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(54) **ROBOT SYSTEM AND ARTICLE TRANSFER METHOD**

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(57) **ABSTRACT**

A robot system according to an aspect of embodiments includes an information acquisition unit, a plurality of robots, and a distribution unit. The information acquisition unit acquires information indicating a two-dimensional position on a surface of a conveyance path of an article conveyed on the conveyance path. The plurality of robots transfers the article from the conveyance path. The distribution unit distributes the articles on the surface of the conveyance path to the plurality of robots as transfer targets on the basis of the information acquired by the information acquisition unit.

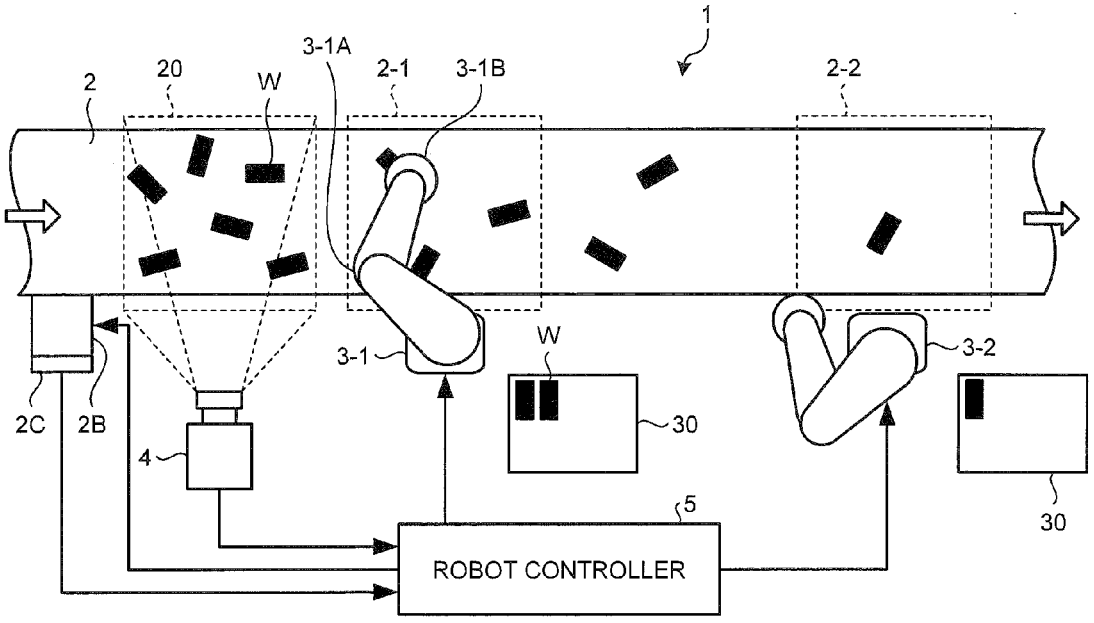


FIG.1

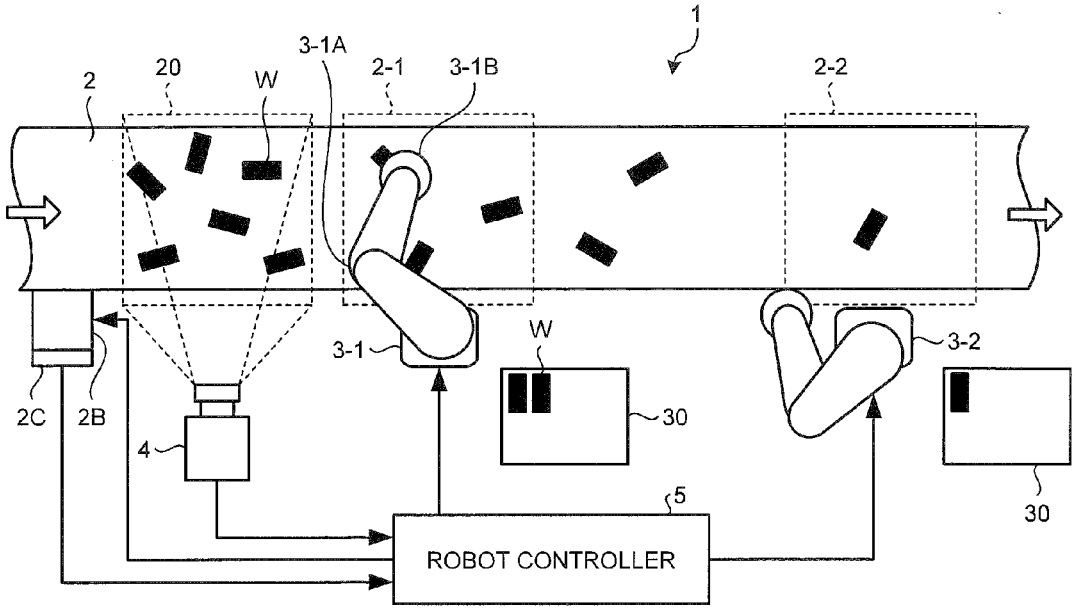

1
2
20
W
3-1A
2-1
3-1B
2-2
3-1
W
3-2
2C
2B
4
30
30
5
ROBOT CONTROLLER

FIG.2

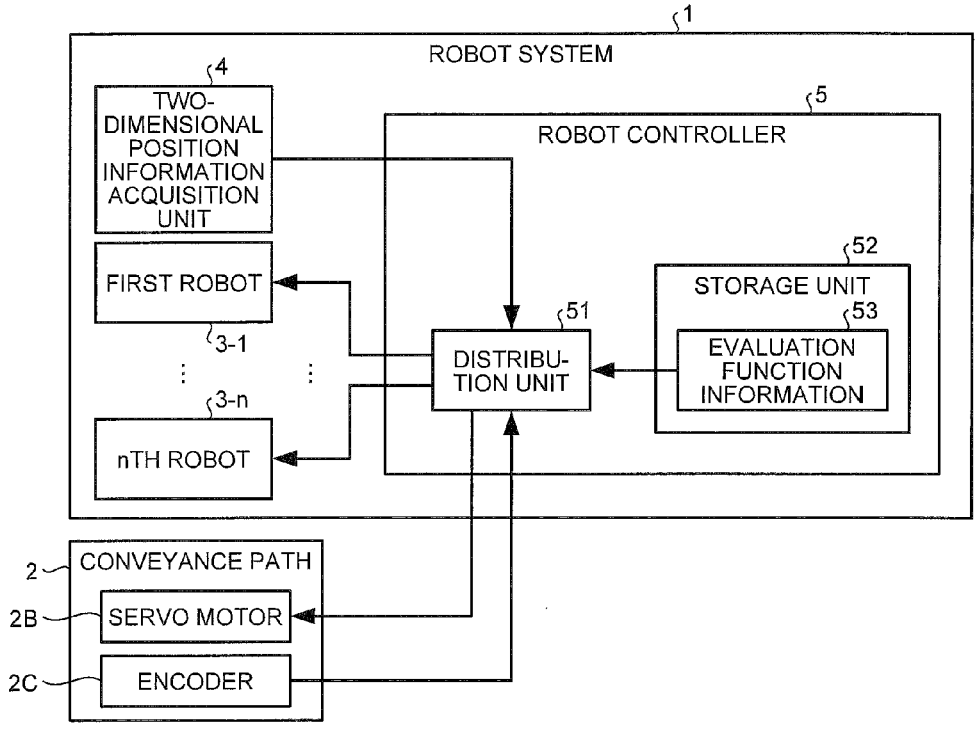

1
ROBOT SYSTEM
4
TWO-DIMENSIONAL POSITION INFORMATION ACQUISITION UNIT
5
ROBOT CONTROLLER
52
STORAGE UNIT
53
EVALUATION FUNCTION INFORMATION
FIRST ROBOT
3-1
51
DISTRIBU-TION UNIT
3-n
nTH ROBOT
2
CONVEYANCE PATH
2B
SERVO MOTOR
2C
ENCODER

