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(54) **WORK CONTROL METHOD OF CONSTRUCTION MACHINE, WORK CONTROL SYSTEM, AND WORK CONTROL APPARATUS**

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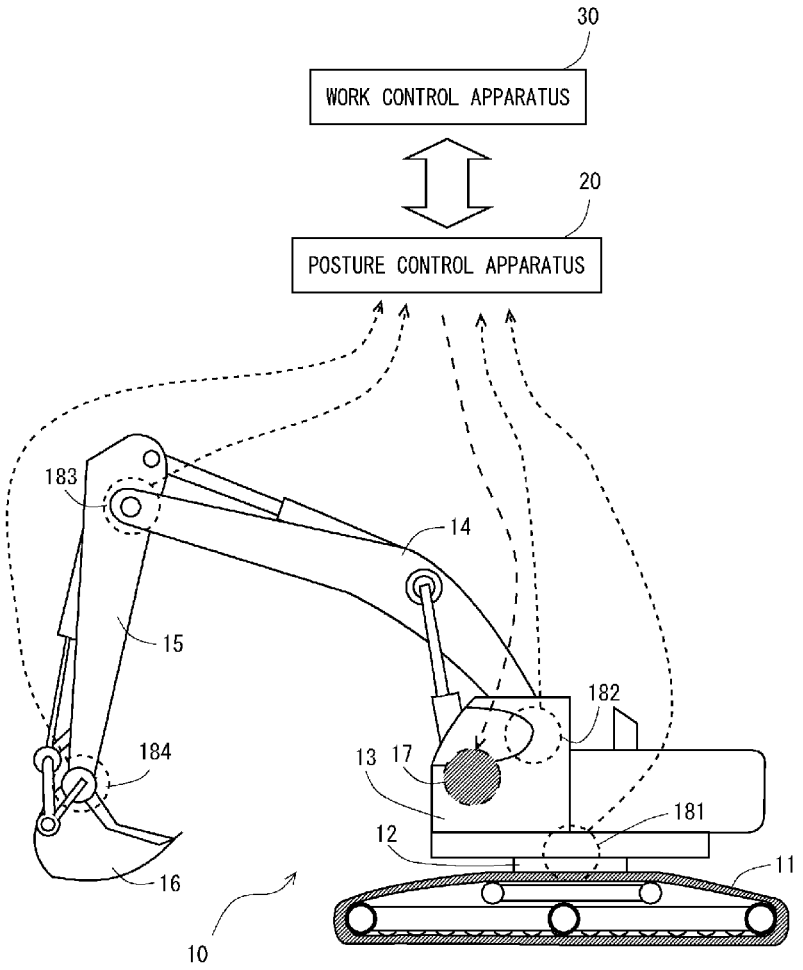
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(57) **ABSTRACT**

A work control method according to the present invention includes: an initial motion input model generation step; and a feedback control step, in which the initial motion input model generation step includes: a first initial motion input value measurement step of measuring a first initial motion measurement value at which the movable part is caused to start to move in a first state of the movable part; a second initial motion input value measurement step of measuring a second initial motion measurement value at which the movable part is caused to start to move in a second state of the movable part; and a model generation step of generating an initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and derives the initial motion input value with respect to a desired posture of the construction machine.



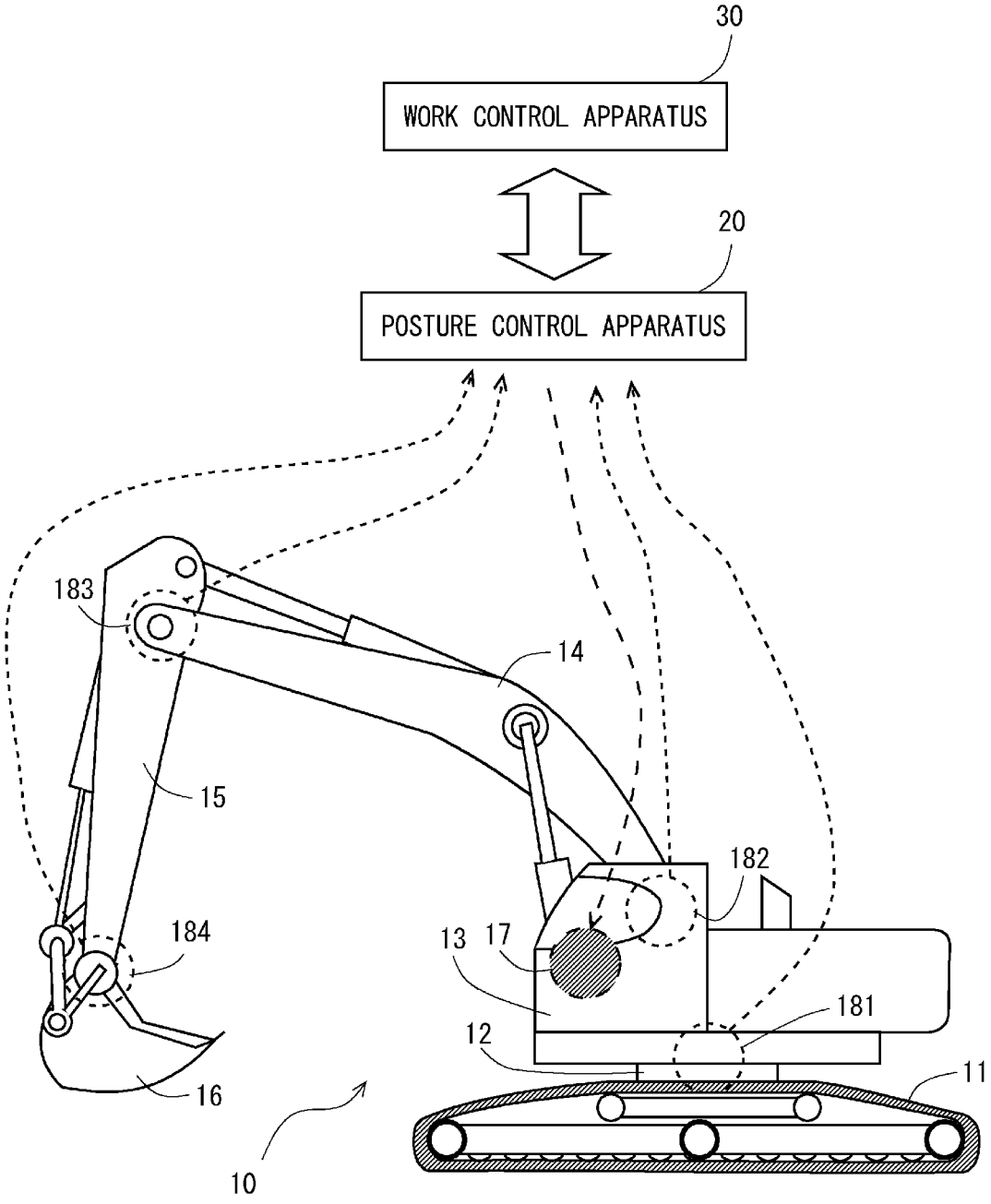

30
WORK CONTROL APPARATUS
20
POSTURE CONTROL APPARATUS
183
14
15
182
184
13
17
181
12
11
16
10

Fig. 1

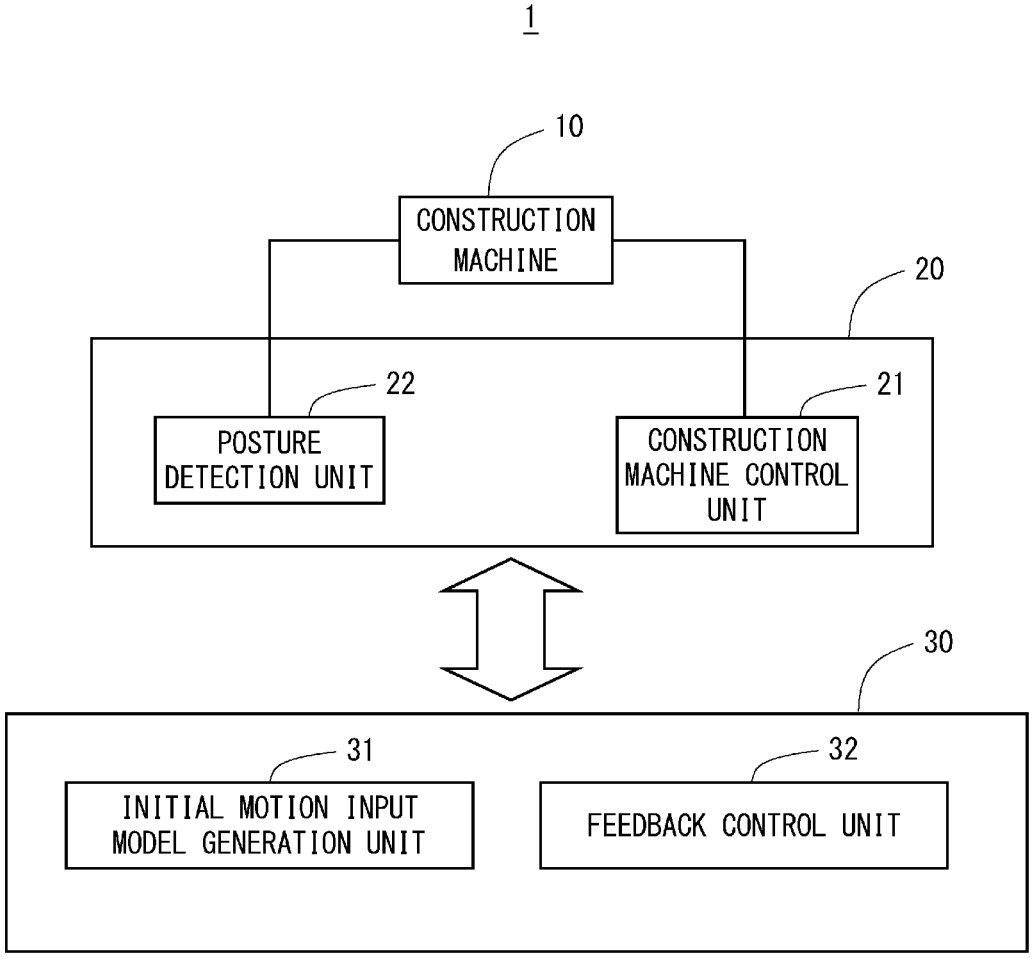

1
10
CONSTRUCTION MACHINE
20
22
POSTURE DETECTION UNIT
21
CONSTRUCTION MACHINE CONTROL UNIT
30
31
INITIAL MOTION INPUT MODEL GENERATION UNIT
32
FEEDBACK CONTROL UNIT

