming the natural ground DS, the height of the natural ground DS, the shape of the natural ground

DS, and the volume of the natural ground DS.

[0053] The calculation unit 86 may calculate, in addition to the distance from the wheel loader 1 to the transport vehicle LS, the height of the vessel BE of the transport vehicle LS as the parameter regarding the transport vehicle LS. In the present embodiment, the parameter regarding the transport vehicle LS includes at least one of the distance from the wheel loader 1 to the transport vehicle LS, the height of the vessel BE of the transport vehicle LS, the total length of the transport vehicle LS, the total length of the opening of the vessel BE, and the height of the rock and soil protruding from the upper end of the vessel BE.

[0054] When the work mode of the wheel loader 1 is determined to be the excavation work mode, and when the first algorithm is selected by the algorithm selection unit 85, the calculation unit 86 processes the measurement data regarding the natural ground DS based on the first algorithm to calculate the distance from the wheel loader 1 to the natural ground DS. When the work mode of the wheel loader 1 is determined to be the loading work mode, and when the second algorithm is selected by the algorithm selection unit 85, the calculation unit 86 processes the measurement data regarding the transport vehicle LS based on the second algorithm to calculate the distance from the wheel loader 1 to the transport vehicle LS.

[0055] The distance from the wheel loader 1 to the natural ground DS includes the distance from the wheel loader 1 to the boundary DP between the natural ground DS and the ground RS and the distance from the distal end 12B of the bucket 12 of the wheel loader 1 to the boundary DP between the natural ground DS and the ground RS. The distance from the wheel loader 1 to the transport vehicle LS includes the distance from the wheel loader 1 to a vessel BS, and the distance from the wheel loader 1 to the transport vehicle LS includes the distance from the distal end 12B of the bucket 12 of the wheel loader 1 to the front side surface of the vessel BS.

[0056] The working-equipment control unit 87 controls the operation of the working equipment 10 based on the distance to the work target calculated by the calculation unit 86. The working-equipment control unit 87 may control the operation of the working equipment 10 based on the angle of repose of the natural ground DS or the height of the vessel BE calculated by the calculation unit 86. The control of the operation of working equipment 10 includes the control of the operation of at least one of the boom cylinder 13 and the bucket cylinder 14. The wheel loader 1 includes a hydraulic pump (not illustrated), a boom control valve (not illustrated) that controls the flow rate and direction of the hydraulic oil supplied from the hydraulic pump to the boom cylinder 13, and a bucket control valve (not illustrated) that controls the flow rate and direction of the hydraulic oil supplied from the hydraulic pump to the bucket cylinder 14. The working-equipment control unit 87 outputs a control signal to the boom control valve to control the flow rate and direction

of the hydraulic oil supplied to the boom cylinder 13, thereby controlling raising and lowering of the boom 11, the speed of the raising, and the speed of the lowering. The working-equipment control unit 87 further outputs a control signal to the bucket control valve to control the flow rate and direction of the hydraulic oil supplied to the bucket cylinder 14, thereby controlling the dumping operation and the tilt operation of the bucket 12, the speed of the dumping operation, and the speed of the tilt operation.

[0057] In the present embodiment, the wheel loader 1 includes a transmission control unit 88 and a traveling control unit 89.

[0058] The transmission control unit 88 controls the operation of the transmission device 30 based on the operation of the traveling operation device 40 by the driver of the wheel loader 1. The control of the operation of the transmission device 30 includes the control of shift change.

[0059] The traveling control unit 89 controls the operation of the traveling device 4 based on the operation of the traveling operation device 40 by the driver of the wheel loader 1. The traveling control unit 89 outputs operation commands including an accelerator command for operating the driving device 4A, a brake command for operating the braking device 4B, and a steering command for operating the steering device 4C.

[Switching of work modes]

[0060] FIG. 6 is a flowchart illustrating a control method of the wheel loader 1 according to the present embodiment, and illustrates a method of switching work modes. Note that, FIG. 6 illustrates a process using the stereo camera 22 as the three-dimensional measurement device 20.

[0061] As described with reference to FIGS. 2, 3, and 4, in the excavation work mode, the wheel loader 1 moves forward toward the natural ground DS to excavate the natural ground DS with the bucket 12 as indicated by the arrow M1 in FIG. 2, while no excavated object is held in the bucket 12.

[0062] The excavated-object determination unit 83 can determine, based on the detection data of the excavated-object determination sensor 51, that the bucket 12 holds no excavated object. The forward/backward-movement determination unit 84 can determine, based on the detection data of the rotation sensor 52, that the wheel loader 1 is moving forward. The algorithm selection unit 85 can determine, based on the determination data of the excavated-object determination unit 83 and the determination data of the forward/backward-movement determination unit 84, that the wheel loader 1 is moving forward toward the natural ground DS to excavate the natural ground DS with the bucket 12, while no excavated object is held in the bucket 12 (step S1).

[0063] When determining that the wheel loader 1 is moving forward toward the natural ground DS to exca-

vate the natural ground DS with the working equipment 10, the algorithm selection unit 85 selects the first algorithm from the algorithms stored in the storage unit 82 (step S2).

[0064] The calculation unit 86 processes, based on the first algorithm selected by the algorithm selection unit 85, the measurement data regarding the natural ground DS measured by the stereo camera 22 to calculate the distance from the wheel loader 1 to the natural ground DS.

[0065] After the natural ground DS is excavated by the bucket 12 and the excavated object is held in the bucket 12, the wheel loader 1 moves backward to be separated from the natural ground DS as indicated by the arrow M2 in FIG. 2, while the excavated object is held in the bucket 12.

[0066] Next, the loading work mode is performed. In the loading work mode, the wheel loader 1 moves forward toward the transport vehicle LS to load the excavated object excavated by the bucket 12 as indicated by the arrow M3 in FIG. 2, while the excavated object is held in the bucket 12.

[0067] The excavated-object determination unit 83 can determine, based on the detection data of the excavated-object determination sensor 51, that the bucket 12 is holding the excavated object. The forward/backward-movement determination unit 84 can determine, based on the detection data of the rotation sensor 52, that the wheel loader 1 is moving forward. The algorithm selection unit 85 can determine, based on the determination data of the excavated-object determination unit 83 and the determination data of the forward/backward-movement determination unit 84, that the wheel loader 1 is moving forward toward the vessel BE of the transport vehicle LS to load the excavated object excavated by the bucket 12, while the excavated object is held in the bucket 12 (step S3).

[0068] When determining that the wheel loader 1 is moving forward toward the vessel BE of the transport vehicle LS to load the excavated object excavated by the working equipment 10, the algorithm selection unit 85 selects the second algorithm from the algorithms stored in the storage unit 82 (step S4).

[0069] The calculation unit 86 processes, based on the second algorithm selected by the algorithm selection unit 85, the measurement data regarding the transport vehicle LS measured by the three-dimensional measurement device 20 to calculate the distance from the wheel loader 1 to the transport vehicle LS.

[0070] After the excavated object is discharged from the bucket 12 and loaded on the vessel BE, the wheel loader 1 moves backward to be separated from the transport vehicle LS as indicated by the arrow M4 in FIG. 2, while no excavated object is held in the bucket 12.

[0071] Note that, when the laser radar 21 is used as the three-dimensional measurement device 20, the first algorithm for using the laser radar 21 is selected in step S2, and the second algorithm for using the laser radar 21 is selected in step S5.

[Processing with first algorithm]

[0072] FIG. 7 is a flowchart illustrating a control method of the wheel loader 1 according to the present embodiment and illustrates a method for processing, based on the first algorithm, the measurement data of the stereo camera 22 regarding the natural ground DS. The process illustrated in FIG. 7 corresponds to the subroutine of step S2 described with reference to FIG. 6.

[0073] In the excavation work mode in which the wheel loader 1 moves forward toward the natural ground DS to excavate the natural ground DS with the working equipment 10, the stereo camera 22 measures the natural ground DS. The measurement-data acquisition unit 81 acquires, from the stereo camera 22, the measurement data of the stereo camera 22 that has measured the natural ground DS (step S201).