FIG.3

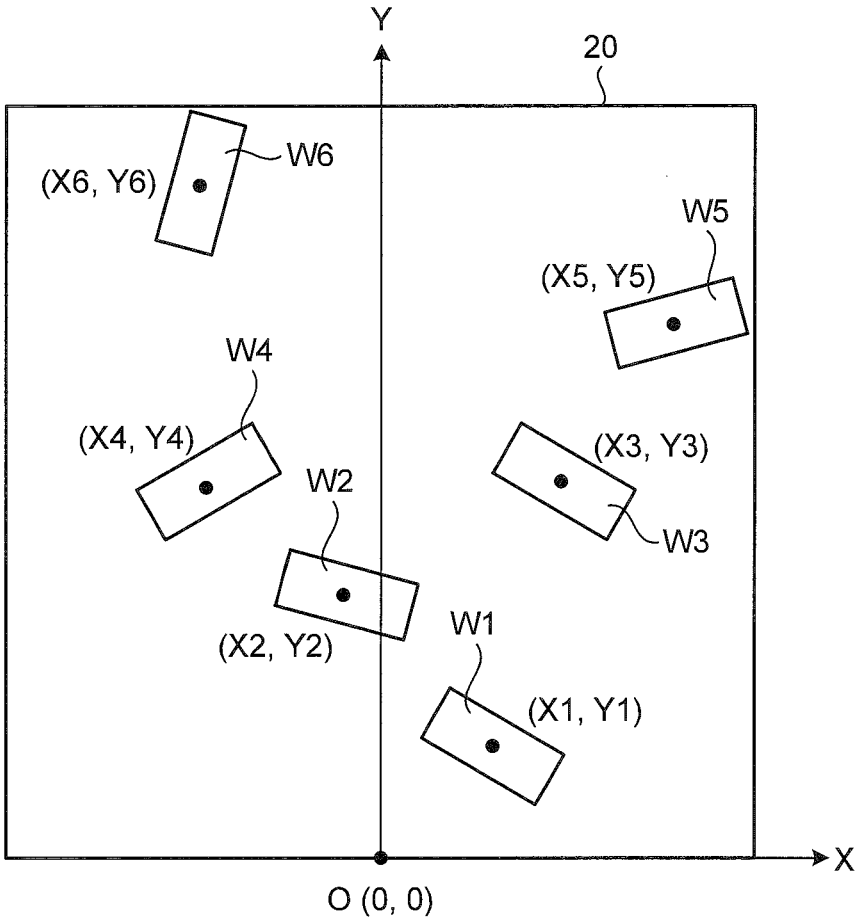


FIG.4

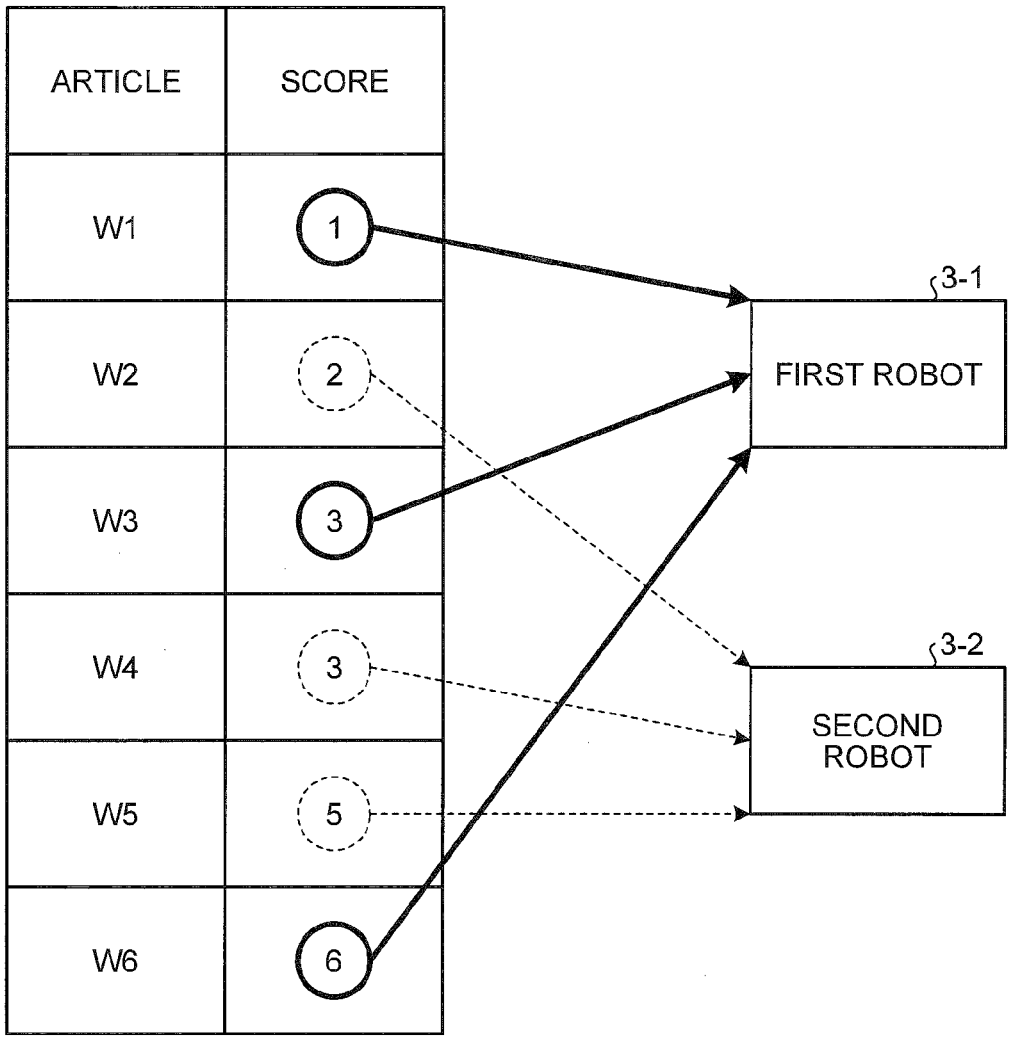

ARTICLE
SCORE
W1
1
W2
2
W3
3
W4
3
W5
5
W6
6
3-1
FIRST ROBOT
3-2
SECOND ROBOT

FIG.5

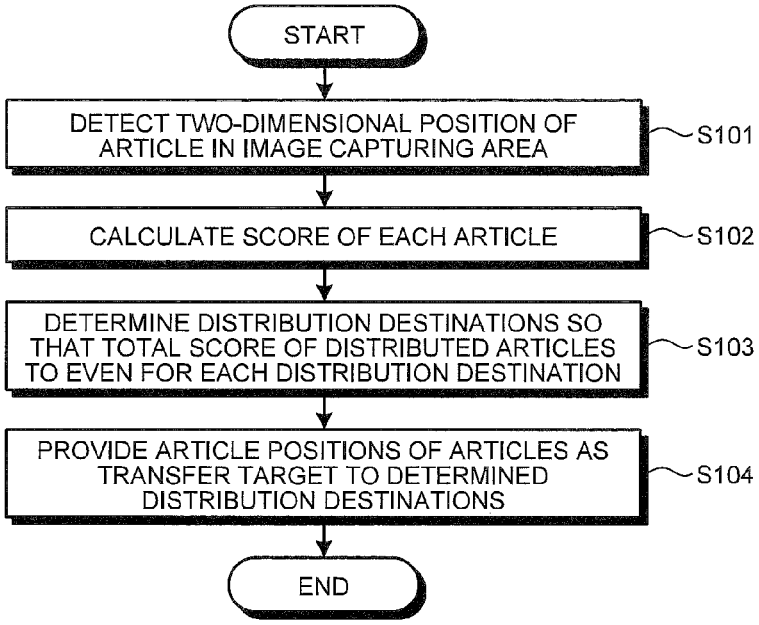

START
DETECT TWO-DIMENSIONAL POSITION OF ARTICLE IN IMAGE CAPTURING AREA
S101
CALCULATE SCORE OF EACH ARTICLE
S102
DETERMINE DISTRIBUTION DESTINATIONS SO THAT TOTAL SCORE OF DISTRIBUTED ARTICLES TO EVEN FOR EACH DISTRIBUTION DESTINATION
S103