Fig. 2

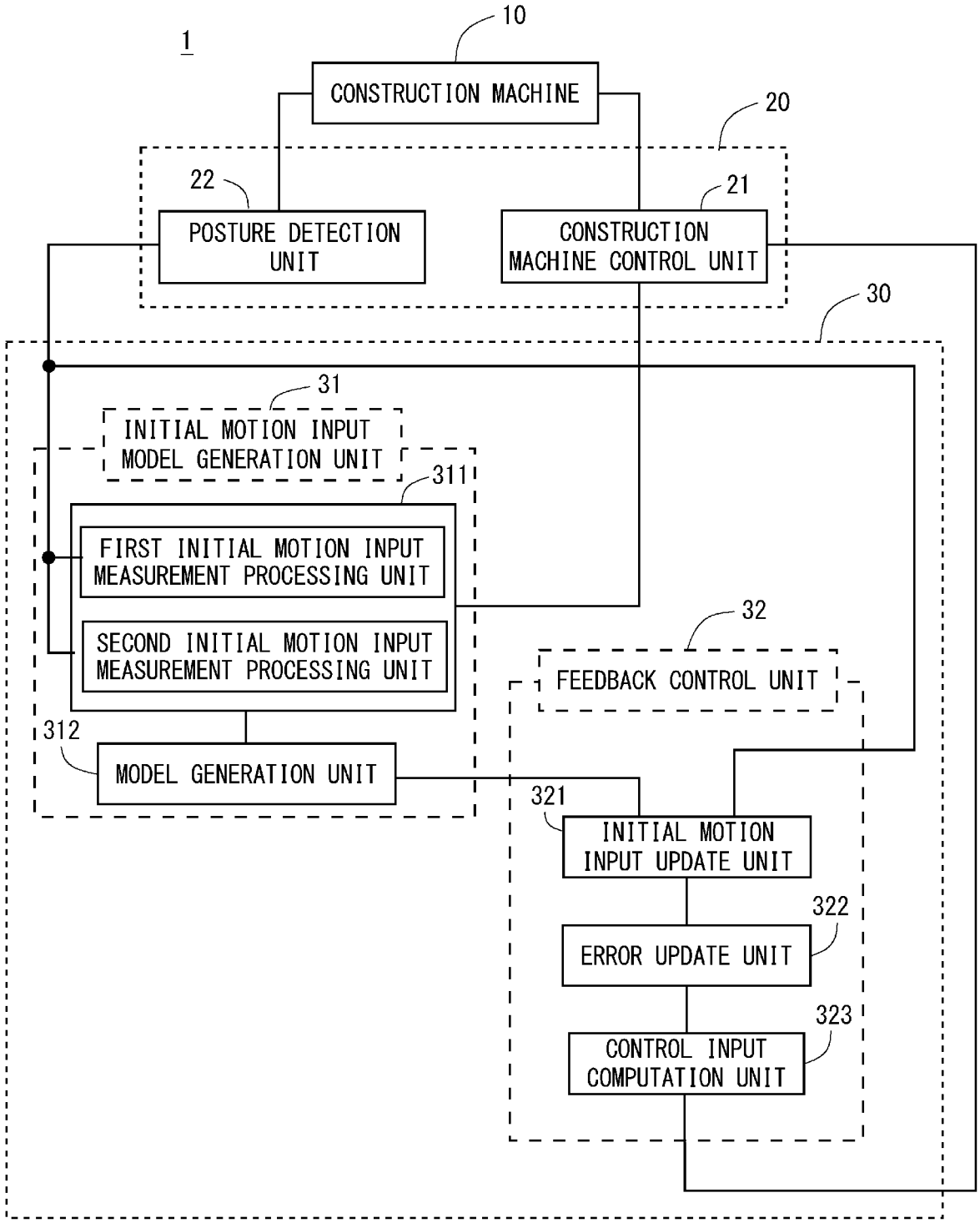

1
10
CONSTRUCTION MACHINE
20
22
POSTURE DETECTION UNIT
21
CONSTRUCTION MACHINE CONTROL UNIT
30
31
INITIAL MOTION INPUT MODEL GENERATION UNIT
311
FIRST INITIAL MOTION INPUT MEASUREMENT PROCESSING UNIT
SECOND INITIAL MOTION INPUT MEASUREMENT PROCESSING UNIT
312
MODEL GENERATION UNIT
32
FEEDBACK CONTROL UNIT
321
INITIAL MOTION INPUT UPDATE UNIT
322
ERROR UPDATE UNIT
323
CONTROL INPUT COMPUTATION UNIT

Fig. 3

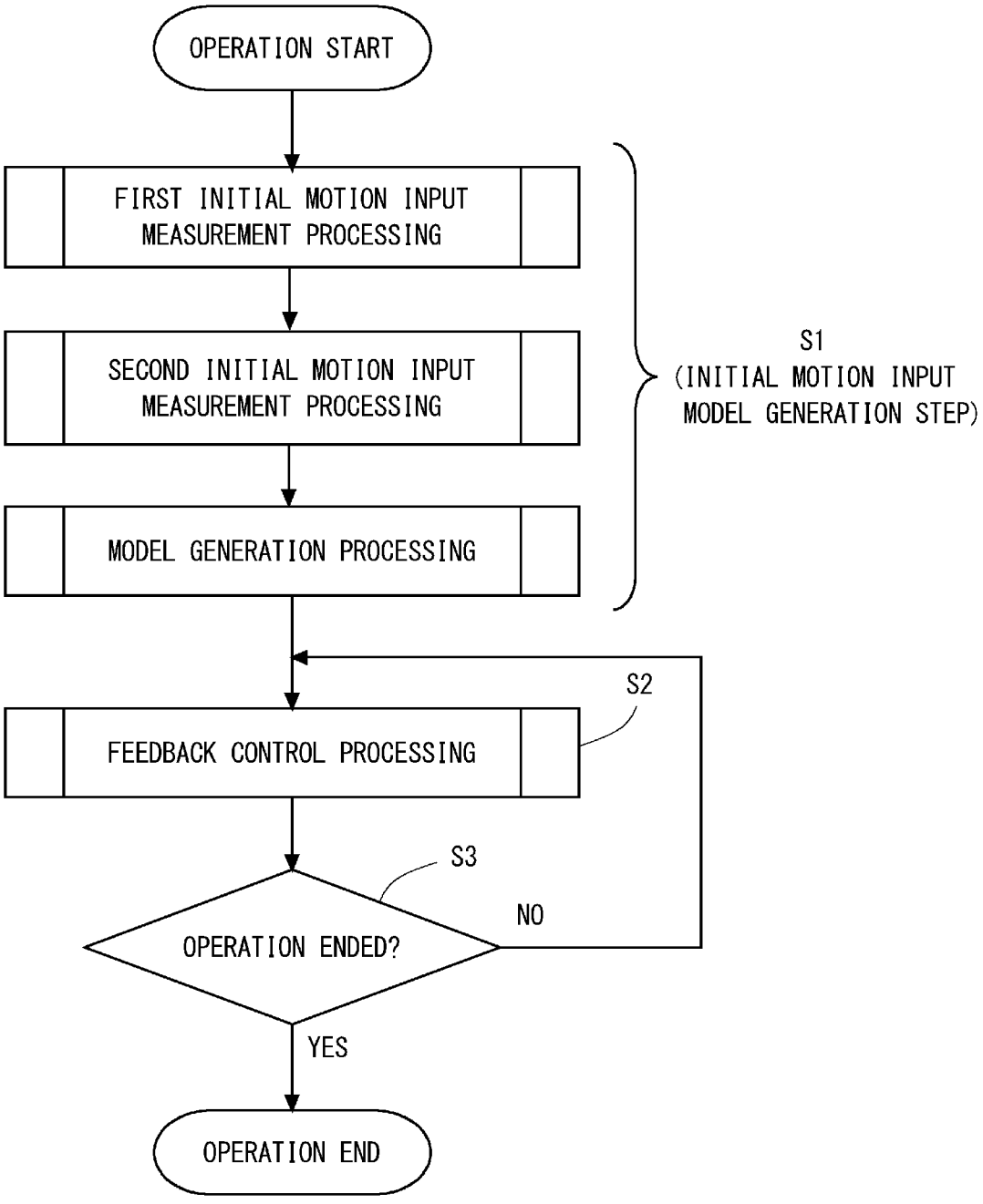

OPERATION START
FIRST INITIAL MOTION INPUT MEASUREMENT PROCESSING
SECOND INITIAL MOTION INPUT MEASUREMENT PROCESSING
MODEL GENERATION PROCESSING
S1
(INITIAL MOTION INPUT MODEL GENERATION STEP)
S2
FEEDBACK CONTROL PROCESSING
S3
OPERATION ENDED?
NO
YES
OPERATION END