[0074] FIG. 8 is a diagram schematically illustrating the control method of the wheel loader 1 according to the present embodiment and schematically illustrates the measurement method by the stereo camera 22. As illustrated in FIG. 8, the stereo camera 22 measures the distance to each of a plurality of measurement points PI on the surface of the natural ground DS.

[0075] The position of the slope of the natural ground DS is defined in the vehicle body coordinate system of the wheel loader 1. The installation position of the stereo camera 22 in the vehicle body coordinate system is known data derived from the design data of the wheel loader 1. The calculation unit 86 calculates the distance from the stereo camera 22 to each of the measurement points PI on the slope of the natural ground DS in the vehicle body coordinate system. The position of the slope of the natural ground DS is defined by the distance from the stereo camera 22 to the slope of the natural ground DS in the vehicle body coordinate system. The calculation unit 86 calculates the three-dimensional shape of the natural ground DS based on the distance to each of the measurement points PI on the surface of the natural ground DS (step S202).

[0076] The calculation unit 86 calculates the distance from the wheel loader 1 to the natural ground DS based on the first algorithm. The calculation unit 86 performs straight line fitting on the measurement points PI to calculate a virtual straight line IL based on the measurement points PI. The straight line IL indicates the estimated shape of the slope of the natural ground DS. That is, the calculation unit 86 performs straight line fitting on the measurement points PI to calculate the position of the slope of the natural ground DS (step S203).

[0077] The calculation unit 86 calculates the position of the ground RS based on the ground contact surfaces of the tires 6 (step S204). The positions of the contact surfaces of the tires 6 in the vehicle body coordinate system are known data derived from the design data of the wheel loader 1. The position of the ground RS in the vehicle body coordinate system is determined from the ground contact surfaces of at least three tires 6 of the

four tires 6.

[0078] Note that, the calculation unit 86 may determine the position of the ground RS based on the detection data of an inertial measurement unit (IMU) or an inclination sensor. Alternatively, when the ground RS is in the measurement range of the stereo camera 22, the position of the ground RS may be calculated based on the measurement data of the stereo camera 22. Alternatively, when the ground RS is in the measurement range of the stereo camera 22, and when the position of the ground RS is determined based on the ground contact surfaces of the tires 6, the position data of the stereo camera 22 regarding the measurement points PI on the ground RS may be removed. When the position data regarding the measurement points PI is removed, a height threshold may be set, and the position data regarding the measurement points PI may be removed based on the height threshold.

[0079] After the position of the slope of the natural ground DS and the position of the ground RS are calculated, the calculation unit 86 calculates the position of the boundary DP between the slope of the natural ground DS and the ground RS (step S205).

[0080] The calculation unit 86 calculates the distance from the stereo camera 22 to the boundary DP or the distance from the distal end 12B of the working equipment 10 to the boundary DP (step S206). The calculation unit 86 uses, in addition to the distance from the stereo camera 22 to the boundary DP, the installation position of the stereo camera 22, the installation position of the working equipment 10, the size of the working equipment 10, the angle of the working equipment 10, and the like in the vehicle body coordinate system to calculate the distance from the distal end 12B of the working equipment 10 to the boundary DP.

[0081] The working-equipment control unit 87 controls the working equipment 10 based on the distance to the boundary DP calculated by the calculation unit 86 (step S207).

[0082] As described above, in the present embodiment, the processing with the first algorithm includes determining the three-dimensional shape of the natural ground DS from the measurement data of the stereo camera 22, determining the slope of the natural ground DS, determining the position of the boundary DP, and calculating the distance from the wheel loader 1 to the boundary DP. Thus, as described with reference to FIG. 3, based on the distance to the boundary DP calculated by the calculation unit 86, the working-equipment control unit 87 can lower the boom 11 and control the angle of the bucket 12 so that the distal end 12B of the bucket 12 approaches the boundary DP, while the wheel loader 1 is moving forward toward the natural ground DS. The wheel loader 1 further moves forward, and the distal end 12B of the bucket 12 is thereby inserted from the boundary DP into the natural ground DS. The natural ground DS is thereby excavated by the bucket 12, and the bucket 12 can scoop the excavated object.

[Processing with second algorithm]

[0083] FIG. 9 is a flowchart illustrating a control method of the wheel loader 1 according to the present embodiment and illustrates a method for processing, based on the second algorithm, the measurement data of the stereo camera 22 regarding the transport vehicle LS. The process illustrated in FIG. 9 corresponds to the subroutine of step S4 described with reference to FIG. 6.

[0084] In the loading work mode in which the wheel loader 1 moves forward toward the transport vehicle LS to load the excavated object excavated by the working equipment 10, the stereo camera 22 measures the transport vehicle LS. The measurement-data acquisition unit 81 acquires, from the stereo camera 22, the measurement data of the stereo camera 22 that has measured the transport vehicle LS (step S401).

[0085] The stereo camera 22 measures the distance to each of a plurality of measurement points PI on the surface of the transport vehicle LS.

[0086] FIG. 10 is a diagram illustrating an example of image data including the transport vehicle LS acquired by the stereo camera 22 according to the present embodiment. Although only one measurement point PI (point data) is illustrated in FIG. 10, the measurement point PI is set for each pixel of the image data illustrated in FIG. 10. The stereo camera 22 can acquire a range image by performing stereo processing on the image data.

[0087] The calculation unit 86 calculates, based on the measurement data (image data) of the stereo camera 22, the distance, in the vehicle body coordinate system, from the stereo camera 22 to the measurement point PI on the surface of the transport vehicle LS in each pixel. The position of the surface of the transport vehicle LS is defined by the distance from the stereo camera 22 to the surface of the transport vehicle LS in the vehicle body coordinate system. The calculation unit 86 calculates the three-dimensional shape of the transport vehicle LS based on the distance to each of the measurement points PI on the surface of the transport vehicle LS (step S402).

[0088] Next, the calculation unit 86 creates a histogram indicating the relationship between the distances from the stereo camera 22 and the number of pieces of data regarding the measurement points PI each indicating its distance (step S403).

[0089] FIG. 11 is a diagram schematically illustrating a histogram indicating the relationship between the distances from the stereo camera 22 to the measurement points PI and the number of pieces of data regarding the measurement points PI at the respective distances.

[0090] Since the image data illustrated in FIG. 10 includes measurement objects other than the transport vehicle LS, such as the ground, histogram data exists over a wide distance as illustrated in FIG. 11. Meanwhile, the image data illustrated in FIG. 10 has a large area occupied by the transport vehicle LS. Thus, a peak appears at the distance from the stereo camera 22 to the meas-

urement points PI of the transport vehicle LS in the histogram. The calculation unit 86 determines that the distance at which the peak appears is the distance from the stereo camera 22 to the transport vehicle LS. Then, the calculation unit 86 calculates the distance from the wheel loader 1 to the transport vehicle LS based on the histogram (step S404).

[0091] The working-equipment control unit 87 controls the working equipment 10 based on the distance to the transport vehicle LS calculated by the calculation unit 86 (step S405).

[0092] As described above, in the present embodiment, the processing with the first algorithm includes creating, from the measurement data of the stereo camera 22, a histogram indicating the relationship between the distances from the stereo camera 22 and the number of pieces of data regarding the measurement points PI, determining the distance at which a peak appears in the histogram as the distance to the transport vehicle LS, and calculating the distance from the wheel loader 1 to the transport vehicle LS. Accordingly, as described with reference to FIG. 4, based on the distance to the transport vehicle LS calculated by the calculation unit 86, the working-equipment control unit 87 can control the angle of the bucket 12 and raise the boom 11 so that the bucket 12 is positioned above the upper end of the vessel BE and that the excavated object held in the bucket 12 is not fell from the bucket 12, while the wheel loader 1 is moving forward to approach the transport vehicle LS. After the boom 11 is raised to position the bucket 12 above the vessel BE, the working-equipment control unit 87 controls the working equipment 10 so that the bucket 12 performs the tilt operation. The excavated object is thereby discharged from the bucket 12 and loaded on the vessel BE.

[0093] In the present embodiment, the stereo camera 22 has been used as the three-dimensional measurement device 20, and the example in which the processing with the first algorithm and the processing with the second algorithm are selected depending on the work mode has been described. The same applies when the laser radar 21 is used as the three-dimensional measurement device 20. When the laser radar 21 is used, the processing with the first algorithm for the laser radar 21 and the processing with the second algorithm for the laser radar 21 are selected depending on the work mode.