PROVIDE ARTICLE POSITIONS OF ARTICLES AS TRANSFER TARGET TO DETERMINED DISTRIBUTION DESTINATIONS
S104
END

FIG.6

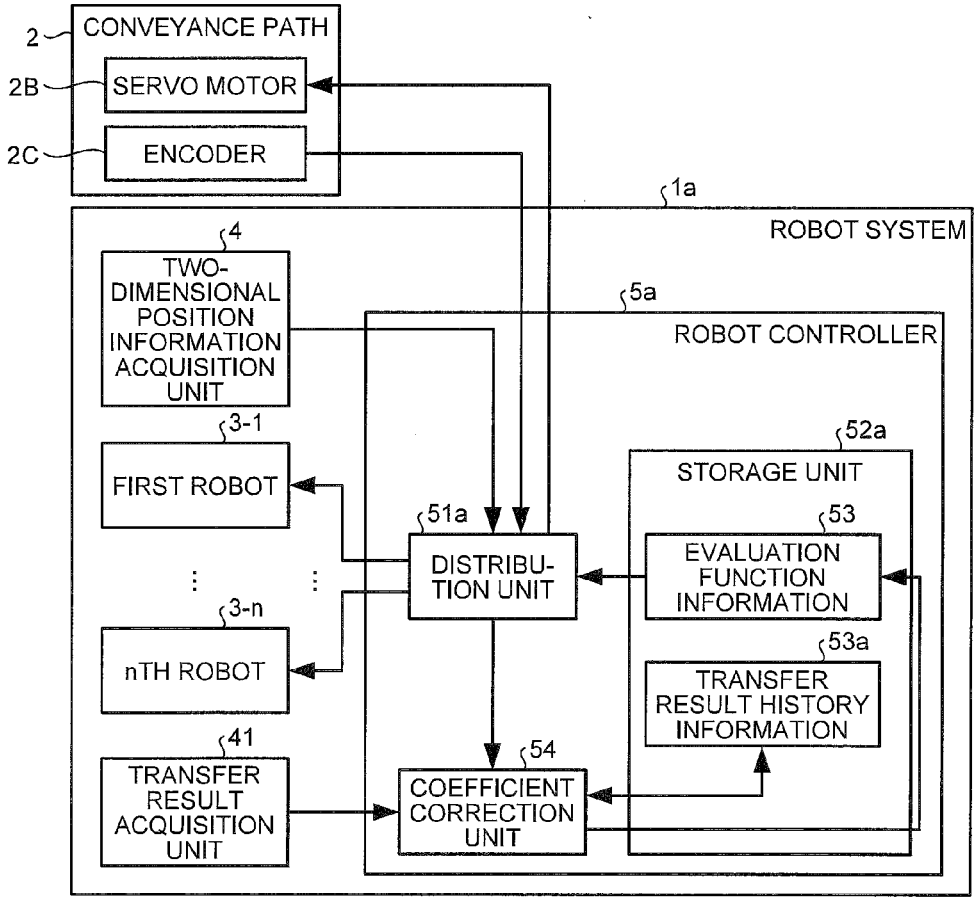

2
CONVEYANCE PATH
2B
SERVO MOTOR
2C
ENCODER
1a
ROBOT SYSTEM
4
TWO-DIMENSIONAL POSITION INFORMATION ACQUISITION UNIT
5a
ROBOT CONTROLLER
3-1
FIRST ROBOT
52a
STORAGE UNIT
51a
DISTRIBU-TION UNIT
53
EVALUATION FUNCTION INFORMATION
3-n
nTH ROBOT
53a
TRANSFER RESULT HISTORY INFORMATION
41
TRANSFER RESULT ACQUISITION UNIT
54
COEFFICIENT CORRECTION UNIT