Fig. 4

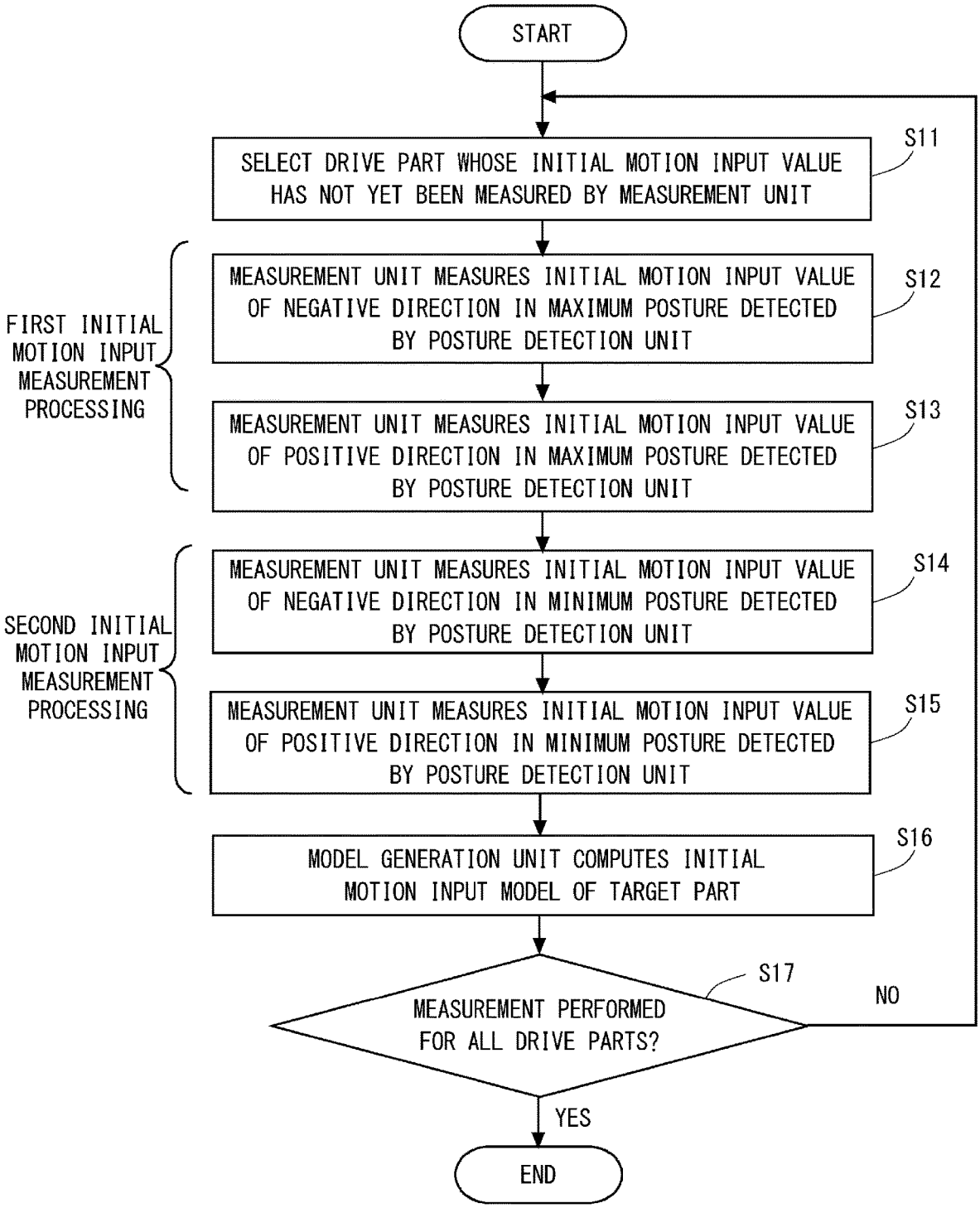

START
SELECT DRIVE PART WHOSE INITIAL MOTION INPUT VALUE HAS NOT YET BEEN MEASURED BY MEASUREMENT UNIT
S11
FIRST INITIAL MOTION INPUT MEASUREMENT PROCESSING
MEASUREMENT UNIT MEASURES INITIAL MOTION INPUT VALUE OF NEGATIVE DIRECTION IN MAXIMUM POSTURE DETECTED BY POSTURE DETECTION UNIT
S12
MEASUREMENT UNIT MEASURES INITIAL MOTION INPUT VALUE OF POSITIVE DIRECTION IN MAXIMUM POSTURE DETECTED BY POSTURE DETECTION UNIT
S13
SECOND INITIAL MOTION INPUT MEASUREMENT PROCESSING
MEASUREMENT UNIT MEASURES INITIAL MOTION INPUT VALUE OF NEGATIVE DIRECTION IN MINIMUM POSTURE DETECTED BY POSTURE DETECTION UNIT
S14
MEASUREMENT UNIT MEASURES INITIAL MOTION INPUT VALUE OF POSITIVE DIRECTION IN MINIMUM POSTURE DETECTED BY POSTURE DETECTION UNIT
S15
MODEL GENERATION UNIT COMPUTES INITIAL MOTION INPUT MODEL OF TARGET PART
S16
MEASUREMENT PERFORMED FOR ALL DRIVE PARTS?
S17
NO
YES
END

Fig. 5

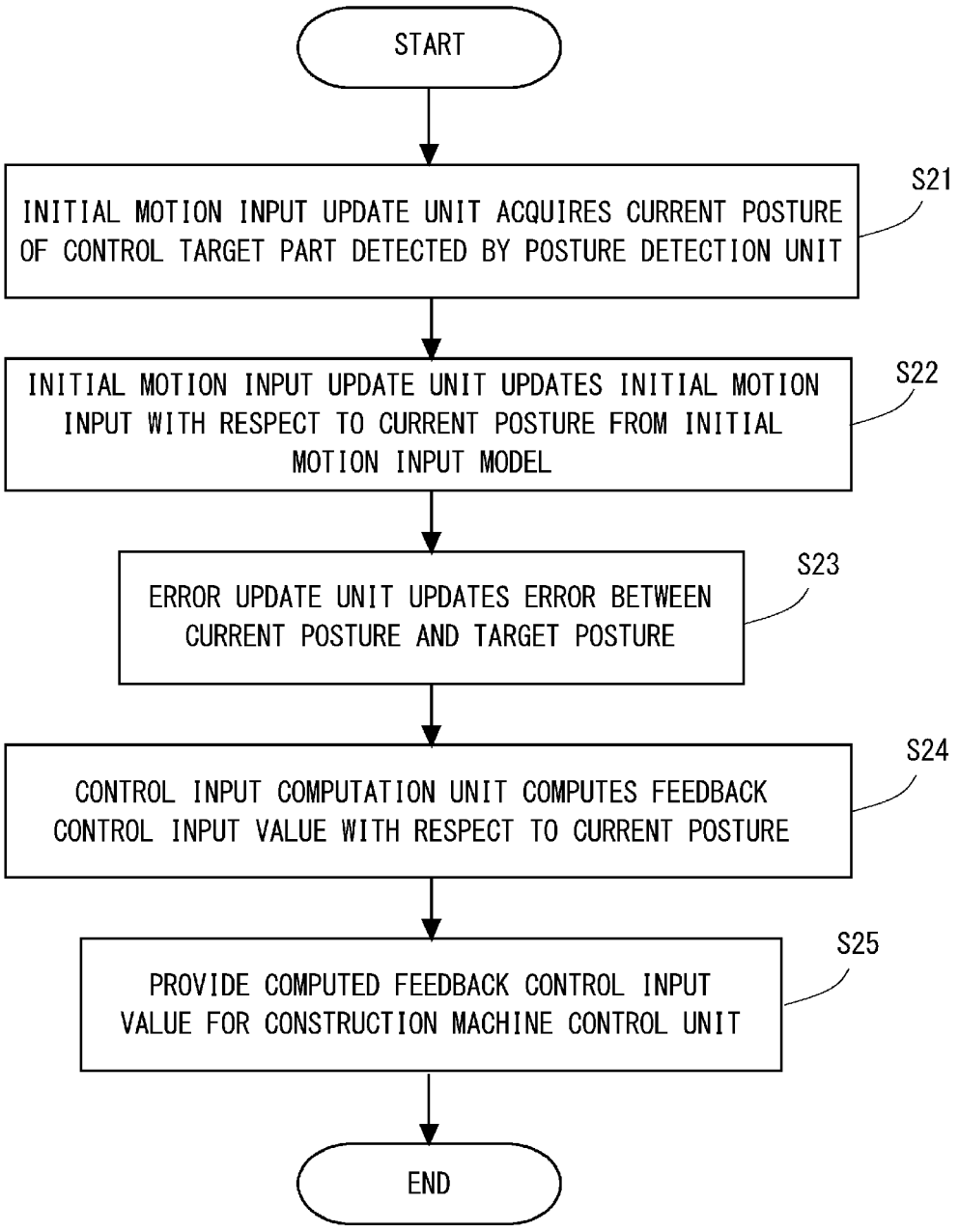

START
INITIAL MOTION INPUT UPDATE UNIT ACQUIRES CURRENT POSTURE OF CONTROL TARGET PART DETECTED BY POSTURE DETECTION UNIT
S21
INITIAL MOTION INPUT UPDATE UNIT UPDATES INITIAL MOTION INPUT WITH RESPECT TO CURRENT POSTURE FROM INITIAL MOTION INPUT MODEL
S22
ERROR UPDATE UNIT UPDATES ERROR BETWEEN CURRENT POSTURE AND TARGET POSTURE
S23
CONTROL INPUT COMPUTATION UNIT COMPUTES FEEDBACK CONTROL INPUT VALUE WITH RESPECT TO CURRENT POSTURE
S24
PROVIDE COMPUTED FEEDBACK CONTROL INPUT VALUE FOR CONSTRUCTION MACHINE CONTROL UNIT
S25
END

Fig. 6

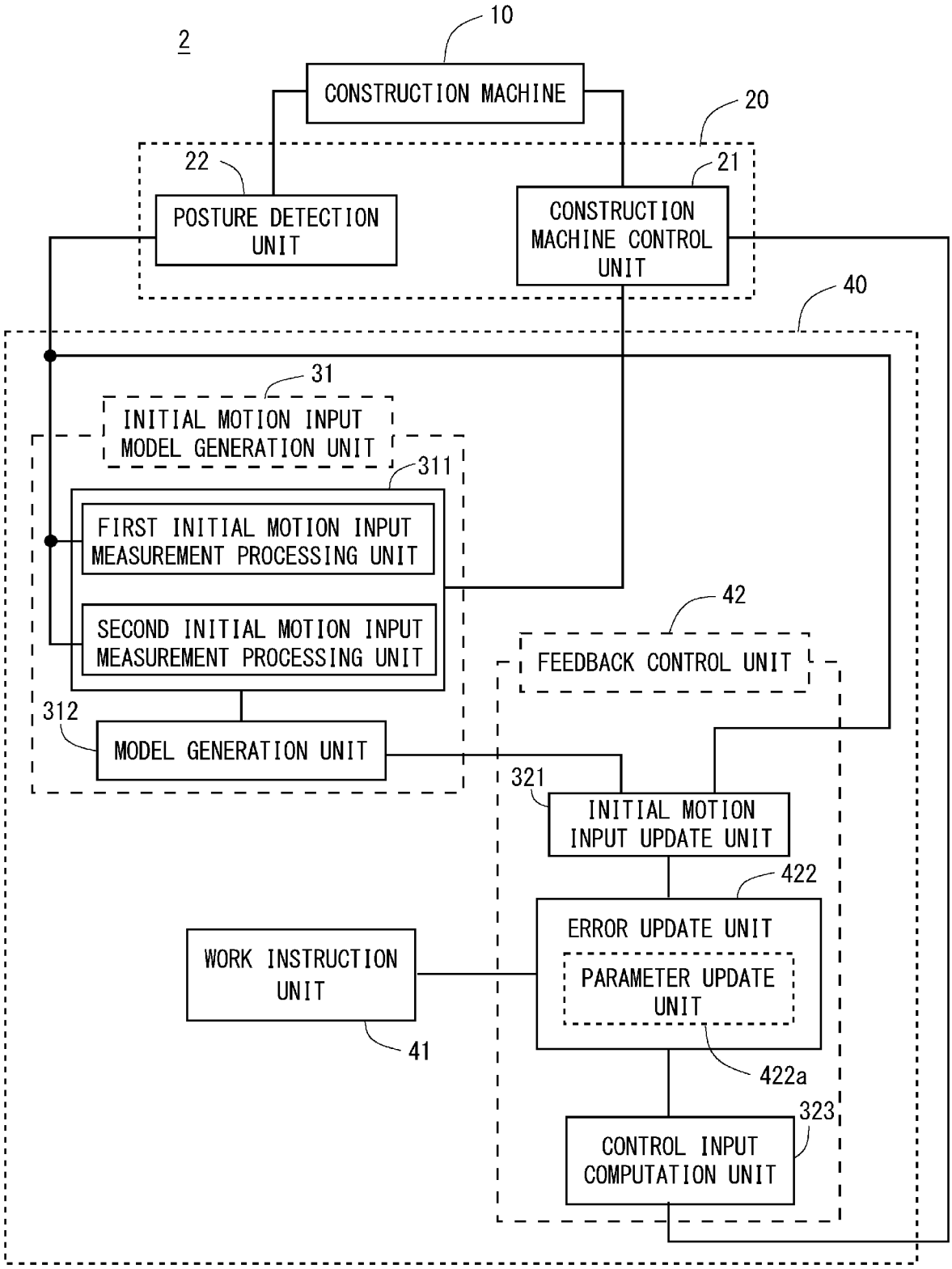

2
10
CONSTRUCTION MACHINE
20
22
21
POSTURE DETECTION UNIT
CONSTRUCTION MACHINE CONTROL UNIT
40
31
INITIAL MOTION INPUT MODEL GENERATION UNIT
311
FIRST INITIAL MOTION INPUT MEASUREMENT PROCESSING UNIT
SECOND INITIAL MOTION INPUT MEASUREMENT PROCESSING UNIT
42
FEEDBACK CONTROL UNIT
312
MODEL GENERATION UNIT
321
INITIAL MOTION INPUT UPDATE UNIT
422
ERROR UPDATE UNIT
PARAMETER UPDATE UNIT
WORK INSTRUCTION UNIT
41
422a
323
CONTROL INPUT COMPUTATION UNIT

