

SPECIFICATION

TITLE OF INVENTION: WORK VEHICLE CONTROL TERMINAL AND WORK
VEHICLE CONTROL METHOD

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TECHNICAL FIELD

[0001]

The present invention relates to a work vehicle control
terminal and a work vehicle control method.

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BACKGROUND ART

[0002]

In the related art, at facility construction, a
construction site, or the like, the positioning of a device,
bolts, or the like to be installed is performed according to
black lines drawn at the site. Therefore, the accuracy of the
black line is very important, and the black lines are drawn
using a method called marking by a skilled craftsman.

[0003]

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In the recent years, a technique for performing the
marking using an autonomous mobile machine has been published.
In a marking robot that performs marking, a technique for
calculating a position serving as a reference for controlling
the marking robot is disclosed in Patent Document 1.

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[0004]

Patent Document 1 describes that "next, a worker installs a prism (not illustrated) at the position of a reference line at a site, and measures the position of the reference line using a tracking type total station 2 (S51). A communication device 3 receives position information of the reference line from the tracking type total station 2 via a wireless communication line, and transmits the position information of the reference line to a marking robot 1. A PC 17 for the marking robot 1 sets the received position information of the reference line (S31). Accordingly, the PC 17 can map a coordinate system of marking data 52 to a coordinate system of the site."

CITATION LIST

PATENT DOCUMENT

[0005]

Patent Document 1: JP 2019-196988 A

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006]

Even in the case of using the marking robot that autonomously travels, there is a need to perform work of matching coordinates with a design drawing using the black lines (referred to as reference lines) serving as a reference

and drawn by a human.

[0007]

In Patent Document 1, the coordinates are set based on the reference lines, but the accuracy of the marking of the reference lines themselves is not taken into consideration. For this reason, when a deviation has occurred in the reference line itself marked on the site, the accuracy of a marking position made by the marking robot also deteriorates, which is a problem.

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SOLUTIONS TO PROBLEMS

[0008]

In order to solve the foregoing problems, the present invention employs, for example, configurations described in the appended claims. This application includes a plurality of means for solving the above-described problems, and as one example, there is provided a work vehicle control terminal including: a drawing data retention unit that retains drawing data created in advance and containing work coordinates at which a work vehicle that autonomously moves performs work and position information of a drawing reference line that is a line serving as a reference for the work coordinates; a site reference line information retention unit that retains measured position information of a site reference line drawn at a work site and corresponding to the drawing reference line;

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a position information transmission unit that transmits position information corresponding to the work coordinates to the work vehicle, based on the position information of the drawing reference line and the measured position information of the site reference line; a display unit that displays information; and a reference line overlay display output unit that outputs data to overlay and display the drawing reference line and the site reference line on the display unit, based on the position information of the drawing reference line and the measured position information of the site reference line.

EFFECTS OF THE INVENTION

[0009]

According to the present invention, it is possible to assist in improving the work accuracy of the work vehicle that autonomously moves to a predetermined position at the work site to perform predetermined work.

BRIEF DESCRIPTION OF THE DRAWINGS

20 [0010]

Fig. 1 is a view illustrating an example of an overall configuration according to a first embodiment.

Fig. 2 is a block diagram of the overall configuration according to the first embodiment.

25 Fig. 3 is a view illustrating an example of a screen

display of a control terminal according to the first embodiment.

Fig. 4 is a flowchart illustrating operations and processes according to the first embodiment.

5 Fig. 5 is a view illustrating an example in which a reference line with a large amount of deviation exists on a screen display of a control terminal according to a second embodiment.

Fig. 6 is a view illustrating an example of a state where
10 sporadic deviations have occurred on a screen display of a control terminal according to a third embodiment.

MODE FOR CARRYING OUT THE INVENTION

[0011]

15 Hereinafter, embodiments of the present invention will be described with reference to the drawings.

First embodiment

[0012]

When marking is performed at a construction site or the
20 like using a marking robot that autonomously travels, in order to perform marking according to a marking place on a design drawing, at least two black lines (reference lines) serving as a reference are drawn at the site, and coordinates on the design drawing and coordinates at the work site are matched
25 based on the black lines. Accordingly, position information

corresponding to the coordinates of the marking location set on the design drawing can be calculated, and the marking robot autonomously moves and performs marking.