FIG.7

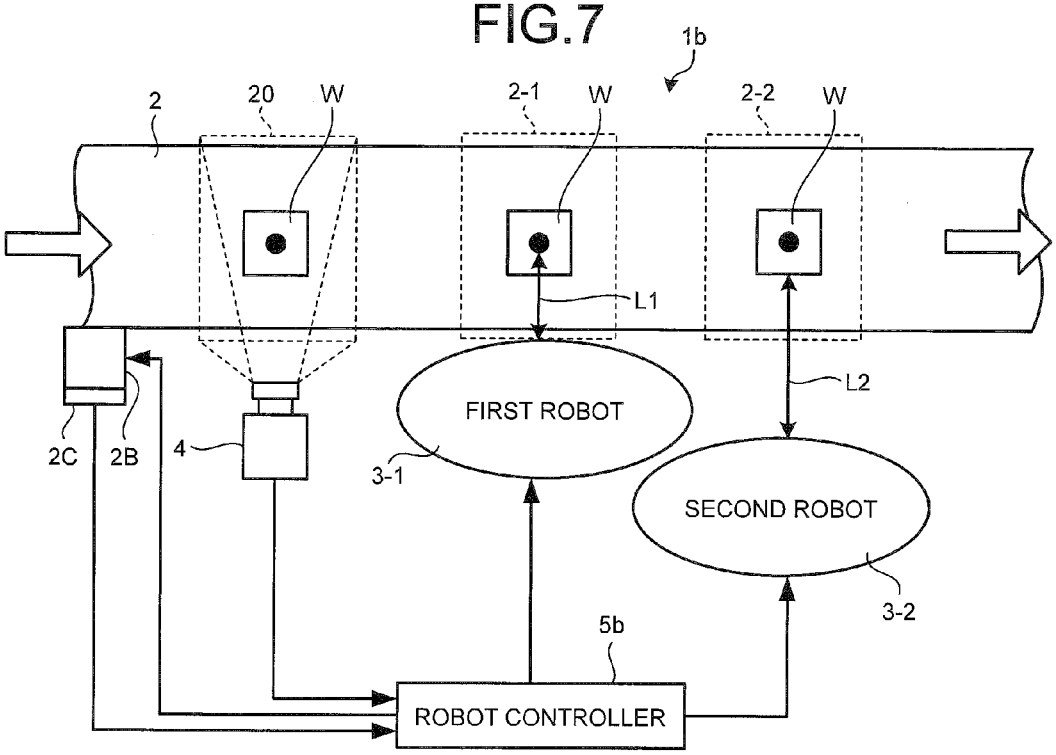
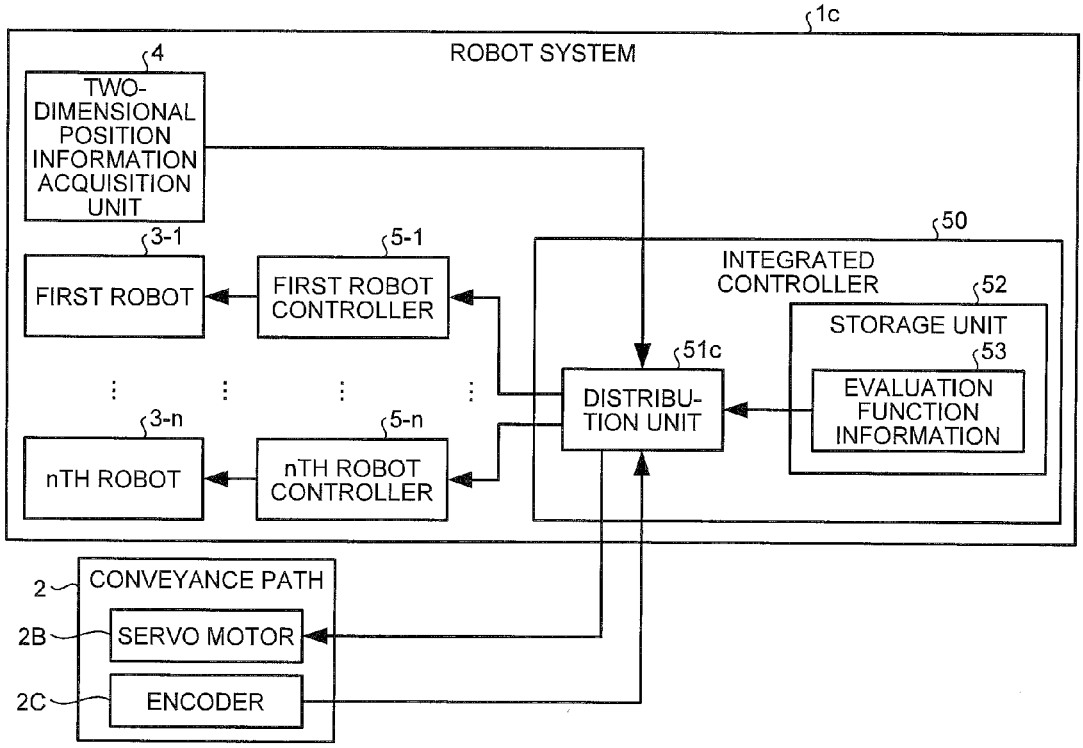

1b
2
20
W
2-1
W
2-2
W
L1
L2
2C
2B
4
FIRST ROBOT
3-1
SECOND ROBOT
3-2
5b
ROBOT CONTROLLER

FIG.8


1c
ROBOT SYSTEM
4
TWO-DIMENSIONAL POSITION INFORMATION ACQUISITION UNIT
3-1
FIRST ROBOT
5-1
FIRST ROBOT CONTROLLER
3-n
nTH ROBOT
5-n
nTH ROBOT CONTROLLER
50
INTEGRATED CONTROLLER
52
STORAGE UNIT
53
EVALUATION FUNCTION INFORMATION
51c
DISTRIBU-TION UNIT
2
CONVEYANCE PATH
2B
SERVO MOTOR
2C
ENCODER

ROBOT SYSTEM AND ARTICLE TRANSFER METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of International Application No. PCT/JP2012/068457, filed on Jul. 20, 2012, the entire contents of which are incorporated herein by reference.

FIELD

[0002] The embodiment discussed herein is directed to a robot system and an article transfer method.

BACKGROUND

[0003] Japanese Patent Application No. 3834088 discloses a technique in which articles on a conveyance path are distributed to each robot in advance as a transfer target on the basis of the order of the articles conveyed on the conveyance path and each robot transfers the distributed articles from the conveyance path.

SUMMARY

[0004] A robot system according to an aspect of embodiments includes an information acquisition unit, a plurality of robots, and a distribution unit. The information acquisition unit acquires information indicating a two-dimensional position on a surface of a conveyance path of an article conveyed on the conveyance path. The plurality of robots transfers the article from the conveyance path. The distribution unit distributes the articles on the surface of the conveyance path to the plurality of robots as transfer targets on the basis of the information acquired by the information acquisition unit.

BRIEF DESCRIPTION OF DRAWINGS

[0005] A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

[0006] FIG. **1** is an explanatory diagram illustrating a part of a robot system according to a first embodiment.

[0007] FIG. **2** is a block diagram illustrating a configuration of the robot system according to the first embodiment.

[0008] FIGS. **3** and **4** are an explanatory diagram illustrating an example of a method of distributing articles by a distribution unit according to the first embodiment.

[0009] FIG. **5** is a flowchart illustrating a process performed by the distribution unit according to the first embodiment.

[0010] FIG. **6** is a block diagram illustrating a configuration of a robot system according to a second embodiment.

[0011] FIG. **7** is an explanatory diagram illustrating a part of a robot system according to a third embodiment.

[0012] FIG. **8** is a block diagram illustrating a configuration of a robot system according to a fourth embodiment.

