

DESCRIPTION

TITLE OF INVENTION:

BINDING SYSTEM AND BINDING PROCESSING PROGRAM

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TECHNICAL FIELD

[0001] The present invention relates to a binding system including a binding machine that binds reinforcing bars with wires and a binding processing program.

10 BACKGROUND ART

[0002] Reinforcing bars are used in concrete structures to improve strength, and the reinforcing bars are bound by a binding machine with wires to be prevented from deviating from predetermined positions during concrete pouring.

At an intersection of the intersecting reinforcing bars, binding is performed with the wires along a direction oblique to any reinforcing bar. For example, when one reinforcing bar along a front-rear direction and the other reinforcing bar along a left-right direction intersect each other, binding can be performed with the wires along a left oblique forward direction and along a right oblique forward direction.

[0003] In a binding system of the related art, binding is simultaneously performed at a plurality of intersections by a plurality of binding machines arranged in a row such that binding directions thereof are alternately different from each other (for example, see Patent Literature 1).

In addition, in another binding system of the related art, a binding machine is mounted on a head of a gantry type mobile apparatus, and binding is sequentially performed at a plurality of intersections of a workpiece (for example, refer to Patent Literature 2).

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CITATION LIST

PATENT LITERATURE

[0004] Patent Literature 1: JP2013-035052A
Patent Literature 2: JPH06-219420A

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SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] In any of the above-described binding systems of the related art, the binding with

the wires is performed while alternately facing different directions at intersections of reinforcing bars along one direction, but the binding with the wires is performed while uniformly facing the same direction at the intersections of the reinforcing bars along the other direction.

5 Therefore, there is room for lowering the binding strength of the reinforcing bars.

[0006] The present invention has been made to solve such a problem, and an object thereof is to provide a binding system and a binding processing program for performing binding with high strength.

SOLUTION TO PROBLEM

10 [0007] In order to solve the above-described problem, a binding system of the present invention is a binding system for binding a workpiece, in which a plurality of reinforcing bars and a plurality of reinforcing bars intersect to form a plurality of intersections, with a binding body by a moving binding device at each of the plurality of intersections, and

the binding system includes:

15 a control unit configured such that, with respect to one reinforcing bar and another reinforcing bar that form the intersection, at least one other intersection in the one reinforcing bar, which is different from the intersection formed by the one reinforcing bar and the other reinforcing bar, and at least one other intersection in the other reinforcing bar, which is different from the intersection formed by the one reinforcing bar and the other reinforcing bar,
20 are bound with the binding body along a direction different from a direction in which the intersection formed by the one reinforcing bar and the other reinforcing bar is bound with the binding body.

[0008] A binding processing program of the present invention causes a computer that controls a binding system for binding a workpiece, in which a plurality of reinforcing bars and
25 a plurality of reinforcing bars intersect to form a plurality of intersections, with a binding body by a moving binding device at each of the plurality of intersections, to realize a function of performing control of

binding, with respect to one reinforcing bar and another reinforcing bar that form the intersection, at least one other intersection in the one reinforcing bar, which is different
30 from the intersection formed by the one reinforcing bar and the other reinforcing bar, and at least one other intersection in the other reinforcing bar, which is different from the intersection formed by the one reinforcing bar and the other reinforcing bar, with the binding body along a direction different from a direction in which the intersection formed by the one

reinforcing bar and the other reinforcing bar is bound with the binding body.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] According to the present invention, it is possible to prevent a plurality of intersections in reinforcing bars constituting a workpiece from being bound with a binding body only in the same direction, to reduce a gap between the reinforcing bars to realize strong binding.