Fig. 7

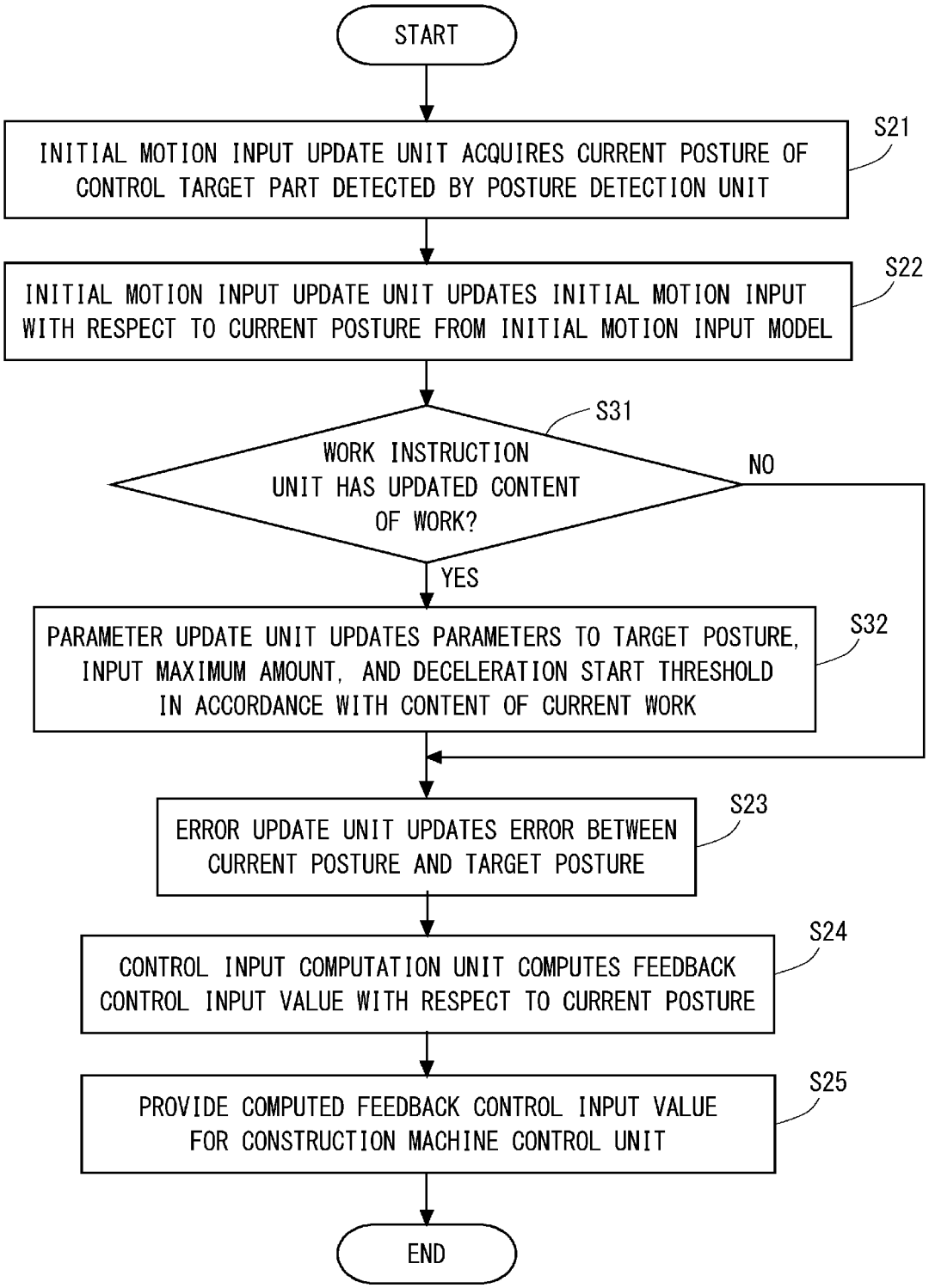

START
INITIAL MOTION INPUT UPDATE UNIT ACQUIRES CURRENT POSTURE OF CONTROL TARGET PART DETECTED BY POSTURE DETECTION UNIT
S21
INITIAL MOTION INPUT UPDATE UNIT UPDATES INITIAL MOTION INPUT WITH RESPECT TO CURRENT POSTURE FROM INITIAL MOTION INPUT MODEL
S22
S31
WORK INSTRUCTION UNIT HAS UPDATED CONTENT OF WORK?
NO
YES
PARAMETER UPDATE UNIT UPDATES PARAMETERS TO TARGET POSTURE, INPUT MAXIMUM AMOUNT, AND DECELERATION START THRESHOLD IN ACCORDANCE WITH CONTENT OF CURRENT WORK
S32
ERROR UPDATE UNIT UPDATES ERROR BETWEEN CURRENT POSTURE AND TARGET POSTURE
S23
CONTROL INPUT COMPUTATION UNIT COMPUTES FEEDBACK CONTROL INPUT VALUE WITH RESPECT TO CURRENT POSTURE
S24
PROVIDE COMPUTED FEEDBACK CONTROL INPUT VALUE FOR CONSTRUCTION MACHINE CONTROL UNIT
S25
END

Fig. 8

WORK CONTROL METHOD OF CONSTRUCTION MACHINE, WORK CONTROL SYSTEM, AND WORK CONTROL APPARATUS

TECHNICAL FIELD

[0001] The present invention relates to a work control method of a construction machine, a work control system, and a work control apparatus, and in particular, to a work control method of a construction machine including a manipulation lever that controls the posture of the construction machine, a work control system, and a work control apparatus.

BACKGROUND ART

[0002] In recent years, many unmanned controls for construction machines have been proposed. For example, Patent Literature 1 and 2 disclose techniques regarding control of construction machines.

[0003] Patent Literature 1 discloses a technique regarding a work machine control apparatus of a construction machine. The work machine control apparatus of the construction machine disclosed in Patent Literature 1 is a construction machine including work machine cylinders that rotationally drive respective arms of a work machine, work machine manipulation levers provided for the respective arms, and a flow rate control system that controls a pressure oil supply flow rate to each of the work machine cylinders in accordance with command signals from the respective levers, the construction machine including: a reference model unit in which desired manipulation response characteristics of each of the work machines is specified, reference model setting means for setting manipulation response characteristics of the reference model, cylinder speed detection means of each of the work machines, and adaptive control means for executing, using a detection value of the cylinder speed detection means as a feedback signal, adaptive control in such a way that the manipulation response characteristics of each of the work machines correspond to the manipulation response characteristics of the reference model unit, correcting a control command value of a pressure oil supply flow rate for each of the work machines, and controlling the speed of each of the work machine cylinders by this corrected control command value.

[0004] Further, Patent Literature 2 discloses a technique regarding an electromagnetic valve control apparatus in a hydraulic circuit of an industrial vehicle. In the electromagnetic valve control apparatus in the hydraulic circuit of the industrial vehicle disclosed in Patent Literature 2, a CPU performs feedback control of a duty output value Dout for deciding a duty value (%) of a PWM signal to be input to a transistor provided between a battery and an electromagnetic valve. A duty output value Dout at a timing when a predetermined period of time (300 ms) has passed after a tilt lever is manipulated (tilt manipulation) for the first time after key-ON, and a target current value Iaim at this time are stored as learning values Drec and Irec, respectively. In the second and subsequent tilt manipulations after key-ON, the learning values Drec and Irec learned in the previous tilt manipulation are used to determine Dout=Iaim·Drec/Irec computed in accordance with the target current value Iaim at this time to be an initial value of the duty output value.

CITATION LIST

Patent Literature

[0005] [Patent Literature 1] Japanese Unexamined Patent Application Publication No. H09-328785

[0006] [Patent Literature 2] Japanese Unexamined Patent Application Publication No. H11-171498

SUMMARY OF INVENTION

Technical Problem

[0007] In construction machines, play, which is a deviation that occurs between a manipulation start point of a manipulation lever and an operation start point of a cylinder, is provided. However, in the techniques disclosed in Patent Literature 1 and 2, the amount of play of the manipulation lever is not taken into account, which causes a problem that an accuracy of unmanned control of the construction machine is not sufficiently high.

Solution to Problem

[0008] One aspect of a work control method of a construction machine according to one example embodiment includes: an initial motion input model generation step of generating an initial motion input model for computing an initial motion input value at which a movable part of a construction machine is caused to start to move; and a feedback control step of computing the initial motion input value that corresponds to the posture of the construction machine using the initial motion input model and determining a control input value equal to or larger than the initial motion input value, in which the initial motion input model generation step includes: a first initial motion input value measurement step of measuring a first initial motion measurement value at which the movable part is caused to start to move in a first state in which the movable part is controlled to a first position within a movable range of the movable part; a second initial motion input value measurement step of measuring a second initial motion measurement value at which the movable part is caused to start to move in a second state in which the movable part is controlled to a second position that is different from the first position within the movable range of the movable part; and a model generation step of generating the initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and derives the initial motion input value with respect to a desired posture of the construction machine.

[0009] One aspect of a work control system of a construction machine according to one example embodiment includes: an initial motion input model generation unit configured to generate an initial motion input model for computing an initial motion input value at which a movable part of a construction machine is caused to start to move; and a feedback control unit configured to compute the initial motion input value that corresponds to the posture of the construction machine using the initial motion input model and determine a control input value equal to or larger than the initial motion input value, in which the initial motion input model generation unit performs: first initial motion input value measurement processing for measuring a first initial motion measurement value at which the movable part is caused to start to move in a first state in which the movable

part is controlled to a first position within a movable range of the movable part; second initial motion input value measurement processing for measuring a second initial motion measurement value at which the movable part is caused to start to move in a second state in which the movable part is controlled to a second position that is different from the first position within the movable range of the movable part; and model generation processing for generating the initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and deriving the initial motion input value with respect to a desired posture of the construction machine.

[0010] One aspect of a work control apparatus of a construction machine according to one example embodiment includes: an initial motion input model generation unit configured to generate an initial motion input model for computing an initial motion input value at which a movable part of a construction machine is caused to start to move; and a feedback control unit configured to compute the initial motion input value that corresponds to the posture of the construction machine using the initial motion input model and determine a control input value equal to or larger than the initial motion input value, in which the initial motion input model generation unit performs: first initial motion input value measurement processing for measuring a first initial motion measurement value at which the movable part is caused to start to move in a first state in which the movable part is controlled to a first position within a movable range of the movable part; second initial motion input value measurement processing for measuring a second initial motion measurement value at which the movable part is caused to start to move in a second state in which the movable part is controlled to a second position that is different from the first position within the movable range of the movable part; and model generation processing for generating the initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and deriving the initial motion input value with respect to a desired posture of the construction machine.

Advantageous Effects of Invention

[0011] With a work control method of a construction machine, a work method system, and a work control apparatus according to example embodiments, it is possible to control the posture of a construction machine with a high accuracy even when an amount of play in a manipulation lever is changed.