[0013]

5 However, a floor surface at the site cannot be perfectly flat, and the reference lines are drawn by a human (craftsman). For this reason, straight lines and angles may not strictly match the design drawing.

[0014]

10 Therefore, according to the present invention, by overlaying and displaying the reference lines drawn at the site and reference lines on the design drawing, a deviation between the reference lines on the design drawing and the actually drawn reference lines is visualized.

15 [0015]

By recognizing the deviation, it is possible to assist in performing marking at least at a more accurate position. For example, when it can be recognized that a deviation is large, by redoing marking at the site based on the deviation, it is possible to assist in improving the accuracy of the marking location made by the marking robot. In addition, even when marking is not redone at the site, by correcting the coordinates of the marking location based on the identified deviation, it is also possible to contribute to improving the accuracy of marking.

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[0016]

Hereinafter, embodiments of the present invention will be described with reference to the drawings.

[0017]

5 Fig. 1 is a view illustrating an example of an overall configuration of a first embodiment.

 A surveying instrument 101 transmits measurement information of a black line (reference line) 104 to a marking robot 102, so that the marking robot 102 calculates and
10 identifies an installation position of the surveying instrument 101 at a construction site. Further, a marking position 105 is specified based on coordinate information of a marking point on a design drawing held by a control terminal 103 and on coordinate information obtained by actually
15 measuring a position of the marking robot 102 using the surveying instrument 101. The marking robot 102 can autonomously move and perform printing on the ground to perform marking at the site according to the marking point as described on the design drawing.

20 [0018]

 The marking robot 102 is equipped with a prism serving as the surveying point of the surveying instrument 101. In addition, the marking robot 102 has a traveling function, and can autonomously move to the marking position 105. Further,
25 marking is performed by causing an equipped printing mechanism

to depict ink dots on a floor surface located in a vertical direction of the prism.

[0019]

The control terminal 103 is a device that performs
5 communication with the surveying instrument 101 and the
marking robot 102, and that enables an operator to perform
instructions or control. In addition, the control terminal 103
stores the state of the surveying instrument 101 or the
marking robot 102 required at that time, or coordinate
10 information required for marking. In the first embodiment as
well, the operator can set a suitable surveying instrument
position based on information displayed on the control
terminal 103.

[0020]

15 The reference lines 104 are lines prepared by a worker so
as to serve as a reference for various construction positions
at the construction site, and is generally formed of a
plurality of lines drawn in a grid pattern.

[0021]

20 The marking position 105 is position information
indicating an attachment place when a facility device or the
like is constructed, specifies a position based on distances
from the reference lines 104, and is depicted with a cross
line or the like. This drawing illustrates an example in which
25 two reference lines 104 are depicted to intersect each other

as an X-axis and a Y-axis.

[0022]

A prism 106 is placed on the reference line 104 to measure a distance between the reference line 104 drawn by the worker and the surveying instrument 101. In order to specify a position of one reference line 104, measurements are performed at at least two points on the same one reference line 104.

[0023]

Fig. 2 is a block diagram of the overall configuration according to the first embodiment.

The control terminal 201 includes a CPU 202, a ROM 203, a RAM 204, a touch panel display 205, a control application 206, and a wireless communication unit 207. In other words, the control terminal 201 is display means for the design drawing and the like, and is input means for setting or instructing the system.

[0024]

The ROM 203 is a storage device that stores a program executed by the CPU 202 or design drawing data. The RAM 204 is a primary storage device used when the CPU 202 executes the program or the like. The touch panel display 204 is a display device capable of simultaneously displaying both the design drawing data and the reference lines 104 measured at the site.

[0025]

The control application 206 is a program that enables

instructing the marking robot 208 or the overlaying and displaying of the design drawing and the measured reference lines. The CPU 202 is means for executing the program stored in the ROM 203. The wireless communication unit 207 is an
5 interface for performing communication with the marking robot 208 or the surveying instrument 215.

[0026]

The marking robot 208 includes a PC 209, a traveling mechanism 210, a printing mechanism 211, a directional prism
10 212, a marking robot control application 213, and a wireless communication unit 214. The PC 209 is control means for the marking robot 208.

[0027]

The traveling mechanism 210 includes wheels, and is
15 traveling means for controlling the rotation of the wheels. The printing mechanism 211 includes an inkjet printer mechanism, and is means for depicting lines or characters at a marking position.