BRIEF DESCRIPTION OF DRAWINGS

[0010] [FIG. 1] FIG. 1 is a perspective view illustrating a device body of a binding system according to an embodiment;

[FIG. 2] FIG. 2 is a block diagram illustrating a schematic control configuration of the binding system according to the embodiment;

[FIG. 3] FIG. 3 is a side view illustrating the binding device in a posture when performing a binding operation;

[FIG. 4] FIG. 4 is a schematic diagram illustrating a workpiece on a holding table of a workpiece holding unit as viewed from above;

[FIG. 5] FIG. 5 is a plan view illustrating an intersection at which binding is performed in a first direction of a binding direction;

[FIG. 6] FIG. 6 is a plan view illustrating an intersection at which binding is performed in a second direction of the binding direction;

[FIG. 7] FIG. 7 is a diagram illustrating the distinction among an "intersection located at a corner", an "intersection located on an outer edge", and the other intersections;

[FIG. 8] FIG. 8 is a plan view illustrating a workpiece that has been subjected to a binding direction determination process under a condition (1);

[FIG. 9] FIG. 9 is a plan view illustrating the workpiece that has been subjected to the binding direction determination process under a condition (2);

[FIG. 10] FIG. 10 is a plan view illustrating the workpiece that has been subjected to the binding direction determination process under a condition (3);

[FIG. 11] FIG. 11 is a plan view illustrating the workpiece that has been subjected to the binding direction determination process under a condition (4);

[FIG. 12] FIG. 12 is an enlarged plan view illustrating the workpiece at the intersection that has been subjected to the binding direction determination process under the condition (4);

[FIG. 13] FIG. 13 is a plan view illustrating the workpiece that has been subjected to the binding direction determination process under a condition (5);

[FIG. 14] FIG. 14 is a plan view illustrating a binding device in FIG. 3 viewed from one side of a turning axis;

[FIG. 15] FIG. 15 is a plan view in which a part of a configuration of the device body is omitted; and

[FIG. 16] FIG. 16 is a flow chart illustrating a procedure when the binding system performs a binding process.

DESCRIPTION OF EMBODIMENTS

[0011] Hereinafter, a first embodiment of the present invention will be described with reference to the drawings.

[0012] [Configuration of Binding System]

FIG. 1 is a perspective view illustrating a device body 10C included in a binding system 1D according to the present embodiment, and FIG. 2 is a block diagram illustrating a schematic control configuration of the binding system 1D.

As illustrated in these drawings, the binding system 1D binds, with a wire W as a binding body, a workpiece B in which a plurality of reinforcing bars S are arranged in a grid pattern at intersections P (see FIG. 4) at which the plurality of reinforcing bars S intersect.

Specifically, the binding system 1D includes the device body 10C and a control device 7D.

[0013] The device body 10C includes a workpiece holding unit 2, an entire imaging unit 3, a robotic arm 4, an individual imaging unit 5, and a binding device 6C. Of these, the workpiece holding unit 2 is disposed inside a gantry 11 of the device body 10C, and the entire imaging unit 3, the robotic arm 4, the individual imaging unit 5, and the binding device 6C are mounted on the gantry 11.

In the following description, X, Y, and Z directions refer to directions illustrated in FIG. 1. The X, Y, and Z directions are orthogonal to each other, an XY plane is a substantially horizontal plane, and the Z direction is a direction substantially along a vertical direction. For the sake of convenience, it is assumed that the X, Y, and Z directions coincide with a coordinate system of a robot in the robotic arm 4 to be described later.

[0014] The gantry 11 is formed in a rectangular parallelepiped shape elongated in the X direction, and includes four support columns 12 erected at four corners in the X direction and

the Y direction, and four beams 13 bridged in the X direction and the Y direction at upper ends of the support columns 12.

In an area inside the gantry 11, a substantially half portion on one side (right side in FIG. 1) in the X direction is an imaging area E1 in which imaging by the entire imaging unit 3 is performed, and a half portion on the other side (left side in FIG. 1) is a binding area E2 in which a binding work by the robotic arm 4 and the binding device 6C is performed.

[0015] <Workpiece Holding Unit>

The workpiece holding unit 2 holds the workpiece B and moves the held workpiece B between the imaging area E1 and the binding area E2. Specifically, the workpiece holding unit 2 includes a holding table 21 that holds the workpiece B, a rail 22 that movably supports the holding table 21, and a driving motor 23 that drives the rail 22.