[Effects]

[0094] As described above, in the present embodiment, the algorithm for processing the measurement data of the three-dimensional measurement device 20 is switched based on the work mode of the wheel loader 1. Accordingly, if the work target changes depending on the work mode, an appropriate algorithm is selected depending on the work target, and the distance from the wheel loader 1 to the work target is calculated based on the selected algorithm.

[0095] At a work site, measurement targets of the three-dimensional measurement device 20 may have large differences in shapes, such as the natural ground DS and the transport vehicle LS. In addition, the information required for controlling the working equipment 10 differs depending on the work target. For example, when the work target is the natural ground DS, the angle of repose of the natural ground DS or the position of the boundary DP is required to control the working equipment 10. When the work target is the transport vehicle LS, the distance to the vessel BE and the height of the vessel BE are required to control the working equipment 10. At a work site, the three-dimensional measurement device 20 sequentially measures work objects having different shapes or necessary information. In order to calculate with high accuracy the distances to the work targets whose shapes and the information required to control the working equipment 10 are different, it is effective to use different algorithms depending on the work target. When there is only one algorithm for processing the measurement data of the three-dimensional measurement device 20, it can be difficult to calculate the distance to the work target with sufficient accuracy to control the working equipment 10.

[0096] According to the present embodiment, the work mode of the wheel loader 1 is determined, and the algorithm for processing the measurement data is selected depending on the work mode. Thus, if the work target is switched, the distance DS to the measurement target can be calculated with high accuracy. That is, when a different algorithm is selected by the algorithm selection unit 85, the calculation unit 86 can calculate and output parameters regarding a different work target.

[0097] In the present embodiment, as described with reference to FIG. 2, the wheel loader 1 repeats moving forward while no excavated object is held in the bucket 12 (see the arrow M1), moving backward while an excavated object is held in the bucket 12 (see the arrow M2), moving forward while the excavated object is held in the bucket 12 (see the arrow M3), and moving backward while no excavated object is held in the bucket 12 (see the arrow M4). Thus, the algorithm selection unit 85 can select, based on the determination data of the excavated-object determination unit 83 and the determination data of the forward/backward-movement determination unit 84, an appropriate algorithm depending on the work mode from the algorithms stored in the storage unit 82.

[0098] In the present embodiment, the distance from the wheel loader 1 to the natural ground DS includes the distance from the wheel loader 1 to the boundary DP between the natural ground DS and the ground RS. Accordingly, as described with reference to FIG. 3, based on the measurement data of the three-dimensional measurement device 20, the control device 80 can lower the boom 11 and control the angle of the bucket 12 so that the distal end 12B of the bucket 12 approaches the boundary DP.

[0099] In the present embodiment, the distance from

the wheel loader 1 to the transport vehicle LS includes the distance from the wheel loader 1 to the front side surface of the transport vehicle LS. Accordingly, as described with reference to FIG. 4, based on the measurement data of the three-dimensional measurement device 20, the control device 80 can control the angle of the bucket 12 and raise the boom 11 so that the bucket 12 is positioned above the upper end of the vessel BE and that the excavated object held in the bucket 12 is not fallen from the bucket 12. After the boom 11 is raised to position the bucket 12 above the vessel BE, the control device 80 can control the working equipment 10 so that the bucket 12 performs the tilt operation.

[Computer system]

[0100] FIG. 12 is a block diagram illustrating an example of a computer system 1000. The control device 80 includes the computer system 1000. The computer system 1000 includes a processor 1001, such as a central processing unit (CPU), a main memory 1002 including a nonvolatile memory, such as a read only memory (ROM), and a volatile memory, such as a random access memory (RAM), a storage 1003, and an interface 1004 including an input/output circuit. The function of the control device 80 is stored in the storage 1003 as a program. The processor 1001 reads the program from the storage 1003, loads the program in the main memory 1002, and executes the above processing according to the program. Note that, the program may be distributed to the computer system 1000 via a network.

[0101] The computer system 1000 including the control device 80 can perform acquiring measurement data of the three-dimensional measurement device 20 that is mounted on the wheel loader 1 and measures the three-dimensional shape of a work target, selecting a specific algorithm for processing the measurement data depending on the work of the wheel loader 1, and processing the measurement data based on the selected algorithm to calculate a parameter regarding the work target.

[Other embodiments]

[0102] In the above embodiment, both the laser radar 21 and the stereo camera 22 have been provided in the wheel loader 1 as the three-dimensional measurement device 20. One of the laser radar 21 and the stereo camera 22 may be provided in the wheel loader 1. The three-dimensional measurement device 20 is only required to measure the three-dimensional shape of the work target and the relative position with the work target and is not limited to the laser radar 21 and the stereo camera 22. If an arbitrary three-dimensional measurement device 20 is used, the algorithm for processing the measurement data of the natural ground DS and the algorithm for processing the measurement data of the transport vehicle LS are selected, and a parameter regarding the work target is thereby calculated.

[0103] In the above embodiments, the work site where the wheel loader 1 works may be a mining site, a construction site, or a building site.

[0104] The wheel loader 1 may be used for snow removal work, work in the agriculture and livestock industry, or work in the forestry industry.

[0105] In the above embodiments, the work targets are not limited to the excavation target and the loading target, and may include, for example, an embankment target, a land leveling target, and an earth removal target. In addition, the work modes are not limited to the excavation work mode and the loading work mode and may include, for example, an embankment work mode, a land leveling work mode, an earth removal work mode, a snow removal work mode, and a standby mode.

[0106] In the above embodiments, the calculation unit 86 has calculated the distance from the wheel loader 1 to the natural ground DS and the angle of repose of the natural ground DS as the parameters regarding the natural ground DS. The calculation unit 86 may calculate another parameter regarding the natural ground DS. In addition, the calculation unit 86 has calculated the distance from the wheel loader 1 to the transport vehicle LS and the height of the vessel BE as the parameters regarding the transport vehicle LS. The calculation unit 86 may calculate another parameter regarding the transport vehicle LS.

[0107] In the above embodiment, the bucket 12 may have a plurality of blades or may have a straight blade edge.

[0108] The working member coupled to the distal end of the boom 11 may not be the bucket 12 and may be a snow plow or a snow bucket used for snow removal work, a bale glove or a fork used for work in the agriculture and livestock industry, or a fork or a bucket used for work in the forestry industry.

[0109] The work machine is not limited to the wheel loader, and the control device 80 and the control method described in the above embodiments can be applied to a work machine including a working equipment, such as an excavator or a bulldozer.

[0110] In the above embodiment, the first work mode has been the excavation work mode and the second work mode has been the loading work mode. The work modes are not limited to the excavation work mode and the loading work mode. In the above embodiment, the work modes have been two work modes of the first work mode and the second work mode, but may include three or more work modes.

[0111] In the above embodiment, the measurement device mounted on the wheel loader 1 has been the three-dimensional measurement device 20, and the measurement data acquired by the measurement-data acquisition unit 81 has been three-dimensional data indicating the three-dimensional shape of the work target, but they are not limited thereto. As the measurement device, in addition to the three-dimensional measurement device 20 for measuring the work target, the camera,

which is a photographic measurement device for photographing the work target, and a position measurement device for measuring the position of the work target may be mounted on the wheel loader 1. Alternatively, the measurement device may include the excavated-object determination sensor 51. In this case, the measurement data acquired by the measurement-data acquisition unit 81 includes, in addition to the three-dimensional data of the work target, at least one of the image data of the work target captured by the camera, the position data of the work target measured by the position measurement device, and the detection data of the excavated-object determination sensor 51.

[0112] In the above embodiment, the calculation unit 86 has calculated the distance from the distal end 12B of the bucket 12 to the work target as the distance from the wheel loader 1 to the work target. The calculation unit 86 may calculate the distance from any part of the bucket 12 (for example, the bottom surface) to the work target, the distance from any part of the working equipment 10 to the work target, or the distance from any part of the vehicle body 2 to the work target.