[0028]

20 The directional prism 212 is attached to an upper portion of the printing mechanism 211, and a position of the marking robot 208 is specified by measuring a position of the directional prism 212 using the surveying instrument 215. The marking robot control application 213 is a program that
25 coordinates direction control of the traveling mechanism 210,

the printing mechanism 211, and the directional prism 212 to perform marking work.

[0029]

The wireless communication unit 214 is an interface for performing communication with the control terminal 201 or the surveying instrument 215. The marking robot 208 includes the PC 209, the traveling mechanism 210, the printing mechanism 211, the directional prism 212, the marking robot control application 213, and the wireless communication unit 214.

10 [0030]

Incidentally, the surveying instrument 215 has the function of measuring and making a notification of position information of the prism 212 serving as a surveying point.

[0031]

15 Fig. 3 is a view illustrating an example of a screen display of the control terminal of the first embodiment.

A drawing 302 of construction drawing data stored in the control terminal 103 is displayed on a screen 301 of the control terminal 103. A surveying instrument position 303 can be overlaid and displayed on the drawing 302 of the construction drawing data on the control terminal 103 based on installation position information obtained by measurements performed by the surveying instrument 101. A marking position 306 indicated by a cross is information included in the drawing 302 of the construction drawing data, and indicating a

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coordinate position where marking is actually performed by the marking robot 102.

[0032]

In addition, reference lines 304 of the design drawing
5 and reference lines 305 obtained by measurements from the
installation position of the surveying instrument 102 can be
overlaid and displayed on the screen 301. By displaying each
of the reference lines on the same drawing, a difference
between the design drawing and the site that are not in strict
10 alignment can be visualized.

[0033]

Fig. 4 is a flowchart illustrating operations and
processes of the first embodiment.

A processing flow in the control terminal 201 will be
15 described. In S401, an instruction for the reading of data for
marking work is issued. The instruction is wirelessly
transmitted to and read by the marking robot 102.

[0034]

In S402, the position of the prism 106 installed at an
20 arbitrary position on the reference line 104 is received as
the result of measurements performed by the surveying
instrument 101. In order to identify position information of
one reference line, measurements are performed at at least two
different points on the reference line 104. Therefore, in
25 order to measure and depicting positions of two reference

lines, measurements are performed at at least two points (at least three points in a case where the prism 106 is installed at an intersection point of the reference lines intersect) for each of the reference lines, and the measurement results are
5 received.

[0035]

The measurement results are also wirelessly transmitted to the marking robot 102, and the position of the surveying instrument 101 is identified from the measurement results.
10 Namely, when it is considered that the two reference lines 104 correspond to the X-axis and the Y-axis orthogonal to each other on a two-dimensional plane, by performing measurements as described above, information corresponding to an X-coordinate and a Y-coordinate of the surveying instrument 101
15 can be acquired.

[0036]

In S403, the position of the surveying instrument 101 obtained from the measurement results and the measured reference lines 104 are overlaid and displayed on the design
20 drawing 302.

[0037]

In S404, in a state where the construction drawing 302 is fixed and displayed, a correction can be performed to move the coordinates of the surveying instrument 101 upward, downward,
25 leftward, and rightward, and to rotate the coordinates, and

the reference lines 104 measured by the surveying instrument 101 are moved in conjunction with the correction. The correction allows both the reference lines 104 to overlap and align with each other more closely. The marking robot 102
5 receives information about the correction, and identifies the position of the surveying instrument 101. Incidentally, by fixing the reference lines 305 obtained by the measurements and moving the construction drawing 302, both the reference lines 104 may be corrected to positions where the reference
10 lines 104 overlap the reference lines 305 more closely.

[0038]

In S405, an instruction to perform marking is issued, and the marking robot 102 performs marking based on the set position information of the surveying instrument 101.

15 [0039]

A processing flow in the marking robot 208 will be described.

[0040]

In S411, the instruction is received from the control
20 application 206, and the data for marking work is read. The marking robot 102 acquires the coordinates of the reference lines on the drawing and the coordinates of ink dots required for the marking work.

[0041]

25 In S412, the position of the surveying instrument 101 is

calculated and identified from the results measured by the surveying instrument 101. Since the position is calculated from partial information (two axes in the case of the reference lines 104) of the measured results, the position is
5 an intermediate generated value in this proposed method.

[0042]

In S413, the information about the correction performed in S404 is received and added to the position information of the surveying instrument 101 calculated in S412 to finalize
10 the position information as new position information.