The holding table 21 is formed in a rectangular plate shape having four sides along the X direction and the Y direction. Support plates 211 that support the plurality of reinforcing bars S constituting the workpiece B are erected on the four sides of the holding table 21. Each of the support plates 211 has a plurality of U-shaped grooves 211a opening upward, and the reinforcing bars S are inserted into the U-shaped grooves 211a. The plurality of reinforcing bars S are arranged in a grid pattern along the X direction and the Y direction in a state where ends of the reinforcing bars S are inserted into the U-shaped grooves 211a of the support plates 211.

The rail 22 is laid along the X direction and guides the holding table 21 in the X direction. The rail 22 according to the present embodiment is laid such that the holding table 21 (workpiece B) is movable at least over the imaging area E1 and the binding area E2. However, the rail 22 may be extended to an outside of the gantry 11, and the workpiece B may be movable to a work process before and after binding.

The driving motor 23 is a driving source that causes the holding table 21 to move. The driving motor 23 causes the holding table 21 to move to the imaging area E1 and the binding area E2 based on a driving command from the control device 7D.

[0016] <Entire Imaging Unit>

The entire imaging unit 3 images the entire workpiece B in the imaging area E1. Specifically, the entire imaging unit 3 includes a first camera 31 disposed above the imaging area E1 and a movement mechanism 32 that movably supports the first camera 31.

The first camera 31 is disposed to face downward, images the workpiece B held by the workpiece holding unit 2 from above in the imaging area E1, and acquires signal

information including distance information to the reinforcing bars and image information of the workpiece. Specifically, the first camera 31 according to the present embodiment is a compound-eye (for example, four-eye) stereo camera (RGB-D camera), acquires distance information in a depth direction (upper-lower direction) together with image information on the XY plane, and outputs the distance information to the control device 7D. The first camera 31 is an example of a first information acquisition unit according to the present invention. A sensor type or the like of the first camera 31 is not particularly limited as long as the first camera 31 can acquire the distance information (depth information) together with the image information, and may be a time of flight (TOF) sensor or the like. Further, a sensor such as a 3D laser scanner or a light detection and ranging (LiDAR) sensor may be used instead of the camera.

The movement mechanism 32 includes a Y direction slider 33 extending along the Y direction. The Y direction slider 33 is bridged over the beams 13 along the X direction and is supported by the beams 13 to be movable in the X direction. The first camera 31 is suspended from the Y direction slider 33 to be movable in the Y direction. The movement mechanism 32 drives a driving source (not illustrated) based on a control command from the control device 7D to cause the first camera 31 to move to a predetermined position (XY coordinates).

The movement mechanism 32 is for imaging the entire workpiece B a plurality of times in order to obtain an image of the workpiece B with a desired resolution. Therefore, depending on the performance of the first camera 31, a shape of the workpiece B, and the like, the movement mechanism 32 may include an X direction slider that causes the Y direction slider 33 to move in the X direction, may cause the first camera 31 to move only in one of the X and Y directions, or may not be provided. In addition, when an imaging range of the first camera 31 is that the entire holding table 21 or the entire workpiece B located in the imaging area E1 can be imaged at one time, the first camera 31 may be fixedly supported at a fixed point.

[0017] <Robotic Arm>

The robotic arm 4 is an example of a moving body according to the present invention, is mounted with the individual imaging unit 5 and the binding device 6C, and causes the individual imaging unit 5 and the binding device 6C to move to desired positions in the binding area E2. The robotic arm 4 according to the present embodiment includes a movement mechanism 46, a robotic arm body 40, and a controller 49.

[0018] The movement mechanism 46 causes the robotic arm body 40 to move. The movement mechanism 46 according to the present embodiment includes Y direction sliders 461 bridged over the beams 13 of the gantry 11. The Y direction sliders 461 cause the robotic arm body 40 to move in the Y direction.