[0113] In the above embodiment, the algorithm selection unit 85 has determined the work mode of the wheel loader 1 or selected a specific algorithm based on the determination data of the excavated-object determination unit 83 and the determination data of the forward/backward-movement determination unit 84. The algorithm selection unit 85 may determine the work mode or select an algorithm based on other data different from the determination data of the excavated-object determination unit 83 and the forward/backward-movement determination unit 84. Other data includes, for example, at least one of three-dimensional data of the work target, which is measurement data of the three-dimensional measurement device 20, detection data of the excavated-object determination sensor 51, image data of the work target captured by the camera mounted on the wheel loader 1, and position data of the work target measured by the position measurement device mounted on the wheel loader 1.

[0114] In the above embodiment, the algorithm selection unit 85 has determined the work mode, but is not limited thereto, and may determine, for example, the work target by some method and select an algorithm depending on the determined work target. The method for determining the work target includes, for example, a method using at least one of three-dimensional data of the work target, which is measurement data of the three-dimensional measurement device 20, detection data of the excavated-object determination sensor 51, image data of the work target captured by the camera mounted on the wheel loader 1, and position data of the work target measured by the position measurement device mounted on the wheel loader 1.

[0115] As described above, the work of the wheel loader 1 is a concept including at least one of the work mode of the wheel loader 1 and the operation of the wheel load-

er 1 to the work target. The algorithm selection unit 85 can select an algorithm depending on the work of the wheel loader 1. The algorithm selection unit 85 can select an algorithm depending on the work mode of the wheel loader 1 or select an algorithm depending on the work target of the wheel loader 1. The work mode includes a state in which the wheel loader 1 performs a predetermined operation. The work mode includes a single work mode, such as the excavation work mode or the loading work mode as described above, and a work mode including a plurality of work modes. The work mode including a plurality of work modes is, for example, a "V shape work mode" including a series of work modes of the above excavation work mode M1, a mode M2 for being separated from the natural ground DS, a loading work mode M3, and a mode M4 for being separated from the transport vehicle LS.

[0116] In the above embodiment, the transmission device 30 and the traveling operation device 40 of the wheel loader 1 have been driven by the operation of the driver. The transmission control unit 88 and the traveling control unit 89 may automatically control the transmission device 30 and the traveling device 4. The transmission control unit 88 and the traveling control unit 89 can control the transmission device 30 and the traveling device 4 based on the distance from the wheel loader 1 to the work target calculated by the calculation unit 86.

Reference Signs List

[0117]

1	WHEEL LOADER (WORK MACHINE)
2	VEHICLE BODY
2F	FRONT VEHICLE BODY
2R	REAR VEHICLE BODY
3	CAB
4	TRAVELING DEVICE
4A	DRIVING DEVICE
4B	BRAKING DEVICE
4C	STEERING DEVICE
5	WHEEL
5F	FRONT WHEEL
5R	REAR WHEEL
6	TIRE
6F	FRONT TIRE
6R	REAR TIRE
9	JOINT MECHANISM
10	WORKING EQUIPMENT
11	BOOM
12	BUCKET
12B	DISTAL END
13	BOOM CYLINDER
14	BUCKET CYLINDER
15	BELL CRANK
16	LINK
20	THREE-DIMENSIONAL MEASUREMENT DEVICE

21 LASER RADAR
 22 STEREO CAMERA
 30 TRANSMISSION DEVICE
 40 TRAVELING OPERATION DEVICE
 41 SHIFT LEVER
 51 EXCAVATED-OBJECT DETERMINATION
 SENSOR
 52 ROTATION SENSOR
 80 CONTROL DEVICE
 81 MEASUREMENT-DATA ACQUISITION UNIT
 82 STORAGE UNIT
 83 EXCAVATED-OBJECT DETERMINATION
 UNIT
 84 FORWARD/BACKWARD-MOVEMENT DE-
 TERMINATION UNIT
 85 ALGORITHM SELECTION UNIT
 86 CALCULATION UNIT
 87 WORKING-EQUIPMENT CONTROL UNIT
 88 TRANSMISSION CONTROL UNIT
 89 TRAVELING CONTROL UNIT
 BE VESSEL (LOADING TARGET, WORK TAR-
 GET)
 DS NATURAL GROUND (EXCAVATION TARGET,
 WORK TARGET)
 LS TRANSPORT VEHICLE
 RS GROUND

Claims

1. A work machine control device comprising:

a measurement-data acquisition unit configured
 to acquire measurement data of a measurement
 device configured to measure a work target, the
 measurement device being mounted on a work
 machine including a working equipment;
 an algorithm selection unit configured to select
 a specific algorithm that processes the meas-
 urement data depending on work of the work
 machine; and
 a calculation unit configured to process the
 measurement data based on the algorithm se-
 lected by the algorithm selection unit to calculate
 a parameter regarding the work target.

2. The work machine control device according to claim
 1, wherein
 the algorithm selection unit is configured select the
 specific algorithm that processes the measurement
 data depending on a work mode of the work machine.

3. The work machine control device according to claim
 2, wherein
 the work target includes an excavation target and a
 loading target,
 the algorithm selection unit is configured to select a
 first algorithm when the work machine is in an exca-

vation work mode and select a second algorithm
 when the work machine is in a loading work mode,
 and
 the calculation unit is configured to calculate a dis-
 tance to the excavation target based on the first al-
 gorithm and calculate a distance to the loading target
 based on the second algorithm.

4. The work machine control device according to any
 one of claims 1 to 3, comprising
 a working-equipment control unit configured to con-
 trol the working equipment based on the distance to
 the work target calculated by the calculation unit.

5. The work machine control device according to claim
 1, wherein
 the algorithm selection unit is configured select the
 specific algorithm that processes the measurement
 data according to the work target.

6. The work machine control device according to claim
 5, wherein
 the work target includes an excavation target and a
 loading target,
 the algorithm selection unit is configured to select a
 first algorithm when the work target is the excavation
 target and select a second algorithm when the work
 target is the loading target, and
 the calculation unit is configured to calculate a dis-
 tance to the excavation target based on the first al-
 gorithm and calculate a distance to the loading target
 based on the second algorithm.

7. A work machine control device comprising:

a measurement-data acquisition unit configured
 to acquire measurement data of a three-dimen-
 sional measurement device configured to meas-
 ure three-dimensional shapes of an excavation
 target and a loading target, the three-dimension-
 al measurement device being mounted on a
 work machine including a working equipment;
 an algorithm selection unit configured to select
 a first algorithm that calculates a parameter re-
 garding the excavation target when the work ma-
 chine performs work on the excavation target
 and select a second algorithm that calculates a
 parameter regarding the loading target when the
 work machine perform work on the loading tar-
 get; and
 a calculation unit configured to calculate differ-
 ent parameters when the first algorithm is se-
 lected and when the second algorithm is select-
 ed.

8. The work machine control device according to claim
 7, wherein
 the calculation unit is configured to calculate a dis-

tance to the excavation target and an angle of repose of the excavation target when the first algorithm is selected and calculate a distance to the loading target and a height of the loading target when the second algorithm is selected.

5

9. A work machine control method comprising:

acquiring measurement data of a measurement device configured to measure a work target; 10
selecting a specific algorithm that processes the measurement data depending on work of a work machine; and
processing the measurement data based on the selected algorithm to calculate a parameter re- 15
garding the work target.