DESCRIPTION OF EMBODIMENTS

[0013] Hereinafter, embodiments of the robot system and the article transfer method disclosed by the present application will be described in detail with reference to the accompanying drawings. The present invention is not limited by the embodiments described below.

First Embodiment

[0014] FIG. **1** is an explanatory diagram illustrating a part of a robot system **1** according to a first embodiment. As illustrated in FIG. **1**, the robot system **1** is a system that transfers articles W sequentially conveyed on a conveyance path **2** to a predetermined placement table (hereinafter referred to as a "place **30**") arranged beside the conveyance path **2**.

[0015] Here, the conveyance path **2** according to the present embodiment is a conveyor device such as a belt conveyor and a roller conveyor. The conveyor device includes a servo motor **2**B that operates the conveyor device and an encoder **2**C that detects a rotational position (that is, a conveyance position of the conveyor device) of the servo motor **2**B. The servo motor **2**B and the encoder **2**C are connected to a control device (a robot controller **5** in the present embodiment).

[0016] The servo motor **2**B operates according to an instruction of the robot controller **5**. Thereby, the conveyance path **2** sequentially conveys a plurality of articles W from an upstream side to a downstream side in a conveyance direction indicated by void arrows in FIG. **1**. The encoder **2**C outputs the rotational position of the servo motor **2**B to the robot controller **5**.

[0017] The conveyance path **2** may convey the articles W at a constant conveyance speed set in advance. The conveyance path **2** is not limited to a conveyor, but may be a shooter or the like which is formed so that a conveyance surface forms a downslope from the upstream side to the downstream side and conveys the articles W from the upstream side to the downstream side.

[0018] The robot system **1** includes a plurality of robots **3-1** and **3-2** that take out the article W from the conveyance path **2** and transfer the article W to the place **30**. Although, in FIG. **1**, two robots **3-1** and **3-2** are illustrated, the robot system **1** includes n robots (n is a natural number) (see FIG. **2**).

[0019] In the description below, when a specific robot is indicated from among the n robots included in the robot system **1**, the robots are referred to as a first robot **3-1**, a second robot **3-2**, . . . , and nth robot **3-***n* in an order from the robot of which takeout position of the article W on the conveyance path **2** is the most upstream. When a specific robot is not indicated, each robot is referred to as simply a robot.

[0020] The robot system **1** further includes a two-dimensional position information acquisition unit **4** that acquires information indicating a two-dimensional position on the surface of the conveyance path **2** of the article W conveyed on the conveyance path **2** and the robot controller **5** that controls operations of the conveyance path **2** and the first robot **3-1** to the nth robot **3-***n*.

[0021] Here, the two-dimensional position information acquisition unit **4** is, for example, an image capturing device. The two-dimensional position information acquisition unit **4** captures an image of the article W conveyed to an image capturing area **20** defined on the immediately upstream side of a first takeout area **2-1** on the conveyance path **2** from which the first robot **3-1** takes out the article W, and outputs image information of the captured image to the robot controller **5**.

[0022] The first robot **3-1** includes a single-arm serial link robot arm **3-1**A and an end effector **3-1**B provided at the tip of the robot arm **3-1**A. Here, the end effector **3-1**B includes, for

example, a sucker which adsorbs and holds an article by applying negative pressure by a vacuum pump and releases the article by releasing the negative pressure. The end effector **3-1**B is not limited to a device that adsorbs and holds an article as long as the end effector **3-1**B has a mechanism that can hold and convey an article.

[0023] The first robot **3-1** takes out the article W from the first takeout area **2-1** of the conveyance path **2** according to control of the robot controller **5** and transfers the article W to a place **30** provided at a predetermined position.

[0024] The second robot **3-2** to the nth robot **3-***n* (see FIG. **2**) have the same configuration as that of the first robot **3-1** and perform the same operation as that of the first robot **3-1**. For example, the second robot **3-2** takes out the article W from a second takeout area **2-2** on the immediate downstream side of the first takeout area **2-1** on the conveyance path **2** and transfers the article W to a place **30** provided at a predetermined position.

[0025] Although FIG. **1** illustrates a case in which the first robot **3-1** and the second robot **3-2** are a serial link robot, the first robot **3-1** to the nth robot **3-***n* may be a parallel link robot.

[0026] The robot controller **5** is a control device that controls operations of the conveyance path **2** and the first robot **3-1** to the nth robot **3-***n* (see FIG. **2**). The robot controller **5** detects a two-dimensional position of the article W in the image capturing area **20** from the image information inputted from the two-dimensional position information acquisition unit **4**.

[0027] Then, the robot controller **5** distributes the articles W on the surface of the conveyance path **2** to each robot as transfer targets so that the transfer load of the articles W of each robot becomes even on the basis of the detected two-dimensional positions of the articles W in the image capturing area **20** and the rotational position of the servo motor B inputted from the encoder **2**C of the conveyance path **2**.

[0028] Thereby, in the robot system **1**, it is possible to prevent the workload of each robot from becoming uneven. A specific example of the method for the robot controller **5** to distribute the articles W will be described later with reference to FIGS. **3** and **4**.

[0029] Next, a configuration of the robot system **1** will be described with reference to FIG. **2**. FIG. **2** is a block diagram illustrating the configuration of the robot system **1** according to the first embodiment. As illustrated in FIG. **2**, the robot system **1** includes n robots, which are the first robot **3-1** to the nth robot **3-***n*, the two-dimensional position information acquisition unit **4**, and the robot controller **5**. The two-dimensional position information acquisition unit **4** and the conveyance path **2** have already been described, so that the description of these will be omitted here.

[0030] The robot controller **5** includes a distribution unit **51** and a storage unit **52**. Although omitted here in FIG. **2**, the robot controller **5** includes an instruction unit that instructs the first robot **3-1** to the nth robot **3-***n* to perform various operations in addition to the distribution unit **51** and the storage unit **52**.

[0031] The storage unit **52** stores predetermined evaluation function information **53**. The evaluation function information **53** is a function which calculates the workload of the robot as a score when the robot transfers the article W by substituting the two-dimensional position of the article W in the image capturing area **20** in the function. In the present embodiment, the following Formula (1) is used as the evaluation function information **53**.

$$R=A|X|+BY \qquad \text{Formula (1)}$$

[0032] Here, R in Formula (1) is a score indicating the workload of the robot, and X and Y are variables where the X coordinate and the Y coordinate of the article W in an XY orthogonal coordinate system defined in the image capturing area **20** (see FIG. **1**) are substituted respectively. An example of the XY orthogonal coordinate system defined in the image capturing area **20** will be described later with reference to FIG. **3**.

[0033] A and B are predetermined coefficients. Specifically, A is a coefficient for converting a moving distance of the end effector **3-1**B moved by the robot in a direction in parallel with the X axis in the XY orthogonal coordinate system into the workload of the robot.

[0034] B is a coefficient for converting a moving distance of the end effector **3-1**B moved by the robot in a direction in parallel with the Y axis in the XY orthogonal coordinate system into the workload of the robot. In Formula (1), the larger the distance from the robot to the position of the article W on the conveyance path **2** when the article W is transferred by the robot is, the higher the calculated score becomes.