[0043]

In S414, movements to the marking position 105 and the printing of ink dots are repeated based on the position information acquired in S413.

15 [0044]

Incidentally, the present invention illustrates an example in which when a position of a marking location is calculated, the position of the surveying instrument 101 calculated from each of distances between the two reference
20 lines 104 and the surveying instrument 101 is used as a reference, and a positional relationship relative to the position of the surveying instrument 101 is calculated to move and control the marking robot 102; however, the position of the surveying instrument 101 does not need to be necessarily
25 used as a reference. For example, when the positional

relationship between the two reference lines 104 is known, the intersection point of the two reference lines 104 may be considered to be zero coordinates (0, 0), the zero coordinates may be used as a reference to calculate a position of a marking location, and the coordinates of the position may be taught to the marking robot 102.

Second embodiment

[0045]

Coordinates at which marking is performed are calculated based on two orthogonal black lines (reference lines) serve as a reference. However, as described above, straight lines do not strictly match the design drawing. By measuring a plurality of black lines and by visualizing a difference between the measurements and the drawing, it is possible to specify the reference line with a larger amount of deviation, and it is possible to contribute to selecting the reference line that enables more accurate calculation of coordinates at which marking is performed.

[0046]

Hereinafter, a second embodiment of the present invention will be described with reference to the drawings.

[0047]

Fig. 5 is a view illustrating an example of a screen display of a control terminal of the second embodiment, and illustrating a state where a reference line with a large

amount of deviation exists. Reference lines 501 are depicted on a drawing based on the results of measurements of a plurality of reference lines. By comparing the reference lines 501 with reference lines 502 on a design drawing, it can be
5 recognized that there is the reference line with a large deviation such as a reference line 503. By calculating coordinates at which marking is performed, based on reference lines 504 other than the reference line with a large deviation, accurate marking can be performed.

10 [0048]

In such a manner, since at least two black lines are used to calculate the coordinates at which marking is performed, in a case where three or more black lines are drawn at a site, when the black lines are overlaid and displayed, it is easy
15 for human eyes to see which black line at the site has a large deviation. Further, the reference lines used when the marking coordinates are calculated can be selected. In other words, since the reference line with a large deviation can be excluded from the calculation of the marking coordinates, more
20 accurate marking coordinates can be obtained.

[0049]

In order to visualize the magnitude of the deviation, in a state where the reference lines are overlaid and displayed, the colors or lines of the reference lines themselves or
25 surrounding colors are changed and displayed in a highlighting

manner according to the degrees of deviations (distance) between the reference lines on the drawing and the corresponding reference lines obtained by measurements, so that the black line with a large deviation can be identified.

5 Third embodiment

[0050]

In a method in which a plurality of black lines are measured and in a state where deviations have occurred not only in one specific black line but also sporadically, any of
10 the reference lines is selected and used to calculate coordinates at which marking is performed, there is a possibility that portions in which large deviations occur are generated in the result of marking. In a third embodiment, by correcting a calculated position of the surveying instrument,
15 deviations of a plurality of marking positions can be averaged.

[0051]

Hereinafter, the third embodiment of the present invention will be described with reference to the drawings.

[0052]

20 Fig. 6 is a view illustrating an example of a screen display of a control terminal of the third embodiment, and illustrating a state where sporadic deviations have occurred.

Reference lines 601 are depicted on a drawing based on the results of measurements of a plurality of reference lines.
25 By comparing the reference lines 601 with reference lines 602

on a design drawing, it can be determined that no matter which reference line is used to calculate coordinates at which marking is performed, the result of the marking has a large error. By correcting the position of the surveying instrument and by finding a state 603 where the amounts of deviations are averaged, the possibility of being able to perform marking within an allowable error range can be expanded.

[0053]

Incidentally, the present invention is not limited to the above-described embodiments, and include various modification examples.

For example, the above-described embodiments have been described in detail to facilitate understanding of the present invention, and are not necessarily limited to including all the described configurations. The marking robot can also be applied to a work vehicle that autonomously moves to a predetermined location on a floor surface, wall surface, or ceiling to perform predetermined work.

[0054]

In addition, a part of a configuration of an embodiment can also be replaced with a configuration of another embodiment. In addition, a configuration of another embodiment can also be added to a configuration of an embodiment.