BRIEF DESCRIPTION OF DRAWINGS

[0012] FIG. **1** is a schematic view of a work control system according to a first example embodiment;

[0013] FIG. **2** is a schematic block diagram of the work control system according to the first example embodiment;

[0014] FIG. **3** is a detailed block diagram of the work control system according to the first example embodiment;

[0015] FIG. **4** is a flowchart for describing an operation of the work control system according to the first example embodiment;

[0016] FIG. **5** is a flowchart for describing an operation of an initial motion input model generation unit according to the first example embodiment;

[0017] FIG. **6** is a flowchart for describing an operation of a feedback control unit according to the first example embodiment;

[0018] FIG. **7** is a block diagram of a work control system according to a second example embodiment; and

[0019] FIG. **8** is a flowchart for describing an operation of a feedback control unit according to the second example embodiment.

EXAMPLE EMBODIMENT

First Example Embodiment

[0020] Hereinafter, with reference to the drawings, example embodiments of the present invention will be described. A work control method, a work control system, and a work control apparatus of a construction machine described below control a construction machine that drives joints of a machine using a cylinder. The following description will be made taking a backhoe as an example of the construction machine. Further, while a work control system in which process blocks that perform work control processing are arranged in a plurality of places in a distributed manner via a network will be described in the following description, a work control apparatus in which the process blocks included in the work control system are formed of one apparatus may be employed. Further, the content of the control performed in the work control system will be referred to as a work control method. Specific examples thereof will be described later in detail.

[0021] FIG. **1** shows a schematic view of a work control system **1** according to a first example embodiment. A construction machine **10** shown in FIG. **1** is a backhoe. The construction machine **10** includes a crawler **11**, a turning base **12**, a cockpit **13**, a boom **14**, an arm **15**, and a bucket **16**. The crawler **11** is a caterpillar for moving the construction machine **10**. The turning base **12** turns a chassis on which the cockpit **13**, the boom **14** and the like are mounted. The cockpit **13** is a manipulation room in which a manipulation lever and the like for manipulating the posture of the construction machine **10** are disposed. Further, while the drawings are in a simplified form, in the work control system **1**, an actuator **17** for manipulating the manipulation lever is disposed in the cockpit **13**. Further, each of the boom **14**, the arm **15**, and the bucket **16** corresponds to a movable part and is operated by a hydraulic cylinder. This hydraulic cylinder is elongated or contracted by manipulating the manipulation lever installed in the cockpit **13**. While the part that corresponds to the movable part includes, for example, besides the hydraulic cylinder, a part that is driven by a motor, a hydraulic cylinder will be described as an example of the movable part in the following description.

[0022] Further, in the work control system **1** according to the first example embodiment, posture sensors **181**-**184** for detecting posture angles are attached to the movable parts of the construction machine **10**. In the example shown in FIG. **1**, the posture sensor **181** detects the rotation angle of the turning base **12**, the posture sensor **182** detects the current angle of the boom **14**, the posture sensor **183** detects the relative angle of the boom **14** and the arm **15**, and the posture sensor **184** detects the relative angle of the arm **15** and the bucket **16**.

[0023] In the work control system **1** according to the first example embodiment, a posture control apparatus **20** and a work control apparatus **30** that correspond to the construc-

tion machine **10** are provided. The posture control apparatus **20** provides instructions for operating the actuator **17**. The posture control apparatus **20** further generates a posture detection value based on information on the angles acquired from the posture sensors **181-184**. The work control apparatus **30** generates a control input value for deciding the posture of the construction machine **10** based on the information obtained from the posture control apparatus **20**.

[0024] In the work control system **1** according to the first example embodiment, an input value at which the movable parts such as the boom **14** of the construction machine **10** are caused to start to operate in accordance with an amount of displacement of the manipulation lever of the construction machine **10** provided via the actuator **17** will be referred to as an initial motion input value. Then the construction machine **10** is controlled using the initial motion input value as the basis for control. Further, this initial motion input value varies depending on an amount of elongation or contraction of the cylinder in terms of the characteristics of the cylinder. The work control system **1** according to the first example embodiment generates an initial motion input model from different elongated/contracted states of the cylinder and updates, using the initial motion input model, the initial motion input value for each posture when the control of the construction machine **10** is started. Then, the work control system **1** according to the first example embodiment computes a feedback control input value to the construction machine control unit so as to compensate the updated initial motion input value as the minimum value of the input value to be provided for the construction machine **10**. In the following description, the work control system **1** according to the first example embodiment will be described below in detail.

[0025] First, a configuration of a process block of the work control system **1** according to the first example embodiment will be described. FIG. **2** shows a schematic block diagram of the work control system according to the first example embodiment. Note that the construction machine **10** is shown in FIG. **2** as a target to be controlled by the work control system **1**. In the example shown in FIG. **2**, the posture control apparatus **20** is provided with a construction machine control unit **21** and a posture detection unit **22**. The work control apparatus **30** is provided with an initial motion input model generation unit **31** and a feedback control unit **32**. Then the construction machine **10** is manipulated using the posture control apparatus **20** and the work control apparatus **30**.

[0026] The example shown in FIG. **2** is merely one example. For example, the posture control apparatus **20** and the work control apparatus **30** may be integrated as one apparatus and the construction machine **10** and the posture control apparatus **20** may be connected to each other by communication. Further, the posture control apparatus **20** may be provided in such a way that the posture control apparatus **20** and the construction machine **10** are integrated with each other to obtain a form in which the posture control apparatus **20** and the work control apparatus **30** are connected to each other by communication. For example, the work control apparatus **30** may be disposed in a cloud storage and the work control apparatus **30** may be connected to the posture control apparatus **20** via communication. Further, the construction machine **10** is a target to be controlled by the work control apparatus **30** and the posture control apparatus **20** may be an interface for allowing the work control apparatus **30** to actually operate the construction machine **10**. In this case, it can be considered that the work control apparatus **30** is a main part of the work control system **1**.

[0027] The work control apparatus **30** includes the initial motion input model generation unit **31** and the feedback control unit **32**. The initial motion input model generation unit **31** generates an initial motion input model for computing an initial motion input value at which the movable parts of the construction machine **10** (e.g., the turning base **12**, the boom **14**, the arm **15**, and the bucket **16**) start to operate. The feedback control unit **32** computes the initial motion input value that corresponds to the posture of the construction machine **10** using the initial motion input model and determines a control input value which is equal to or larger than the initial motion input value. Here, the initial motion input model generation unit **31** performs first initial motion input measurement processing, second initial motion input measurement processing, and model generation processing. In the first initial motion input measurement processing, a first initial motion measurement value at which the movable parts are caused to start to move is measured in a first state in which the movable parts are controlled to a first position in the movable range of the movable parts. In the second initial motion input measurement processing, a second initial motion measurement value at which the movable parts are caused to start to move is measured in a second state in which the movable parts are controlled to a second position, which is different from the first position in the movable range of the movable parts. In the model generation processing, an initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and derives the initial motion input value with respect to a desired posture of the construction machine **10** is generated.

[0028] Next, a more detailed configuration of the work control system **1** according to the first example embodiment will be described. FIG. **3** shows a block diagram of the work control system **1** according to the first example embodiment. Note that, in FIG. **3**, the construction machine **10** controlled by the work control system **1** is also shown for the explanation. As shown in FIG. **3**, the work control system **1** according to the first example embodiment includes the posture control apparatus **20** and the work control apparatus **30**. Then, the posture control apparatus **20** is provided with the construction machine control unit **21** and the posture detection unit **22**. Further, the work control apparatus **30** is provided with the initial motion input model generation unit **31** and the feedback control unit **32**.

[0029] The construction machine control unit **21** operates the actuator based on a feedback control input value computed by the feedback control unit **32**, thereby displacing the manipulation lever in the construction machine **10**. Further, when the initial motion input model generation unit **31** generates an initial motion input model, the construction machine control unit **21** is provided with the control input value from the initial motion input model generation unit **31** and displaces the manipulation lever of the construction machine **10** based on the control input value.

[0030] The posture detection unit **22** acquires the joint angles of the respective movable parts from the sensors **181-184** provided in the movable parts such as the arm of the construction machine **10** and outputs the acquired joint angles as posture detection values indicating the posture of

the construction machine **10**. The initial motion input model generation unit **31** generates an initial motion input model for computing the initial motion input value at which movable parts of the construction machine **10** are caused to start to move. Further, the feedback control unit **32** computes an initial motion input value that corresponds to the current posture using the initial motion input model and computes a feedback control input value that compensates the initial motion input value as the minimum value.

[0031] Here, the initial motion input model generation unit **31** and the feedback control unit **32** will be described in detail. The initial motion input model generation unit **31** includes an initial motion input measurement unit **311** and a model generation unit **312**. The initial motion input measurement unit **311** outputs, when the initial motion input model is generated, an input value to be provided to the construction machine control unit **21** in order to displace the movable parts of the construction machine **10** and detects the state of the movable parts when they start to move based on the posture detection value output from the posture detection unit **22**, thereby measuring the initial motion input value for each posture. More specifically, the initial motion input measurement unit **311** executes a first initial motion input value measurement step and a second initial motion input value measurement step.

[0032] In the first initial motion input measurement step, the first initial motion measurement value at which the movable parts are caused to start to move is measured in the first state in which the movable parts are controlled to the first position in the movable range of the movable parts. In the second initial motion input measurement step, the second initial motion measurement value at which the movable parts are caused to start to move is measured in the second state in which the movable parts are controlled to the second position, which is different from the first position in the movable range of the movable parts. Examples of more specific operations of the first initial motion input measurement step and the second initial motion input measurement step will be those as described below.

[0033] In the first initial motion input value measurement step, the input value that changes in a stepwise manner is applied to the construction machine control unit **21** in the first state in which the cylinder that drives the movable parts is elongated, and the input value at the timing when the movable parts start to move is measured as the first initial motion measurement value. Further, in the first example embodiment, in the first initial motion input value measurement step, the input value is provided for the cylinder which is in the first state in such a way that the cylinder moves in each of a positive direction in which the cylinder is elongated and a negative direction in which the cylinder is contracted and the first initial motion measurement value is measured for each of the positive direction and the negative direction.

[0034] In the second initial motion input value measurement step, an input value that changes in a stepwise manner is applied to the construction machine control unit **21** in the second state in which the cylinder that drives the movable parts is contracted, and the input value at the timing when the movable parts start to move is measured as the second initial motion measurement value. Further, in the first example embodiment, in the second initial motion input value measurement step, the input value is provided for the cylinder which is in the second state in such a way that the cylinder moves in each of the positive direction in which the cylinder is elongated and the negative direction in which the cylinder is contracted and the second initial motion measurement value is measured for each of the positive direction and the negative direction.

[0035] The model generation unit **312** executes a model generation step of generating the initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and derives the initial motion input value with respect to a desired posture of the construction machine **10**.