[0035] The distribution unit **51** is a processing unit that distributes the articles W to each robot to cause the robot to transfer the articles W. The distribution unit **51** detects the two-dimensional position of the article W in the image capturing area **200** (see FIG. **1**) on the basis of the image information inputted from the two-dimensional position information acquisition unit **4** and the rotational position of the servo motor B inputted from the encoder **2**C of the conveyance path **2**.

[0036] Subsequently, the distribution unit **51** reads the evaluation function information **53** from the storage unit **52** and substitutes the detected two-dimensional position of each article W in the aforementioned Formula (1), which is the evaluation function information **53**, to calculate the score indicating the workload of the robot when the robot transfers the article W for each article W.

[0037] Then, the distribution unit **51** determines a robot to be a distribution destination of each article W on the conveyance path **2** so that the sum of the scores of the articles W distributed to the robot as transfer targets is even for each robot.

[0038] Thereafter, the distribution unit **51** sequentially calculates the position of each article W on the conveyance path **2** (hereinafter referred to as an "article position") on the basis of the two-dimensional position of each article W in the image capturing area **20** and the rotational position of the servo motor B inputted from the encoder **2**C of the conveyance path **2**.

[0039] When each article W is conveyed to the takeout area of the robot determined to be a distribution destination, the distribution unit **51** distributes the article W to the robot as a transfer target by providing the article position of the article W conveyed to the takeout area to the robot that is the distribution destination.

[0040] For example, when an article W of which the distribution destination is determined to be the first robot **3-1** is transferred to the first takeout area **2-1** (see FIG. **1**), the distribution unit **51** distributes the article W to the first robot **3-1** as a transfer target by providing the article position of the article W to the first robot **3-1**.

[0041] Next, a specific example of the method for the distribution unit **51** to distribute the articles W will be described with reference to FIGS. **3** and **4**. FIGS. **3** and **4** are explanatory

diagrams illustrating an example of the method for the distribution unit **51** to distribute the articles W according to the first embodiment.

[0042] Here, a case will be described in which, when six articles W**1** to W**6** are conveyed to the image capturing area **20**, the distribution unit **51** distributes the articles W**1** to W**6** to the first robot **3-1** and the second robot **3-2** as transfer targets.

[0043] As illustrated in FIG. **3**, when image information of a captured image of the six articles W**1** to W**6** conveyed to the image capturing area **20** is inputted from the two-dimensional position information acquisition unit **4**, the distribution unit **51** first defines the origin O (0, 0) at a predetermined position in the image capturing area **20** of the captured image.

[0044] Specifically, when the captured image is assumed to be captured in the first takeout area **2-1**, the position closest to the first robot **3-1** in the image capturing area **20** is defined as the origin O, and when the captured image is assumed to be captured in the second takeout area **2-2**, the position closest to the second robot **3-2** in the image capturing area **20** is defined as the origin O.

[0045] Further, the distribution unit **51** defines the XY orthogonal coordinate system by defining a direction which passes through the origin O (0, 0) and which is in parallel with the conveyance direction of the articles W**1** to W**6** conveyed by the conveyance path **2** as the X axis and defining a direction which passes through the origin O (0, 0) and which crosses the image capturing area **20** in a direction perpendicular to the X axis as the Y axis.

[0046] Subsequently, the distribution unit **51** calculates the X coordinate and the Y coordinate of the articles W**1** to W**6** in the XY orthogonal coordinate system, respectively. Then, the distribution unit **51** calculates the score of each of the articles W**1** to W**6** by substituting the calculated X coordinate and Y coordinate of the articles W**1** to W**6** in the aforementioned Formula (1).

[0047] As a result, for example, as illustrated in FIG. **4**, it is assumed that the score of the article W**1** is "1", the score of the article W**2** is "2", the scores of the articles W**3** and W**4** are "3", the score of the article W**5** is "5", and the score of the article W**6** is "6".

[0048] In this case, the distribution unit **51** determines the first robot **3-1** as the distribution destination of the article W**1**, the article W**3**, and the article W**6** as indicated by the solid line arrows in FIG. **4**, and determines the second robot **3-2** as the distribution destination of the article W**2**, the article W**4**, and the article W**5** as indicated by the dashed line arrows in FIG. **4**.

[0049] Thereby, the total score of the scores of the article W**1**, the article W**3**, and the article W**6** which are distributed to the first robot **3-1** as the transfer targets is "10", which is the same as the total score of the scores of the article W**2**, the article W**4**, and the article W**5** which are distributed to the second robot **3-2** as the transfer targets.

[0050] In this way, in the robot system **1**, the distribution destinations of the articles W are determined so that the total score of the articles W distributed to each robot is even for each robot, that is, the workload of each robot when the robot transfers the articles W is even. Therefore, according to the robot system **1**, it is possible to prevent the workload of each robot from becoming uneven.

[0051] Next, a process performed by the distribution unit **51** will be described with reference to FIG. **5**. FIG. **5** is a flowchart illustrating the process performed by the distribution unit **51** according to the first embodiment. The distribution unit **51** performs the process illustrated in FIG. **5** every time the image information is inputted from the two-dimensional position information acquisition unit **4**.

[0052] Specifically, as illustrated in FIG. **5**, the distribution unit **51** analyzes the image of the inputted image information and detects the two-dimensional position of each article W in the image capturing area **20** (step S**101**). Subsequently, the distribution unit **51** calculates the score of each article W by substituting the detected two-dimensional position of each article W in Formula (1) of the evaluation function information **53** (see FIG. **2**) (step S**102**).

[0053] Then, the distribution unit **51** determines robots to be distribution destinations so that the total score of the articles W distributed to one robot as transfer targets is even for each robot (step S**103**). Thereafter, the distribution unit **51** provides the article positions on the conveyance path **2** of the articles W, which are transfer targets, to the determined distribution destination robots (step S**104**) and ends the process.

[0054] As described above, in the robot system according to the first embodiment, the articles on the conveyance path surface are distributed to a plurality of robots as transfer targets on the basis of the information indicating the two-dimensional positions of the articles on the conveyance path surface. Thereby, the robot system according to the first embodiment can prevent the workload of each robot from becoming uneven.

[0055] In the present embodiment, the score of each article W is calculated by substituting the two-dimensional position of the article W in the image capturing area **20** into Formula (1). However, the formula used to calculate the score is not limited to Formula (1).

[0056] For example, the score of each article W may be calculated by using the following Formula (2):

$$R=A|X|+BY+C\alpha \qquad \text{Formula (2)}$$

[0057] Here, Formula (2) is a formula in which a term Cα for converting a factor to be a workload of a robot when the robot transfers the article W other than the two-dimensional position of the article W in the image capturing area **20** into a score is added to the right side of Formula (1).

[0058] The distribution unit **51** calculates the score of each article W by using Formula (2), so that the distribution unit **51** can distribute the articles W on the conveyance path **2** to each robot so that the workload of each robot is more accurately even.