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FIG.1

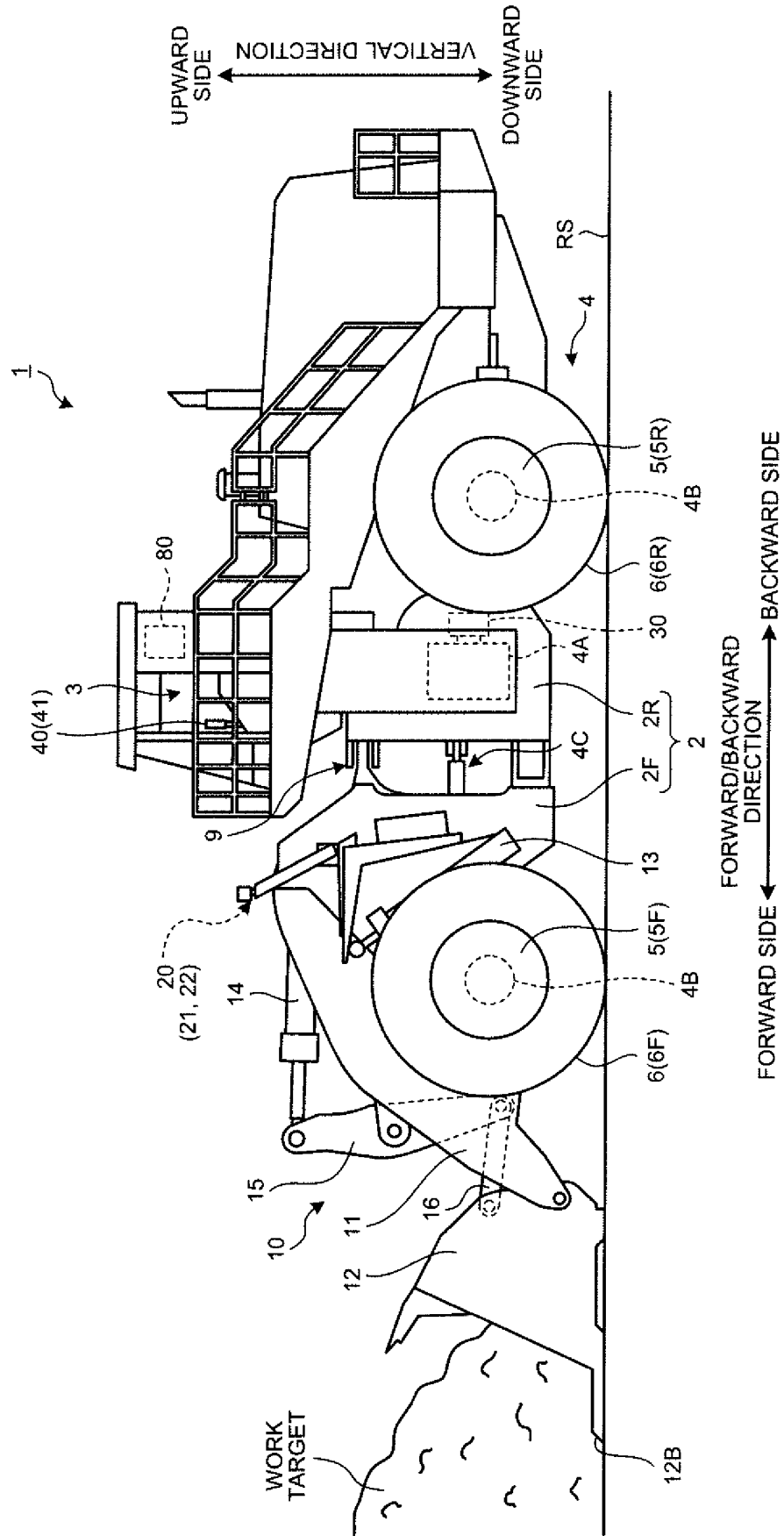


FIG.2

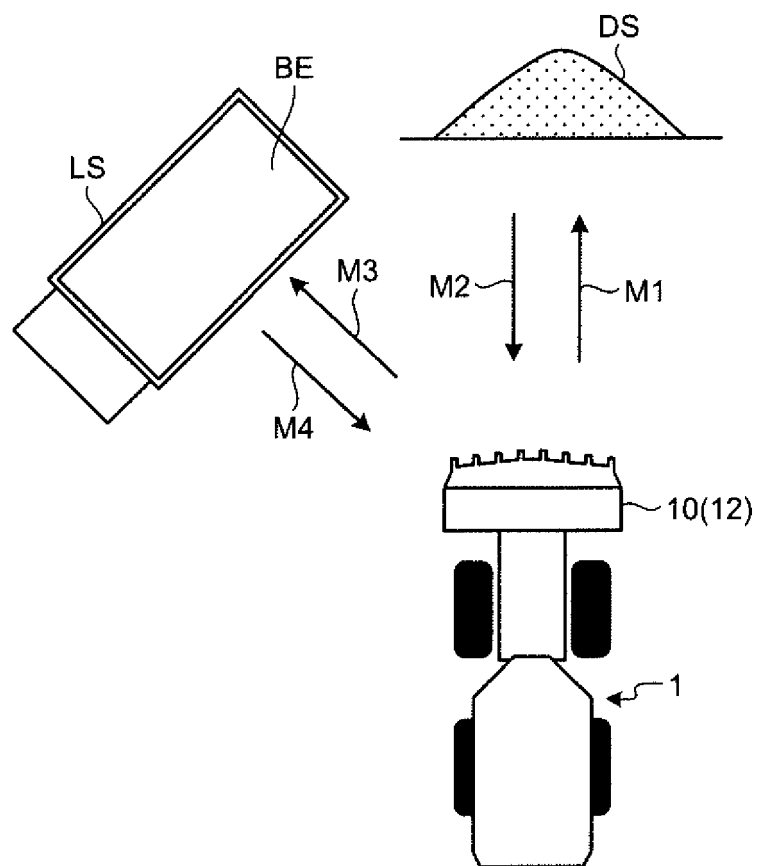


FIG.3

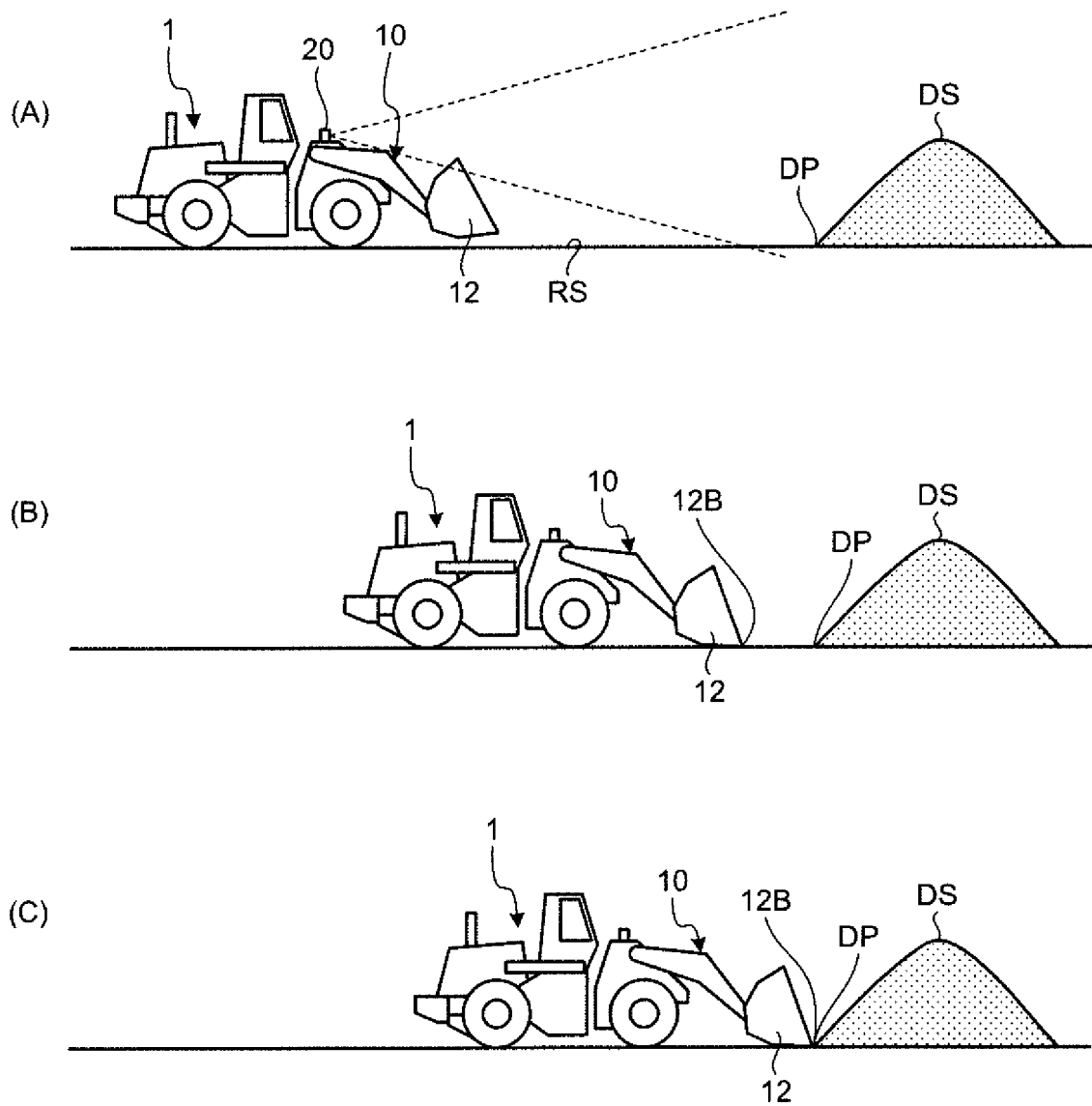


FIG.4

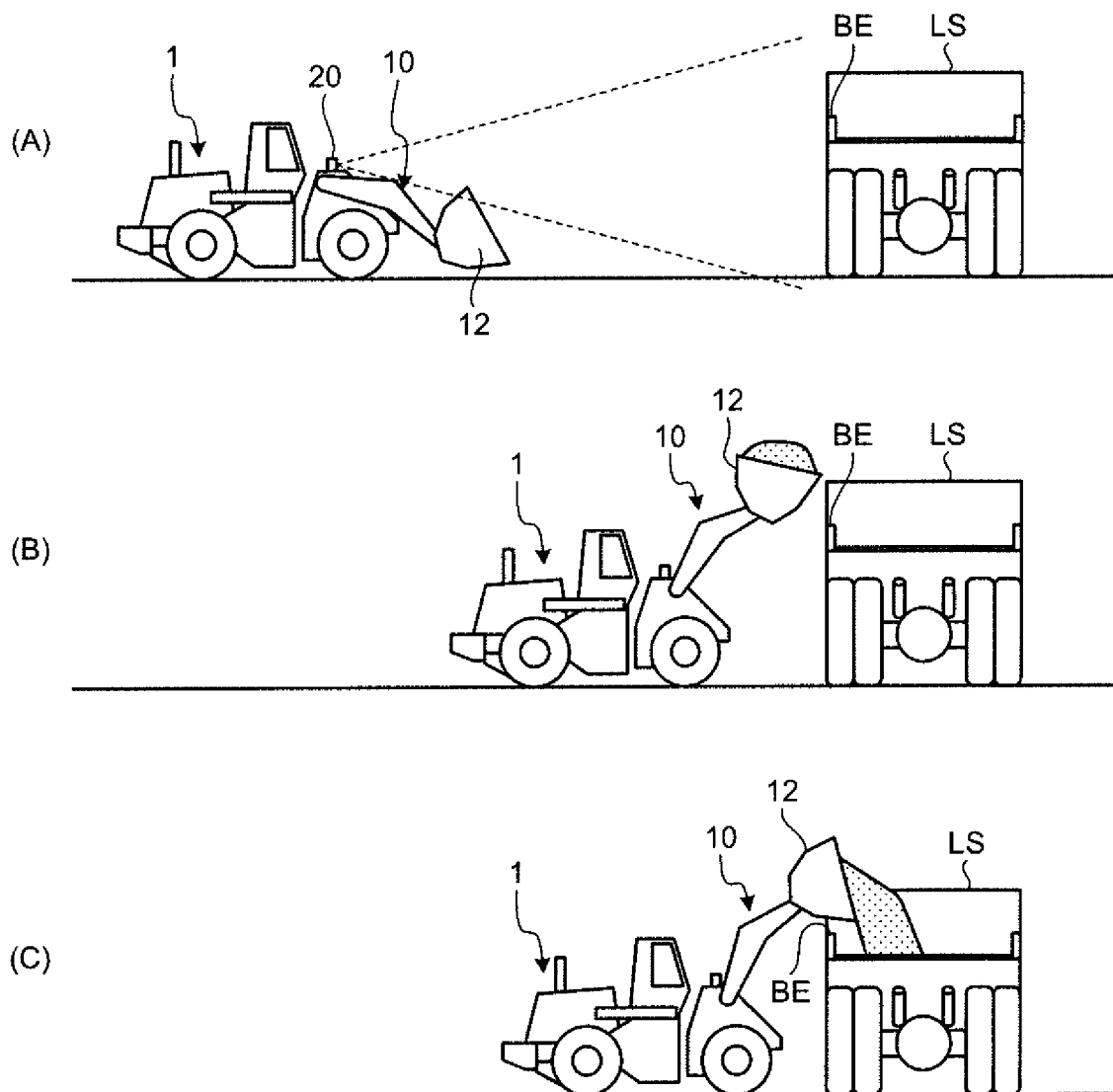


FIG.5

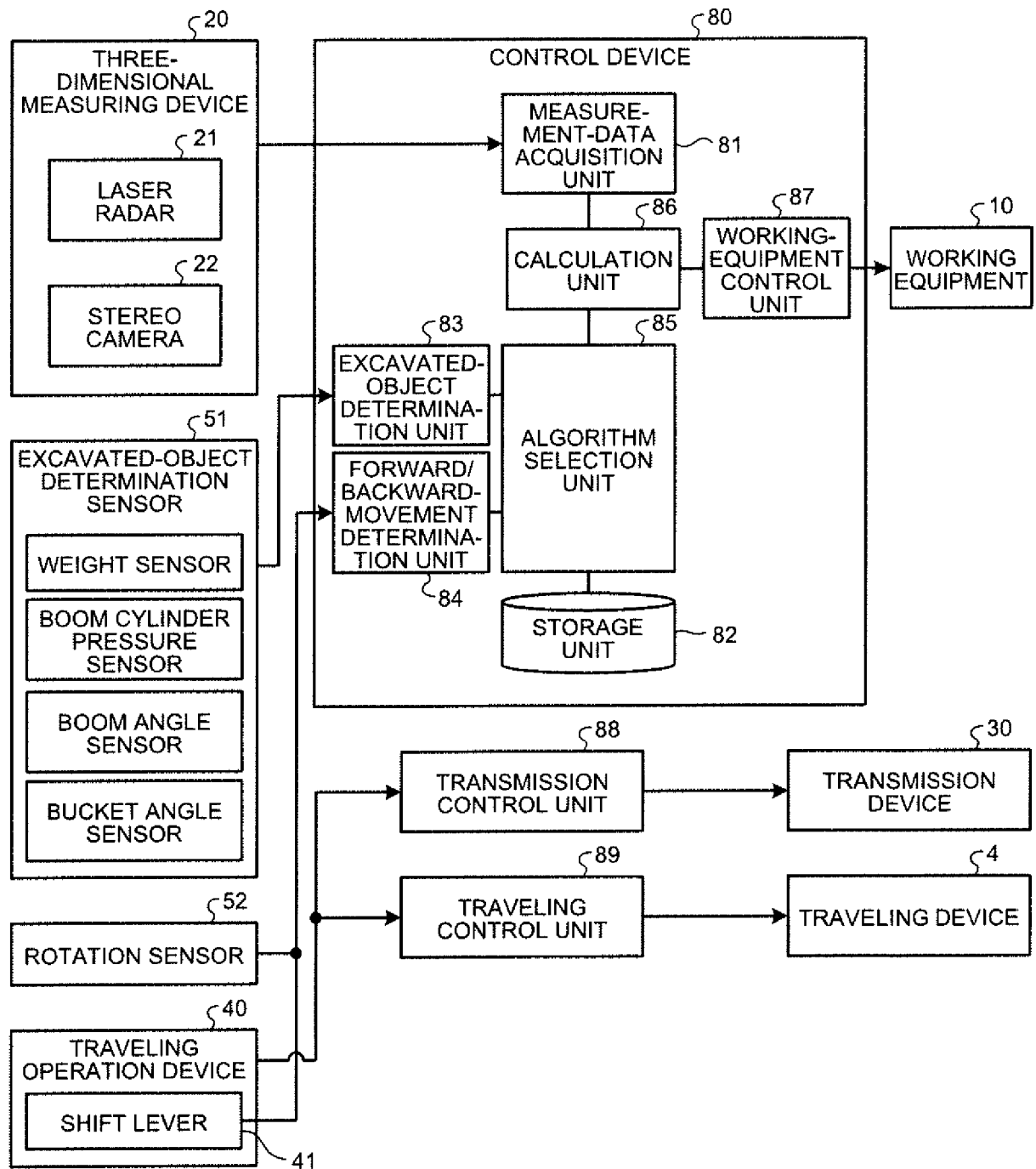


FIG.6

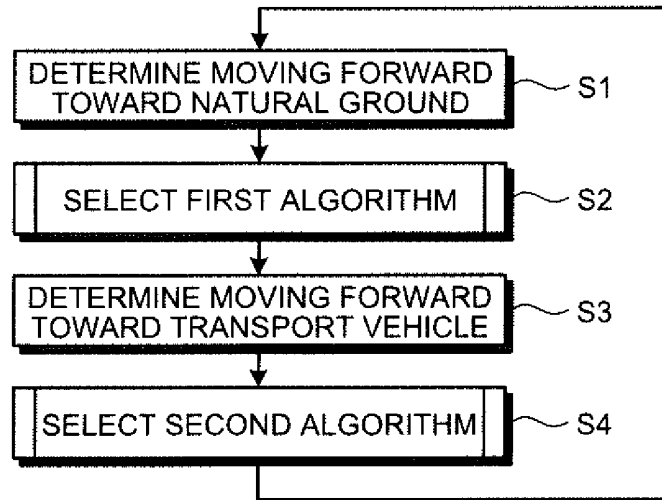


FIG.7

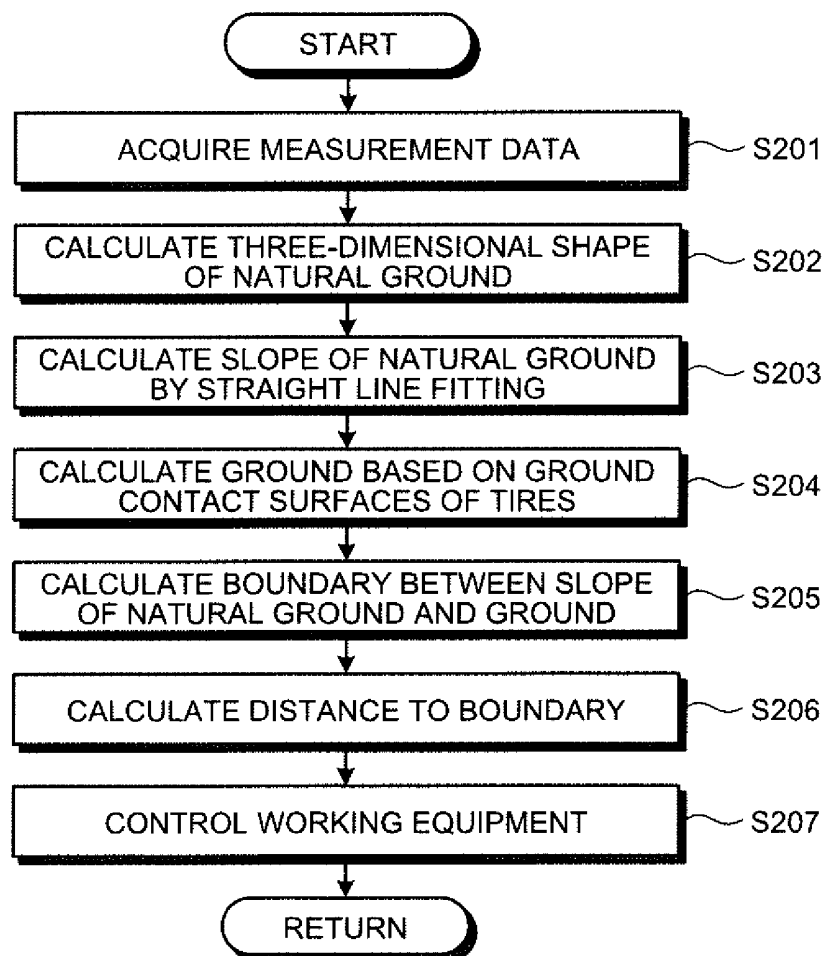


FIG.8

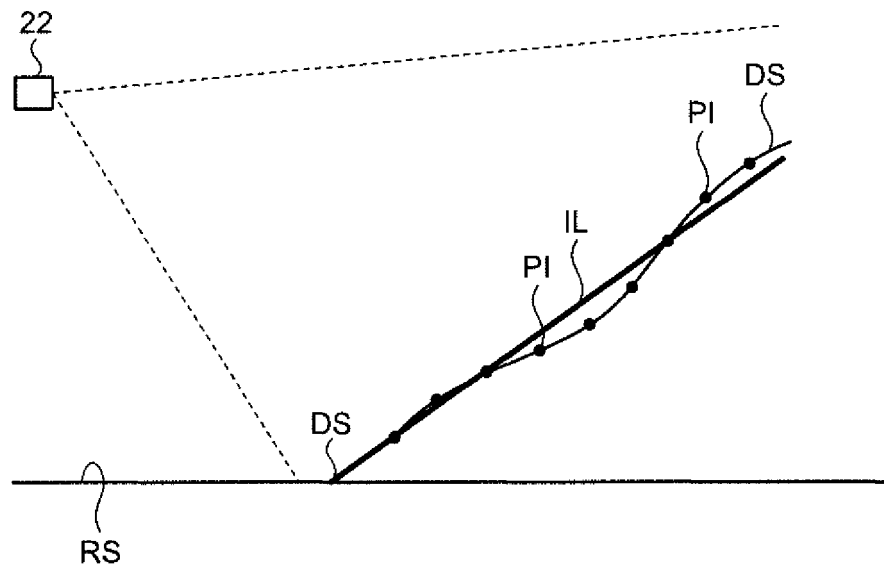


FIG.9

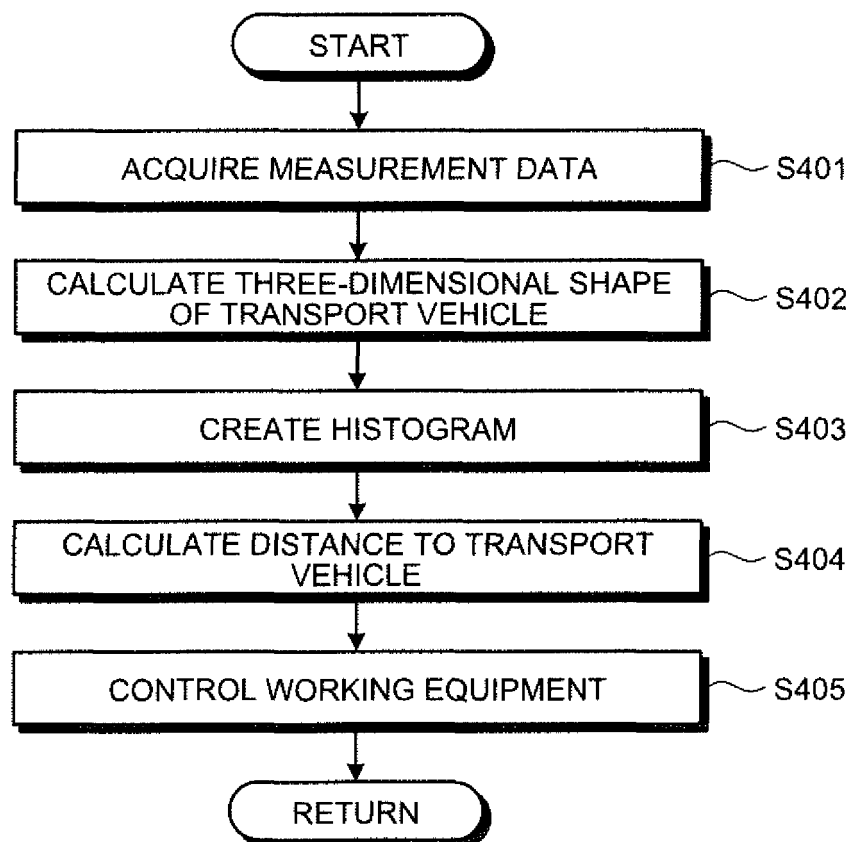