[0055]

In addition, another configuration can be added, removed,

or replaced with a part of a configuration of each embodiment.
 In addition, information about programs, tables, files, and
 the like for implementing each configuration can be stored in
 a recording device such as a hard disk or solid state drive
 5 (SSD) or a recording medium such as an IC card, SD card, or
 DVD.

REFERENCE SIGNS LIST

[0056]

- | | | |
|----|-----|--|
| 10 | 101 | Marking robot |
| | 102 | Tracking type surveying instrument |
| | 103 | Control terminal (tablet PC) |
| | 104 | Reference line |
| | 105 | Marking position |
| 15 | 301 | Screen of control terminal |
| | 302 | Construction design drawing displayed on terminal |
| | 303 | Installation position of surveying instrument calculated
by measurement performed by surveying instrument |
| | 304 | Reference line on construction design drawing |
| 20 | 305 | Reference line calculated from installation position of
surveying instrument and measurement result |
| | 401 | Reference line calculated from installation position of
surveying instrument and measurement result |
| | 502 | Reference line on construction design drawing |
| 25 | 503 | Reference line of which deviation from construction |

design drawing can be recognized

504 Reference line of which alignment with construction
design drawing can be recognized

601 Reference line calculated from installation position of
5 surveying instrument and measurement result

602 Reference line on construction design drawing

603 Comparison state after position of surveying instrument
position is corrected

CLAIMS

1. A work vehicle control terminal comprising:

a drawing data retention unit that retains drawing data created in advance and containing work coordinates at which a work vehicle that autonomously moves performs work and position information of a drawing reference line that is a line serving as a reference for the work coordinates;

a site reference line information retention unit that retains measured position information of a site reference line drawn at a work site and corresponding to the drawing reference line;

a position information transmission unit that transmits position information corresponding to the work coordinates to the work vehicle, based on the position information of the drawing reference line and the measured position information of the site reference line;

a display unit that displays information; and

a reference line overlay display output unit that outputs data to overlay and display the drawing reference line and the site reference line on the display unit, based on the position information of the drawing reference line and the measured position information of the site reference line.

2. The work vehicle control terminal according to claim 1,

further comprising:

a movement command input unit that receives a command to move at least one of the drawing reference line and the work site reference line that are overlaid and displayed, on the display unit,

5 wherein the display unit displays a position of the at least one of the drawing reference line and the work site reference line after being moved, based on the received movement command.

10 3. The work vehicle control terminal according to claim 2,
 wherein the position information transmission unit corrects the position information corresponding to the work coordinates transmitted to the work vehicle, based on a difference in the position of the at least one of the drawing
15 reference line and the work site reference line after the movement.

4. The work vehicle control terminal according to any one of claims 1 to 3,

20 wherein the drawing data retention unit includes position information of a plurality of the drawing reference lines,

 the site reference line information retention unit includes measured position information of a plurality of the site reference lines corresponding to the position information
25 of the plurality of drawing reference lines, and

the position information transmission unit receives a selection of the site reference line used for calculating the position information corresponding to the work coordinates, and transmits the position information corresponding to the work coordinates to the work vehicle, based on the measured position information of the site reference line of which the selection is received and on the position information of the drawing reference line corresponding to the site reference line of which the selection is received.

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5. The work vehicle control terminal according to any one of claims 1 to 4,

wherein according to a magnitude of a deviation between the drawing reference line and the site reference line corresponding to the drawing reference line, the display unit displays the drawing reference line and the site reference line at positions corresponding to the deviation in a highlighting manner.

20 6. A work vehicle control method comprising:

a drawing data retention step of causing a drawing data retention unit to retain drawing data created in advance and containing work coordinates at which a work vehicle that autonomously moves performs work and position information of a drawing reference line that is a line serving as a reference

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for the work coordinates;

a site reference line information retention step of causing a site reference line information retention unit to retain measured position information of a site reference line drawn at a work site and corresponding to the drawing reference line;

a position information transmission step of causing a position information transmission unit to transmit position information corresponding to the work coordinates to the work vehicle, based on the position information of the drawing reference line and the measured position information of the site reference line;

a reference line overlay display output step of causing a reference line overlay display output unit to output data to overlay and display the drawing reference line and the site reference line on a display unit, based on the position information of the drawing reference line and the measured position information of the site reference line; and

an overlay display step of causing the display unit to overlay and display the drawing reference line and the site reference line based on an input from the reference line overlay display output unit.