[0059] Specifically, when an article W is transferred from the conveyance path **2** by the robot, the workload of the robot when the robot transfers the article W varies due to a difference of type of the article W on the conveyance path **2**. For example, regarding a relatively heavy article W and a relatively light article W, the workload for transferring the former is greater than that for transferring the latter.

[0060] Further, regarding an article W that can be transferred relatively roughly and an article W that needs to be transferred relatively carefully, the time required to transfer the latter is longer than that required to transfer the former, so that the workload for transferring the latter is greater than that for transferring the former. The workload of the robot when the robot transfers the article W varies due to, for example, a difference between face up and face down of the conveyed article W and an orientation (angle) of the conveyed article W in addition to the type of the article W.

[0061] When there is a factor to be a workload of the robot when the robot transfers the article W other than the two-

dimensional position of the article W in the image capturing area **20**, the distribution unit **51** calculates the score of each article W by using the aforementioned Formula (2).

[0062] In this case, the distribution unit **51** identifies the type, orientation, face-up/face-down, and the like of the article W in the captured image by analyzing the image of the image information inputted from the two-dimensional position information acquisition unit **4**, calculates a value indicating the workload of the robot according to the identification result, and substitutes the value into Cα in Formula (2). Further, the distribution unit **51** substitutes the two-dimensional position of the article W, of which type, orientation, face-up/face-down, and the like are identified, in the image capturing area **20** into the aforementioned Formula (2) and calculates the score of each article W.

[0063] Thereby, the distribution unit **51** can distribute the articles W on the conveyance path **2** to each robot so that the workload of each robot is more accurately even on the basis of the score of each article W calculated by using Formula (2).

Second Embodiment

[0064] Next, a robot system **1***a* according to a second embodiment will be described with reference to FIG. **6**. FIG. **6** is a block diagram illustrating a configuration of the robot system **1***a* according to the second embodiment. Here, among components of the robot system **1***a*, the same components as those of the robot system **1** illustrated in FIG. **2** are denoted by the same reference numerals as those in FIG. **2** and the description thereof will be omitted.

[0065] As illustrated in FIG. **6**, the robot system **1***a* is different from the robot system **1** illustrated in FIG. **2** in that the robot system **1***a* includes a transfer result acquisition unit **41** in addition to the components illustrated in FIG. **2**, a robot controller **5***a* includes a coefficient correction unit **54**, and a storage unit **52***a* stores transfer result history information **53***a*.

[0066] The transfer result acquisition unit **41** is a processing unit that counts the number of articles W that are not transferred from the conveyance path **2** by any of the first robot **3-1** to the nth robot **3-***n*, for example, the number of articles W which the robots failed to transfer, and outputs the counted number of articles W to the coefficient correction unit **54** as a transfer result.

[0067] For example, the transfer result acquisition unit **41** counts the number of articles W that were not transferred by any of the robots by counting the number of articles W that pass through the takeout area on the conveyance path **2** from which the nth robot **3-***n* takes out the article W without being transferred by the nth robot **3-***n*.

[0068] The counting method of the number of articles W performed by the transfer result acquisition unit **41** is not limited to this. For example, the transfer result acquisition unit **41** may be configured to count the number of articles W that were not transferred by any of the robots by subtracting the sum of the numbers of articles W that are transferred to each place **30** from the total number of articles W that are conveyed by the conveyance path **2**.

[0069] The coefficient correction unit **54** is a processing unit that corrects the coefficients A and B in Formula (1) used to calculate the score of each article W by a distribution unit **51***a*. In the coefficient correction unit **54**, the coefficients A and B in Formula (1) are inputted from the distribution unit **51***a* every predetermined time (for example, every hour) and a transfer result is inputted from the transfer result acquisition unit **41**.

[0070] Then, the coefficient correction unit **54** associates the transfer result inputted from the transfer result acquisition unit **41** with the coefficients A and B inputted from the distribution unit **51***a* and stores the transfer result and the coefficients A and B in the storage unit **52***a* as the transfer result history information **53***a*.

[0071] Further, when the transfer result is inputted from the transfer result acquisition unit **41** and the coefficients A and B are inputted from the distribution unit **51***a*, the coefficient correction unit **54** compares the transfer result and the coefficients A and B which are inputted at this time with the transfer result history information **53***a*.

[0072] Then, the coefficient correction unit **54** corrects the coefficients A and B in Formula (1) of the evaluation function information **53** so that the transfer result to be inputted next time is improved, that is, the number of articles W that were not transferred by any of the robots decreases, on the basis of the comparison result.

[0073] As described above, in the robot system according to the second embodiment, the coefficient correction unit corrects the coefficients in the evaluation function by feedback control so that the next transfer result is improved on the basis of a history of the transfer result at this time and the transfer result in the past.

[0074] Therefore, according to the robot system of the second embodiment, it is possible to prevent the workload of each robot from becoming uneven as well as to reduce the number of articles that are not transferred from the conveyance path by the robots.

Third Embodiment

[0075] Next, a robot system **1***b* according to a third embodiment will be described with reference to FIG. **7**. FIG. **7** is an explanatory diagram illustrating a part of the robot system **1***b* according to the third embodiment. Here, among components of the robot system **1***b*, the same components as those of the robot system **1** illustrated in FIG. **1** are denoted by the same reference numerals as those in FIG. **1** and the description thereof will be omitted. In FIG. **7**, the first robot **3-1** and the second robot **3-2** are indicated by an ellipse.

[0076] As illustrated in FIG. **7**, the robot system **1***b* is different from the robot system **1** illustrated in FIG. **1** in that the distances from each robot to the conveyance path **2** are different from each other and the calculation method of the score of each article W by the distribution unit (not illustrated in FIG. **7**) of a robot controller **5***b* is different from that of the robot system **1**.

[0077] The distribution unit of the robot controller **5***b* according to the present embodiment distributes the articles W on the surface of the conveyance path **2** to a plurality of robots as transfer targets on the basis of the relative position between each robot and the conveyance path **2**. More specifically, the distribution unit distributes the articles W to any of a plurality of robots as transfer targets on the basis of the relative position between a robot and the two-dimensional position of the article W on the conveyance path **2** when the article W is conveyed to a position from which the article W is transferred by the robot.

[0078] For example, it is assumed that the distance from the article W of which image is captured by the two-dimensional position information acquisition unit **4** and which is conveyed to the first takeout area **2-1** to the first robot **3-1** is L1, and the distance from the article W of which image is captured by the

two-dimensional position information acquisition unit **4** and which is conveyed to the second takeout area **2-2** to the second robot **3-2** is L2.

[0079] Here, it is assumed that the distances from each place **30** (see FIG. **1**) that is the transfer destination of the article W to the conveyance path **2** are the same.

[0080] In this case, the workloads from when the first robot **3-1** and the second robot **3-2** hold the article W on the conveyance path **2** to when the first robot **3-1** and the second robot **3-2** transfer the article W to the places **30** are the same. However, the workloads to when the first robot **3-1** and the second robot **3-2** hold the article W on the conveyance path **2** are not the same.