FIG.10

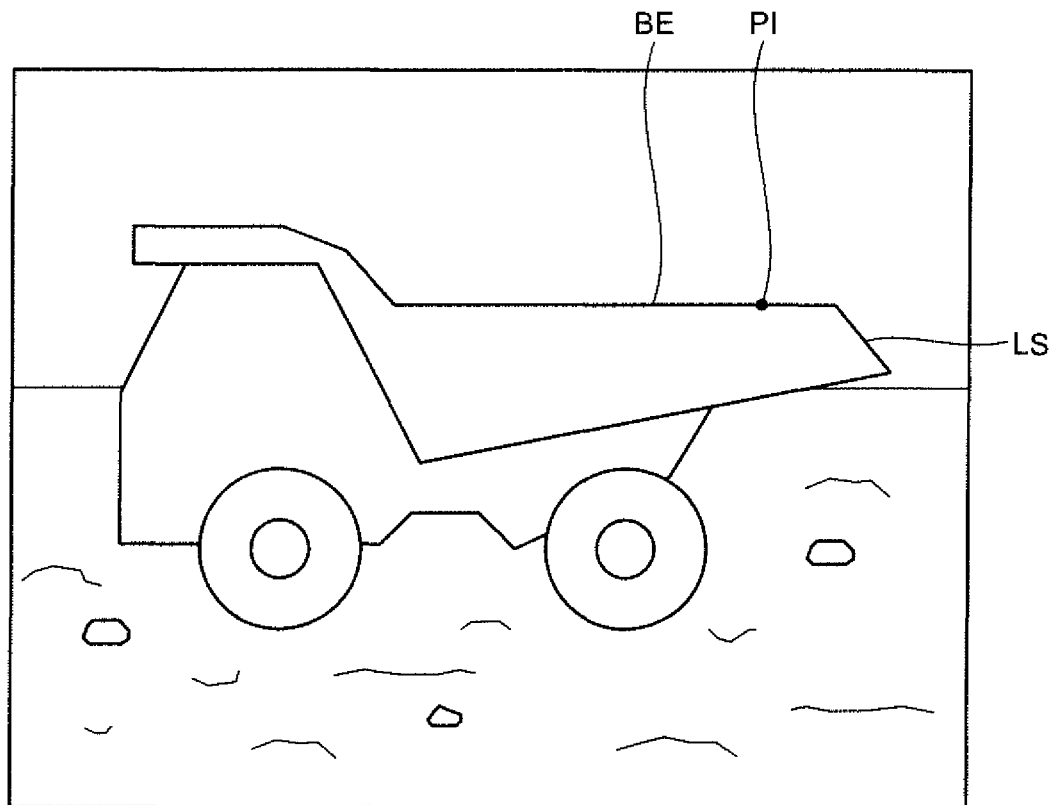


FIG.11

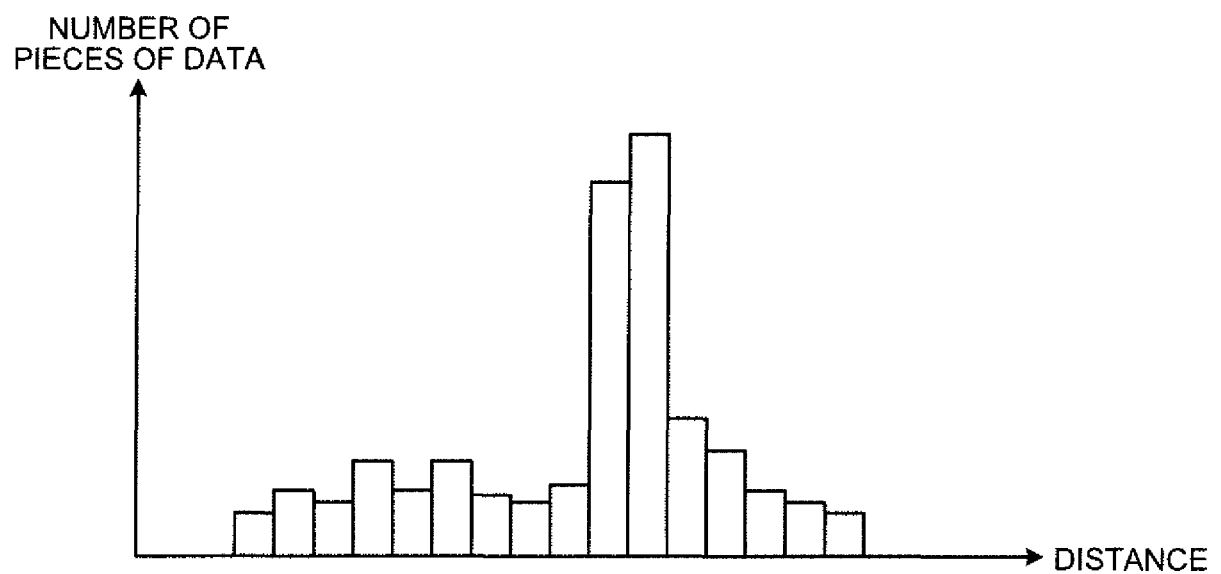
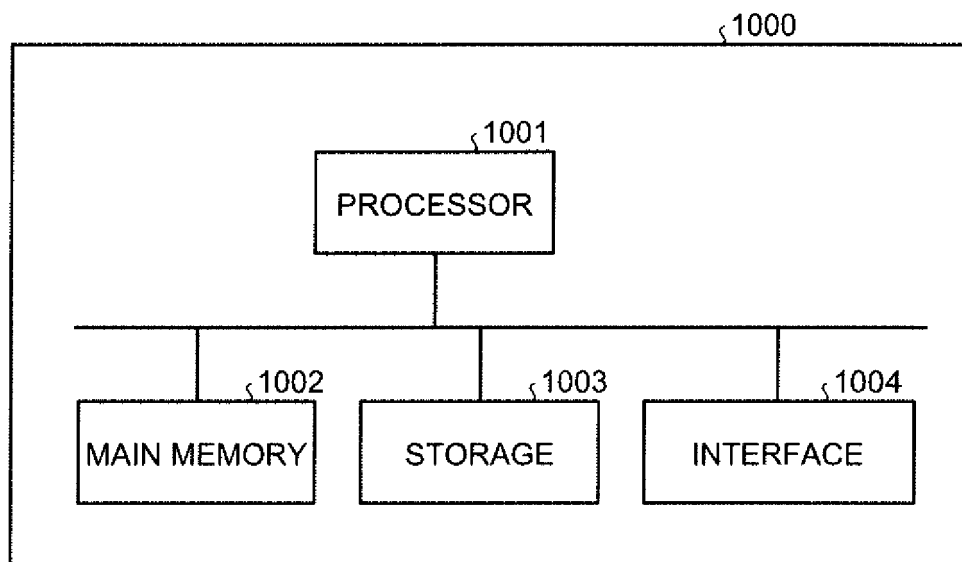


FIG.12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/009799

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. E02F9/20 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. E02F9/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2019
Registered utility model specifications of Japan 1996-2019
Published registered utility model applications of Japan 1994-2019

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 10-88625 A (KOMATSU LTD.) 07 April 1998,	1-7, 9
Y	paragraphs [0020]-[0050], fig. 1, 5-8 & US 6247538 B1, column 4, line 4 to column 8, line 9, fig. 1, 58 & WO 98/11305 A1, page 4, line 23, page 10, line 13, fig. 1, 5-8 & AU 4220697 A	8
Y	JP 2017-43885 A (KOMATSU LTD.) 02 March 2017, paragraphs [0115], [0116] & US 2018/0135273 A1, paragraphs [0141], [0142] & WO 2017/033623 A1, paragraphs [0115], [0116] & EP 3342937 A1, paragraphs [0120], [0121] & CN 107532401 A	8
A	JP 2000-136549 A (CARNEGIE MELLON UNIVERSITY) 16 May 2000 & US 6363632 B1 & GB 2342640 A	1-9



Further documents are listed in the continuation of Box C.



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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 5-297942 A (FUJITA CORP.) 12 November 1993 (Family: none)	1-9

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- JP H10088625 A [0003]