[0036] The feedback control unit **32** includes an initial motion input update unit **321**, an error update unit **322**, and a control input computation unit **323**. The initial motion input update unit **321** executes an initial motion input update step of acquiring the posture of the construction machine **10** based on the positional information (e.g., posture detection value) of the movable parts of the construction machine **10** and updating the initial motion input value that corresponds to the posture by the value computed using the initial motion input model. The error update unit **322** executes the error update step of updating the error between the current posture and the target posture of the construction machine **10**. The control input computation unit **323** executes a control input computation step of receiving the error and the initial motion input value, computing a feedback control input value that reduces the error, and provides the computed feedback control input value for the construction machine **10**.

[0037] Next, an operation of the work control system **1** according to the first example embodiment will be described. FIG. **4** shows a flowchart for describing an operation of the work control system according to the first example embodiment. As shown in FIG. **4**, the work control system **1** according to the first example embodiment performs initial motion input model generation processing before it starts the operation (Step S**1**). In this Step S**1**, processing of generating the initial motion input model using the construction machine control unit **21**, the posture detection unit **22**, and the initial motion input model generation unit **31** is performed. Further, in the initial motion input model generation processing in Step S**1**, first initial motion input measurement processing, second initial motion input measurement processing, and model generation processing are performed. Then, in the work control system **1** according to the first example embodiment, the feedback control processing for executing the operation of the construction machine **10** using the initial motion input model generated in Step S**1** continues until the operation ends (Steps S**2** and S**3**). That is, the work control system **1** according to the first example embodiment generates the initial motion input model in a period other than the operation period in which the construction machine **10** performs the work. In this way, by generating the initial motion input model in the period other than the period during which the construction machine **10** works, it is possible to prevent the initial motion input model from changing during the operation of the construction machine **10** and to stably operate the construction machine **10**.

[0038] Now, the initial motion input model generation processing in Step S**1** and the feedback control processing in Step S**2** will be described in detail. FIG. **5** shows a flowchart for describing an operation of the initial motion input model generation unit according to the first example embodiment.

[0039] The initial motion input model generation unit **31** first selects a drive part whose initial motion input value has not yet been measured by the initial motion input measurement unit **311** (Step S**11**). Next, the initial motion input measurement unit **311** performs processing of Steps S**12** and S**13** as the first initial motion input measurement step. The initial motion input measurement unit **311** measures, for the selected drive part, the initial motion input value of the negative direction of the first initial motion input value measurement step (Step S**12**). More specifically, in Step S**12**, the initial motion input measurement unit **311** measures the initial motion input value of the negative direction in the maximum posture (e.g., the first state) detected by the posture detection unit. Here, the initial motion input value measured in Step S**12** is expressed by Expression (1). In the following description, θ_{upper} is a posture angle that the construction machine control unit **21** has detected from the drive part when it is in the first state.

[Expression 1] Initial motion input value when movable part is changed

$$\text{negative direction in maximum posture}=U_{min}^{-}(\theta_{upper}) \quad (1)$$

[0040] Initial motion input value when movable part is changed in negative direction in maximum posture

[0041] Next, the initial motion input measurement unit **311** measures, for the selected drive part, the initial motion input value of the positive direction of the first initial motion input value measurement step (Step S**13**). More specifically, in Step S**13**, the initial motion input measurement unit **311** measures the initial motion input value of the positive direction in the maximum posture (e.g., the first state) detected by the posture detection unit. The initial motion input value measured in Step S**13** is expressed by Expression (2).

[Expression 2] initial motion input value when movable part is changed

$$\text{in positive direction in maximum posture}=U_{min}^{+}(\theta_{upper}) \quad (2)$$

[0042] Initial motion input value when movable part is changed in positive direction in maximum posture

[0043] Next, the initial motion input measurement unit **311** performs processing of Steps S**14** and S**15** as the second initial motion input measurement step. The initial motion input measurement unit **311** measures, for the selected drive part, the initial motion input value of the negative direction of the second initial motion input value measurement step (Step S**14**). More specifically, in Step S**14**, the initial motion input measurement unit **311** measures the initial motion input value of the negative direction in the minimum posture (e.g., the second state) detected by the posture detection unit. The initial motion input value measured in Step S**14** is expressed by Expression (3). In the following description, θ_{lower} is a posture angle that the construction machine control unit **21** has detected from the drive part when it is in the second state.

[Expression 3] initial motion input value when movable part is changed

$$\text{in negative direction in minimum posture}=U_{min}^{-}(\theta_{upper}) \quad (3)$$

[0044] Initial motion input value when movable part is changed in negative direction in minimum posture

[0045] Next, the initial motion input measurement unit **311** measures, for the selected drive part, the initial motion input value of the positive direction of the second initial motion input value measurement step (Step S**15**). More specifically, in Step S**15**, the initial motion input measurement unit **311** measures the initial motion input value of the positive direction in the minimum posture (e.g., the second state) detected by the posture detection unit. The initial motion input value measured in Step S**15** is expressed by Expression (4).

[Expression 4] Initial motion input value when movable part is changed

$$\text{in positive direction in minimum posture}=U_{min}^{+}(\theta_{upper}) \quad (4)$$

[0046] Initial motion input value when movable part is changed in positive direction in minimum posture

[0047] Next, the initial motion input model generation unit **31** computes the initial motion input model by the model generation unit **312** using the four initial motion input values acquired by the initial motion input measurement unit **311** (Step S**16**). There are, for example, two initial motion input models generated in Step S**16**, that is, that of the positive direction in which the cylinder is elongated and that of the negative direction in which the cylinder is contracted. The initial motion input models generated in the initial motion input model generation unit **31** according to the first example embodiment are expressed by Expressions (5) and (7). Note that Expression (5) shows an initial motion input model Umin_p(θ) when the cylinder is displaced in the positive direction and Expression (7) shows an initial motion input model Umin_m(θ) when the cylinder is displaced in the negative direction. The symbol θ denotes the posture angle of the drive part detected by the posture detection unit **22**.

[Expression 5]

$$U_{min_p}(\theta)=\alpha^{+}\cdot(\theta-\theta_{lower})+U_{min}^{+}(\theta_{lower}) \quad (5)$$

[0048] Note that α^{+} in Expression (5) can be expressed by Expression (6).

[Expression 6]

$$\alpha^{+}=\frac{U_{min}^{+}(\theta_{upper})-U_{min}^{+}(\theta_{lower})}{\theta_{upper}-\theta_{lower}} \quad (6)$$

[Expression 7]

$$U_{min_m}(\theta)=\alpha^{+}\cdot(\theta-\theta_{lower})+U_{min}^{+}(\theta_{lower}) \quad (7)$$

[0049] Note that α^{-} in Expression (7) can be expressed by Expression (8).

[Expression 8]

$$\alpha^{+}=\frac{U_{min}^{+}(\theta_{upper})-U_{min}^{+}(\theta_{lower})}{\theta_{upper}-\theta_{lower}} \quad (8)$$

[0050] The initial motion input model generation unit **31** repeats processing of Steps S**11**-S**16** for all the drive parts of the construction machine **10**. Then, the initial motion input model generation unit **31** ends the initial motion input model

generation processing in accordance with generation of the initial motion input model for all the drive parts of the construction machine **10**. The model generation unit **312** of the initial motion input model generation unit **31** updates the initial motion input model held in the initial motion input update unit **321** by the generated initial motion input model.

[0051] Next, feedback control processing executed by the feedback control unit **32** will be described. FIG. **6** shows a flowchart for describing an operation of the feedback control unit **32** according to the first example embodiment.

[0052] As shown in FIG. **6**, the feedback control unit **32** first acquires the posture detection value of the control target part of the construction machine **10** from the posture detection unit **22** using the initial motion input update unit **321** and grasps the current posture θ of the construction machine **10** (Step S**21**). Next, the initial motion input update unit **321** updates the initial motion input value with respect to the current posture θ using the initial motion input model that is held (Step S**22**).

[0053] Next, the error update unit **322** updates the error between the current posture θ and the target posture (Step S**23**). After that, the control input computation unit **323** computes the feedback control input value with respect to the current posture θ (Step S**24**) and provides the computed feedback control input value for the construction machine control unit **21** (Step S**25**). Note that the feedback control unit **32** performs control until the posture of the construction machine **10** becomes a target posture while repeating the processing of Steps S**23**-S**25**.

[0054] Now, a method for computing the feedback control input value in Step S**24** will be described in detail. First, when the feedback control input value is denoted by u, the feedback control input value u is expressed by Expression (9). In the following expression, θ denotes a current posture, θr denotes a target posture, Umax denotes an input maximum value, Umin(θ) denotes an initial motion input value (note that the posture direction is omitted), Emax denotes a deceleration start position with respect to the error between the target posture and the current posture, and Emin denotes a convergence determination threshold with respect to the target posture.

[Expression 9]

$$u=K_p \cdot e+U_{min}(\theta) \tag{9}$$

[0055] Note that Kp can be expressed by Expression (10).

[Expression 10]

$$K_p = \frac{U_{max} - U_{min}(\theta)}{E_{max} - E_{min}} \tag{10}$$

[0056] Further, e can be expressed by Expression (11).

[Expression 11]

$$e=|\theta_r-\theta| \tag{11}$$

[0057] From the above Expression (9), it can be seen that the feedback control input value is a value that has the initial motion input value Umin(θ) as the minimum value. That is, it can be seen that the control input computation unit **323** is able to compute a feedback control input value in which the initial motion input value computed for each posture of the construction machine **10** when the control is started is compensated as the minimum value.

[0058] From the above description, the work control system **1** according to the first example embodiment sets the drive part of the construction machine **10** to be in the first state and the second state, which are different amounts of displacement, and measures the initial motion input value for each of the first state and the second state. The work control system **1** then generates an initial motion input model capable of computing an initial motion input value appropriate for a desired posture using the measured initial motion input value. The work control system **1** computes the initial motion input value that is optimal to the current posture using the initial motion input model generated by the initial motion input model generation unit **31**, and the initial motion input model generation unit **31** computes a feedback control input value that compensates the initial motion input value as the lowest value.

[0059] Accordingly, the work control system **1** according to the first example embodiment is able to control the construction machine **10** by the feedback control input value with which the construction machine **10** can be controlled with a high accuracy even when the amount of play of the manipulation lever varies for each posture of the construction machine **10**.

Second Example Embodiment

[0060] In a second example embodiment, a work control system **2**, which is another form of the work control system **1** according to the first example embodiment, will be described. In the description of the second example embodiment, the components that are the same as those in the first example embodiment are denoted by the same reference symbols as those given to the components in the first example embodiment and the descriptions thereof will be omitted.

[0061] FIG. **7** shows a block diagram of the work control system **2** according to the second example embodiment. As shown in FIG. **7**, the work control system **2** according to the second example embodiment further includes a work instruction unit **41** in addition to the components of the work control system **1** according to the first example embodiment. Further, in the work control system **2** according to the second example embodiment, the feedback control unit **32** of the work control system **1** according to the first example embodiment is replaced by a feedback control unit **42**. In the feedback control unit **42**, the error update unit **322** is replaced by an error update unit **422**. The error update unit **422** is different from the error update unit **322** in that a parameter update unit **422***a* is added to the components of the error update unit **322**.

[0062] The work instruction unit **41** provides information regarding the content of the work performed using the construction machine **10** for the feedback control unit **42**. The error update unit **422** of the feedback control unit **42** performs, when it is recognized that a work instruction for instructing a work to be performed by the construction machine **10** has been updated based on the instruction given from the work instruction unit **41**, a parameter update step of updating the control parameters including the target posture of the construction machine **10** by the parameter update unit **422***a*. It is assumed that the control parameters include the maximum input amount Umax and the deceleration start threshold Emax included in Expression (10).