[0081] Therefore, when the distribution unit calculates the score of each article W, the distribution unit calculates the score of one article W for each robot by using a different formula of evaluation function according to the difference of the distance from each robot to the conveyance path **2**.

[0082] Then, the distribution unit determines robots to be distribution destinations so that the total score of the articles W distributed to one robot as transfer targets is even for each robot, and provides article positions on the conveyance path **2** of the articles W, which are transfer targets, to the determined distribution destination robots.

[0083] For example, when calculating the score of the article W of which image is captured in the image capturing area **20** illustrated in FIG. **7**, the distribution unit calculates the score when the first robot **3-1** transfers the article W by using the aforementioned Formula (1): R=A|X|+BY.

[0084] On the other hand, the distribution unit calculates the score when the second robot **3-2** transfers the article W by using the following Formula (3):

$$R=A|X|+B(Y+(L2-L1)) \quad \text{Formula (3)}$$

[0085] The distribution unit also calculates the score when another robot transfers the article W by using a formula of a different evaluation function according to the difference of the distance from the robot to the conveyance path **2**. Thereby, the distribution unit of the robot system **1***b* can calculate the score accurately reflecting the workload when each robot transfers the article W.

[0086] Then, the distribution unit calculates the score for each robot for each of a plurality of articles W conveyed to the image capturing area **20** and distributes the articles W, which are transfer targets, to each robot so that the total score of the articles W distributed to one robot as transfer targets is even for each robot.

[0087] As described above, the distribution unit of the robot system according to the third embodiment distributes the articles to any of a plurality of robots as transfer targets on the basis of the relative position between each robot and the two-dimensional position of the article on the conveyance path when the article is conveyed to a position from which the article is transferred by each robot.

[0088] Thereby, according to the robot system of the third embodiment, even when the distance from the conveyance path to each robot is different from each other, it is possible to prevent the workload of each robot from becoming uneven.

[0089] Here, a case in which the robots are arranged on the same side of the conveyance path is described. However, a plurality of robots may be arranged on both sides of the conveyance path. In this case, the distribution unit calculates the score of one article for each robot by using a different formula of evaluation function according to a positional relationship between each robot and the conveyance path.

[0090] Then, the distribution unit distributes the articles, which are transfer targets, to each robot so that the total score of the articles distributed to one robot as transfer targets is even for each robot. Thereby, even when a plurality of robots is arranged on both sides of the conveyance path, it is possible to prevent the workload of each robot from becoming uneven.

Fourth Embodiment

[0091] Next, a robot system **1***c* according to a fourth embodiment will be described with reference to FIG. **8**. FIG. **8** is a block diagram illustrating a configuration of the robot system **1***c* according to the fourth embodiment. Here, among components of the robot system **1***c*, the same components as those of the robot system **1** illustrated in FIG. **2** are denoted by the same reference numerals as those in FIG. **2** and the description thereof will be omitted.

[0092] The robot system **1***c* illustrated in FIG. **8** includes n robot controllers (a first robot controller **5-1** to an nth robot controller **5-***n*), each of which is connected to each of the first robot **3-1** to the nth robot **3-***n*, respectively.

[0093] The first robot controller **5-1** to the nth robot controller **5-***n* function as instruction units that issue various operation instructions to the first robot **3-1** to the nth robot **3-***n*, respectively.

[0094] Further, the robot system **1***c* includes an integrated controller **50** connected to the first robot controller **5-1** to the nth robot controller **5-***n* and the two-dimensional position information acquisition unit **4**. The integrated controller **50** has the same function as that of the distribution unit **51** illustrated in FIG. **2** in the robot system **1***c*.

[0095] In other words, the integrated controller **50** includes a distribution unit **51***c* and the storage unit **52**. In the same manner as the distribution unit **51** illustrated in FIG. **2**, the distribution unit **51***c* of the integrated controller **50** calculates the score of each article W in the image capturing area **20** based on the image information inputted from the two-dimensional position information acquisition unit **4** and the evaluation function information **53** stored in the storage unit **52**.

[0096] Then, the distribution unit **51***c* determines robots to be distribution destinations so that the total score of the articles W distributed to one robot as transfer targets is even for each robot, and provides article positions on the conveyance path **2** of the articles W, which are transfer targets, to the determined distribution destination robots. Thereby, in the robot system **1***c*, it is possible to prevent the workload of each robot from becoming uneven.

[0097] Further, in the robot system **1***c*, it is possible to decentralize the function of the robot controller **5** illustrated in FIG. **2** to the first robot controller **5-1** to the nth robot controller **5-***n* and the integrated controller **50**.

[0098] Therefore, according to the robot system **1***c*, it is possible to use an inexpensive controller having a processing capacity lower than that of the robot controller **5** illustrated in FIG. **2** as the first robot controller **5-1** to the nth robot controller **5-***n* and the integrated controller **50**.

[0099] Further, according to the robot system **1***c*, it is possible to add a robot by only adding the robot and a robot controller that issues operation instructions to the robot without largely changing the control content of the integrated controller **50**. Therefore, according to the robot system **1***c*, it is possible to easily add robots and further improve transfer efficiency of the articles W.

[0100] As described above, according to the fourth embodiment, robots can be easily added, so that it is possible to achieve a robot system that can reduce articles that are not transferred by any of robots at lower cost.

[0101] In the same manner, also in the robot systems **1***a* and **1***b* illustrated in FIGS. **6** and **7**, a robot controller may be provided to each robot and the integrated controller **50** may be provided as a higher-level device of the robot controllers.

[0102] Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

What is claimed is:

1. A robot system comprising:

an information acquisition unit that acquires information indicating a two-dimensional position on a surface of a conveyance path of an article conveyed on the conveyance path;

a plurality of robots that transfer the article from the conveyance path; and

a distribution unit that distributes the articles on the surface of the conveyance path to the plurality of robots as transfer targets on the basis of the information acquired by the information acquisition unit.

2. The robot system according to claim **1**, wherein

the distribution unit distributes the articles on the surface of the conveyance path to the plurality of robots as transfer targets on the basis of a relative position between the robot and the conveyance path.

3. The robot system according to claim **1**, wherein

the distribution unit grades the article for each article based on the information acquired by the information acquisition unit and a predetermined evaluation function and distributes the articles based on a result of the grading.

4. The robot system according to claim **2**, wherein

the distribution unit grades the article for each article based on the information acquired by the information acquisition unit and a predetermined evaluation function and distributes the articles based on a result of the grading.

5. An article transfer method comprising:

acquiring information indicating a two-dimensional position on a surface of a conveyance path of an article conveyed on the conveyance path by an information acquisition unit;

transferring the article from the conveyance path by a plurality of robots; and

distributing the articles on the surface of the conveyance path to the plurality of robots by a distribution unit as transfer targets on the basis of the information acquired by the information acquisition unit.

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