[0063] Next, feedback control processing performed using the feedback control unit **42** according to the second example embodiment will be described in detail. FIG. **8** shows a flowchart for describing an operation of the feedback control unit **42** according to the second example embodiment. In the description of the flowchart shown in FIG. **8**, Steps S**31** and S**32** that are different from those in the flowchart of the work control system **1** according to the first example embodiment shown in FIG. **6** will be described.

[0064] As shown in FIG. **8**, in the operation of the feedback control unit **42** according to the second example embodiment, operations of Steps S**31** and S**32** are added to the operation performed in the feedback control unit **32** according to the first example embodiment. The processing of Steps S**31** and S**32** is performed between Step S**22** and Step S**23**. In Step S**31**, it is determined whether or not the work instruction unit **41** has updated the content of the work. When it is determined in Step S**31** that the content of the work has been updated, the error update unit **422** updates control parameters including the target posture, the input maximum amount, and the deceleration start threshold in accordance with the content of the current work using the parameter update unit **422***a*. Then, the work control system **2** according to the second example embodiment computes the error with the current posture (Step S**24**) based on the target posture, the input maximum amount, and the deceleration start threshold updated in Step S**32** and computes the feedback control input value (Step SS**25**).

[0065] From the above description, with the work control system **2** according to the second example embodiment, by instructing the error update unit **422** to update the content of the work by the work instruction unit **41**, it is possible to perform control with an accuracy as high as that in the work control system **1** according to the first example embodiment while causing the construction machine **10** to perform various kinds of work. In an excavation work, for example, compared to a case in which the bucket **16** is empty, a larger force is required to close the bucket **16** in order to enable the bucket **16** to lifting earth and sand. Therefore, in the excavation work, control parameters with which torque to be provided for the bucket **16** increases will be employed. Further, in another example, when the truck is loaded with earth and sand using the bucket **16**, the control needs to be performed with a high position accuracy in order to avoid a collision between the truck and the bucket **16**. Therefore, in a work for loading a truck with earth and sand, control parameters with which the position accuracy is increased are employed.

[0066] Note that the present invention is not limited to the aforementioned example embodiments and may be changed as appropriate without departing from the spirit of the present invention.

[0067] While the present invention has been described as a hardware configuration in the above example embodiments, the present invention is not limited thereto. The present invention can achieve desired processing (e.g., processing described with reference to FIGS. **4**-**6** and **8**) by causing a Central Processing Unit (CPU) to execute a computer program. Further, the aforementioned program may be stored and provided to a computer using any type of non-transitory computer readable media. Non-transitory computer readable media include any type of tangible storage media. Examples of non-transitory computer readable media include magnetic storage media (such as flexible disks, magnetic tapes, hard disk drives, etc.), optical magnetic storage media (e.g., magneto-optical disks), CD-Read Only Memory (ROM), CD-R, CD-R/W, semiconductor memories (e.g., mask ROM, Programmable ROM (PROM), Erasable PROM (EPROM), flash ROM, Random Access Memory (RAM)). Further, the program may be provided to a computer using any type of transitory computer readable medium. Examples of transitory computer readable media include electric signals, optical signals, and electromagnetic waves. Transitory computer readable media can provide the program to a computer via a wired communication line (e.g., electric wires, and optical fibers) or a wireless communication line.

[0068] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2020-144049, filed on Aug. 28, 2020, the disclosure of which is incorporated herein in its entirety by reference.

[0069] Further, the above example embodiments include the following aspects.

[0070] (Supplementary Note 1)

[0071] A work control method comprising:

[0072] an initial motion input model generation step of generating an initial motion input model for computing an initial motion input value at which a movable part of a construction machine is caused to start to move; and

[0073] a feedback control step of computing the initial motion input value that corresponds to the posture of the construction machine using the initial motion input model and determining a control input value equal to or larger than the initial motion input value, wherein

[0074] the initial motion input model generation step comprises:

[0075] a first initial motion input value measurement step of measuring a first initial motion measurement value at which the movable part is caused to start to move in a first state in which the movable part is controlled to a first position within a movable range of the movable part;

[0076] a second initial motion input value measurement step of measuring a second initial motion measurement value at which the movable part is caused to start to move in a second state in which the movable part is controlled to a second position that is different from the first position within the movable

[0077] range of the movable part; and a model generation step of generating the initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and derives the initial motion input value with respect to a desired posture of the construction machine.

[0078] (Supplementary Note 2)

[0079] The work control method according to Supplementary Note 1, wherein

[0080] in the first initial motion input value measurement step, an input value is provided for the construction machine in such a way that the movable part moves in each of a positive direction of the movable part and a negative direction of the movable part with respect to the movable part which is in the first state, and the first initial motion measurement value is measured for each of the positive direction and the negative direction,

[0081] in the second initial motion input value measurement step, an input value is provided for the

construction machine in such a way that the movable part moves in each of the positive direction of the movable part and the negative direction of the movable part with respect to the movable part which is in the second state, and the second initial motion measurement value is measured for each of the positive direction and the negative direction, and

[0082] the model generation step includes a control input computation step of generating the initial motion input model using the first initial motion measurement value of the positive direction, the first initial motion measurement value of the negative direction, the second initial motion measurement value of the positive direction, and the second initial motion measurement value of the negative direction.

[0083] (Supplementary Note 3)

[0084] The work control method according to Supplementary Note 1 or 2, wherein

[0085] the feedback control step comprises:

[0086] an initial motion input update step of acquiring the current posture of the construction machine based on positional information of the movable part of the construction machine and updating the initial motion input value that corresponds to the current posture by the value computed using the initial motion input model;

[0087] an error update step of updating the error between the current posture and a target posture of the construction machine; and

[0088] a control input computation step of receiving the error and the initial motion input value, computing the control input value that reduces the error, and provides the computed control input value for the construction machine.

[0089] (Supplementary Note 4)

[0090] The work control method according to Supplementary Note 3, wherein, in the error update step, when a work instruction for instructing a work to be performed by the construction machine has been updated, a parameter update step of updating a control parameter including the target posture of the construction machine is performed.

[0091] (Supplementary Note 5)

[0092] The work control method according to any one of Supplementary Notes 1 to 4, wherein the initial motion input model generation step generates the initial motion input model in a period other than an operation period during which the construction machine performs work.

[0093] (Supplementary Note 6)

[0094] The work control method according to any one of Supplementary Notes 1 to 5, wherein

[0095] the construction machine includes a manipulation lever for manipulating the posture of the construction machine and an actuator attached to the manipulation lever, and

[0096] the work control method includes a construction machine control step of controlling the construction machine via the manipulation lever by manipulating the actuator based on the control input value.

[0097] (Supplementary Note 7)

[0098] A work control system comprising:

[0099] initial motion input model generation means for generating an initial motion input model for computing an initial motion input value at which a movable part of a construction machine is caused to start to move; and

[0100] feedback control means for computing the initial motion input value that corresponds to the posture of the construction machine using the initial motion input model and determining a control input value equal to or larger than the initial motion input value, wherein

[0101] the initial motion input model generation means performs:

[0102] first initial motion input value measurement processing for measuring a first initial motion measurement value at which the movable part is caused to start to move in a first state in which the movable part is controlled to a first position within a movable range of the movable part;

[0103] second initial motion input value measurement processing for measuring a second initial motion measurement value at which the movable part is caused to start to move in a second state in which the movable part is controlled to a second position that is different from the first position within the movable range of the movable part; and

[0104] model generation processing for generating the initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and deriving the initial motion input value with respect to a desired posture of the construction machine.

[0105] (Supplementary Note 8)

[0106] The work control system according to Supplementary Note 7, wherein

[0107] in the first initial motion input value measurement processing, an input value is provided for the construction machine in such a way that the movable part moves in each of a positive direction of the movable part and a negative direction of the movable part with respect to the movable part which is in the first state, and the first initial motion measurement value is measured for each of the positive direction and the negative direction,

[0108] in the first initial motion input value measurement processing, an input value is provided for the construction machine in such a way that the movable part moves in each of the positive direction of the movable part and the negative direction of the movable part with respect to the movable part which is in the second state, and the second initial motion measurement value is measured for each of the positive direction and the negative direction, and

[0109] in the model generation processing, the initial motion input model is generated using the first initial motion measurement value of the positive direction, the first initial motion measurement value of the negative direction, the second initial motion measurement value of the positive direction, and the second initial motion measurement value of the negative direction.

[0110] (Supplementary Note 9)

[0111] The work control system according to Supplementary Note 7 or 8, wherein

[0112] the feedback control means comprises:

[0113] initial motion input update means for acquiring the current posture of the construction machine based on positional information of the movable part of the construction machine and updating the initial motion

input value that corresponds to the current posture by the value computed using the initial motion input model;

[0114] error update means for updating the error between the current posture and a target posture of the construction machine; and

[0115] control input computation means for receiving the error and the initial motion input value, computing the control input value that reduces the error, and providing the computed control input value for the construction machine.

[0116] (Supplementary Note 10)

[0117] The work control system according to Supplementary Note 9, wherein the error update means includes parameter update means for updating a control parameter including the target posture of the construction machine when a work instruction for instructing a work to be performed by the construction machine has been updated.

[0118] (Supplementary Note 11)

[0119] The work control system according to any one of Supplementary Notes 7 to 10, wherein the initial motion input model generation means generates the initial motion input model in a period other than an operation period during which the construction machine performs work.

[0120] (Supplementary Note 12)

[0121] The work control system according to any one of Supplementary Notes 7 to 11, wherein

[0122] the construction machine includes a manipulation lever for manipulating the posture of the construction machine and an actuator attached to the manipulation lever, and

[0123] the work control system includes construction machine control means for controlling the construction machine via the manipulation lever by manipulating the actuator based on the control input value.

[0124] (Supplementary Note 13)

[0125] A work control apparatus comprising:

[0126] initial motion input model generation means for generating an initial motion input model for computing an initial motion input value at which a movable part of a construction machine is caused to start to move; and

[0127] feedback control means for computing the initial motion input value that corresponds to the posture of the construction machine using the initial motion input model and determining a control input value equal to or larger than the initial motion input value, wherein

[0128] the initial motion input model generation means performs:

[0129] first initial motion input value measurement processing for measuring a first initial motion measurement value at which the movable part is caused to start to move in a first state in which the movable part is controlled to a first position within a movable range of the movable part;

[0130] second initial motion input value measurement processing for measuring a second initial motion measurement value at which the movable part is caused to start to move in a second state in which the movable part is controlled to a second position that is different from the first position within the movable range of the movable part; and

[0131] model generation processing for generating the initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and deriving the initial motion input value with respect to a desired posture of the construction machine.

[0132] (Supplementary Note 14)

[0133] The work control apparatus according to Supplementary Note 13, wherein

[0134] in the first initial motion input value measurement processing, an input value is provided for the construction machine in such a way that the movable part moves in each of a positive direction of the movable part and a negative direction of the movable part with respect to the movable part which is in the first state, and the first initial motion measurement value is measured for each of the positive direction and the negative direction,

[0135] in the first initial motion input value measurement processing, an input value is provided for the construction machine in such a way that the movable part moves in each of the positive direction of the movable part and the negative direction of the movable part with respect to the movable part which is in the second state, and the second initial motion measurement value is measured for each of the positive direction and the negative direction, and

[0136] in the model generation processing, the initial motion input model is generated using the first initial motion measurement value of the positive direction, the first initial motion measurement value of the negative direction, the second initial motion measurement value of the positive direction, and the second initial motion measurement value of the negative direction.

[0137] (Supplementary Note 15)

[0138] The work control apparatus according to Supplementary Note 13 or 14, wherein

[0139] the feedback control means comprises:

[0140] initial motion input update means for acquiring the current posture of the construction machine based on positional information of the movable part of the construction machine and updating the initial motion input value that corresponds to the current posture by the value computed using the initial motion input model;

[0141] error update means for updating the error between the current posture and a target posture of the construction machine; and

[0142] control input computation means for receiving the error and the initial motion input value, computing the control input value that reduces the error, and providing the computed control input value for the construction machine.

[0143] (Supplementary Note 16)

[0144] The work control apparatus according to Supplementary Note 15, wherein the error update means includes parameter update means for updating a control parameter including the target posture of the construction machine when a work instruction for instructing a work to be performed by the construction machine has been updated.

[0145] (Supplementary Note 17)

[0146] The work control apparatus according to any one of Supplementary Notes 13 to 16, wherein the initial motion input model generation means generates the initial motion input model in a period other than an operation period during which the construction machine performs work.

[0147] (Supplementary Note 18)

[0148] The work control apparatus according to any one of Supplementary Notes 13 to 17, wherein

[0149] the construction machine includes a manipulation lever for manipulating the posture of the construction machine and an actuator attached to the manipulation lever, and

[0150] the work control system includes construction machine control means for controlling the construction machine via the manipulation lever by manipulating the actuator based on the control input value.

REFERENCE SIGNS LIST

[0151] **1** Work Control System
[0152] **2** Work Control System
[0153] **10** Construction Machine
[0154] **11** Crawler
[0155] **12** Turning Base
[0156] **13** Cockpit
[0157] **14** Boom
[0158] **16** Arm
[0159] **16** Bucket
[0160] **17** Actuator
[0161] **181** Posture Sensor
[0162] **182** Posture Sensor
[0163] **183** Posture Sensor
[0164] **184** Posture Sensor
[0165] **20** Posture Control Apparatus
[0166] **21** Construction Machine Control Unit
[0167] **22** Posture Detection Unit
[0168] **30** Work Control Apparatus
[0169] **31** Initial Motion Input Model Generation Unit
[0170] **311** Initial Motion Input Measurement Unit
[0171] **312** Model Generation Unit
[0172] **32** Feedback Control Unit
[0173] **321** Initial Motion Input Update Unit
[0174] **322** Error Update Unit
[0175] **323** Control Input Computation Unit
[0176] **41** Work Instruction Unit
[0177] **42** Feedback Control Unit
[0178] **422** Error Update Unit
[0179] **422***a* Parameter Update Unit

What is claimed is:

1. A work control method comprising:

an initial motion input model generation step of generating an initial motion input model for computing an initial motion input value at which a movable part of a construction machine is caused to start to move; and

a feedback control step of computing the initial motion input value that corresponds to the posture of the construction machine using the initial motion input model and determining a control input value equal to or larger than the initial motion input value, wherein

the initial motion input model generation step comprises:

a first initial motion input value measurement step of measuring a first initial motion measurement value at which the movable part is caused to start to move in a first state in which the movable part is controlled to a first position within a movable range of the movable part;

a second initial motion input value measurement step of measuring a second initial motion measurement value at which the movable part is caused to start to move in a second state in which the movable part is controlled to a second position that is different from the first position within the movable range of the movable part; and

a model generation step of generating the initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and derives the initial motion input value with respect to a desired posture of the construction machine.

2. The work control method according to claim **1**, wherein

in the first initial motion input value measurement step, an input value is provided for the construction machine in such a way that the movable part moves in each of a positive direction of the movable part and a negative direction of the movable part with respect to the movable part which is in the first state, and the first initial motion measurement value is measured for each of the positive direction and the negative direction,

in the second initial motion input value measurement step, an input value is provided for the construction machine in such a way that the movable part moves in each of the positive direction of the movable part and the negative direction of the movable part with respect to the movable part which is in the second state, and the second initial motion measurement value is measured for each of the positive direction and the negative direction, and

the model generation step includes a control input computation step of generating the initial motion input model using the first initial motion measurement value of the positive direction, the first initial motion measurement value of the negative direction, the second initial motion measurement value of the positive direction, and the second initial motion measurement value of the negative direction.

3. The work control method according to claim **1**, wherein

the feedback control step comprises:

an initial motion input update step of acquiring the current posture of the construction machine based on positional information of the movable part of the construction machine and updating the initial motion input value that corresponds to the current posture by the value computed using the initial motion input model;

an error update step of updating the error between the current posture and a target posture of the construction machine; and

a control input computation step of receiving the error and the initial motion input value, computing the control input value that reduces the error, and provides the computed control input value for the construction machine.

4. The work control method according to claim **3**, wherein, in the error update step, when a work instruction for instructing a work to be performed by the construction machine has been updated, a parameter update step of updating a control parameter including the target posture of the construction machine is performed.

5. The work control method according to claim **1**, wherein the initial motion input model generation step generates the initial motion input model in a period other than an operation period during which the construction machine performs work.

6. The work control method according to claim 1, wherein
the construction machine includes a manipulation lever for manipulating the posture of the construction machine and an actuator attached to the manipulation lever, and
the work control method includes a construction machine control step of controlling the construction machine via the manipulation lever by manipulating the actuator based on the control input value.

7. A work control system comprising:
initial motion input model generation means for generating an initial motion input model for computing an initial motion input value at which a movable part of a construction machine is caused to start to move; and
feedback control means for computing the initial motion input value that corresponds to the posture of the construction machine using the initial motion input model and determining a control input value equal to or larger than the initial motion input value, wherein
the initial motion input model generation means performs:
first initial motion input value measurement processing for measuring a first initial motion measurement value at which the movable part is caused to start to move in a first state in which the movable part is controlled to a first position within a movable range of the movable part;
second initial motion input value measurement processing for measuring a second initial motion measurement value at which the movable part is caused to start to move in a second state in which the movable part is controlled to a second position that is different from the first position within the movable range of the movable part; and
model generation processing for generating the initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and deriving the initial motion input value with respect to a desired posture of the construction machine.

8. The work control system according to claim 7, wherein
in the first initial motion input value measurement processing, an input value is provided for the construction machine in such a way that the movable part moves in each of a positive direction of the movable part and a negative direction of the movable part with respect to the movable part which is in the first state, and the first initial motion measurement value is measured for each of the positive direction and the negative direction,
in the second initial motion input value measurement processing, an input value is provided for the construction machine in such a way that the movable part moves in such a way that the movable part moves in each of the positive direction of the movable part and the negative direction of the movable part with respect to the movable part which is in the second state, and the second initial motion measurement value is measured for each of the positive direction and the negative direction, and
in the model generation processing, the initial motion input model is generated using the first initial motion measurement value of the positive direction, the first initial motion measurement value of the negative direction, the second initial motion measurement value of the positive direction, and the second initial motion measurement value of the negative direction.

9. The work control system according to claim 7, wherein the feedback control means comprises:
initial motion input update means for acquiring the current posture of the construction machine based on positional information of the movable part of the construction machine and updating the initial motion input value that corresponds to the current posture by the value computed using the initial motion input model;
error update means for updating the error between the current posture and a target posture of the construction machine; and
control input computation means for receiving the error and the initial motion input value, computing the control input value that reduces the error, and providing the computed control input value for the construction machine.

10. The work control system according to claim 9, wherein the error update means includes parameter update means for updating a control parameter including the target posture of the construction machine when a work instruction for instructing a work to be performed by the construction machine has been updated.

11. The work control system according to claim 7, wherein the initial motion input model generation means generates the initial motion input model in a period other than an operation period during which the construction machine performs work.

12. The work control system according to claim 7, wherein
the construction machine includes a manipulation lever for manipulating the posture of the construction machine and an actuator attached to the manipulation lever, and
the work control system includes construction machine control means for controlling the construction machine via the manipulation lever by manipulating the actuator based on the control input value.

13. A work control apparatus comprising:
initial motion input model generation means for generating an initial motion input model for computing an initial motion input value at which a movable part of a construction machine is caused to start to move; and
feedback control means for computing the initial motion input value that corresponds to the posture of the construction machine using the initial motion input model and determining a control input value equal to or larger than the initial motion input value, wherein
the initial motion input model generation means performs:
first initial motion input value measurement processing for measuring a first initial motion measurement value at which the movable part is caused to start to move in a first state in which the movable part is controlled to a first position within a movable range of the movable part;
second initial motion input value measurement processing for measuring a second initial motion measurement value at which the movable part is caused to start to move in a second state in which the movable part is controlled to a second position that is different from the first position within the movable range of the movable part; and

model generation processing for generating the initial motion input model that complements between the first initial motion measurement value and the second initial motion measurement value and deriving the initial motion input value with respect to a desired posture of the construction machine.

14. The work control apparatus according to claim **13**, wherein

in the first initial motion input value measurement processing, an input value is provided for the construction machine in such a way that the movable part moves in each of a positive direction of the movable part and a negative direction of the movable part with respect to the movable part which is in the first state, and the first initial motion measurement value is measured for each of the positive direction and the negative direction,

in the second initial motion input value measurement processing, an input value is provided for the construction machine in such a way that the movable part moves in each of the positive direction of the movable part and the negative direction of the movable part with respect to the movable part which is in the second state, and the second initial motion measurement value is measured for each of the positive direction and the negative direction, and

in the model generation processing, the initial motion input model is generated using the first initial motion measurement value of the positive direction, the first initial motion measurement value of the negative direction, the second initial motion measurement value of the positive direction, and the second initial motion measurement value of the negative direction.

15. The work control apparatus according to claim **13**, wherein

the feedback control means comprises:

initial motion input update means for acquiring the current posture of the construction machine based on positional information of the movable part of the construction machine and updating the initial motion input value that corresponds to the current posture by the value computed using the initial motion input model;

error update means for updating the error between the current posture and a target posture of the construction machine; and

control input computation means for receiving the error and the initial motion input value, computing the control input value that reduces the error, and providing the computed control input value for the construction machine.

16. The work control apparatus according to claim **15**, wherein the error update means includes parameter update means for updating a control parameter including the target posture of the construction machine when a work instruction for instructing a work to be performed by the construction machine has been updated.

17. The work control apparatus according to claim **13**, wherein the initial motion input model generation means generates the initial motion input model in a period other than an operation period during which the construction machine performs work.

18. The work control apparatus according to claim **13**, wherein

the construction machine includes a manipulation lever for manipulating the posture of the construction machine and an actuator attached to the manipulation lever, and

the work control system includes construction machine control means for controlling the construction machine via the manipulation lever by manipulating the actuator based on the control input value.

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