5 However, a specific configuration of the movement mechanism 46 is not particularly limited, and may include, for example, a mechanism that causes the robotic arm body 40 to move in the X direction. In addition, when an operation range of the robotic arm body 40 can cover the entire binding area E2 without depending on the movement mechanism 46, the movement mechanism 46 may not be provided.

10 [0019] The robotic arm body 40 is a suspended vertical multi-joint robot, and is installed downward on the Y direction sliders 461 bridged over the beams 13 in the binding area E2.

Specifically, the robotic arm body 40 includes a base 41, a plurality of arms 42, an end effector 43, and a plurality of joints 44.

The robotic arm body 40 is not limited to the vertical multi-joint robot as long as the robotic arm body 40 can move the individual imaging unit 5 and the binding device 6C mounted thereon.

[0020] The plurality of arms 42 are coupled in series to each other with the base 41 as a proximal end.

The base 41 is mounted on the Y direction sliders 461 of the movement mechanism 46 and is supported to be movable in the Y direction.

The plurality of joints 44 pivotably couple the base 41, the plurality of arms 42, and the end effector 43. Each joint 44 is provided with a motor 441 that drives the arm 42 (or the end effector 43) coupled to a distal end side of the joint 44, and an encoder 442 that detects a position (speed) of the motor 441 and outputs the position (speed) to the controller 49.

25 The end effector 43 is coupled to distal ends of the plurality of arms 42. The individual imaging unit 5 and the binding device 6C are mounted on the end effector 43. A specific configuration of the robotic arm body 40 is not particularly limited as long as the individual imaging unit 5 and the binding device 6C are mounted on a distal end of the robotic arm body 40. For example, the individual imaging unit 5 may be fixed to the joint 44 on the most distal end side, and the binding device 6C may be coupled as an end effector via a tool changer.

[0021] The controller 49 controls an operation of each part of the robotic arm 4 based on a control command from the control device 7D. Specifically, the controller 49 causes each

motor 441 and the movement mechanism 46 to operate, and outputs information acquired by each encoder 442 to the control device 7D.

The controller 49 may locally control an operation of the mounted individual imaging unit 5 or binding device 6C based on a control command from the control device 7D.

5 [0022] <Individual Imaging Unit>

The individual imaging unit 5 is mounted on a distal end of the robotic arm 4 and individually images the intersections P of the reinforcing bars S as binding objects in the binding area E2 with a resolution higher than that of the imaging by the entire imaging unit 3. Specifically, the individual imaging unit 5 includes a second camera 51, an elevator motor 52,
10 and an illumination unit 53.

The second camera 51 is attached to the end effector 43 of the robotic arm 4 in a distal end (downward) direction, and images the intersections P of the reinforcing bars S as binding objects from above. The second camera 51 is provided to be movable in a distal direction (upper-lower direction) relative to the end effector 43. The second camera 51
15 according to the present embodiment is, for example, an RGB camera, acquires image information (color image) of the intersections P as the binding objects, and outputs the image information to the control device 7D. The second camera 51 is an example of a second information acquisition unit according to the present invention. A sensor type and the like of the second camera 51 are not particularly limited as long as the second camera 51 can acquire
20 an image of at least one intersection P (signal information of an intersection of reinforcing bars including an image).

The elevator motor 52 is a driving source that causes the second camera 51 to move (lift and lower) in the distal direction (upper-lower direction) relative to the end effector 43.

The illumination unit 53 is disposed slightly in front of the second camera 51 in an
25 imaging direction and around an imaging range, and illuminates an imaging object of the second camera 51. The illumination unit 53 according to the present embodiment includes a plurality of light sources (light projectors, not illustrated) capable of illuminating the imaging object of the second camera 51 from different angles. The illumination unit 53 may be configured to emit pattern light from a plurality of directions and acquire three-dimensional
30 information around the intersections P in cooperation with the second camera 51.

[0023] <Binding Machine>

FIG. 3 is a side view of the binding device 6C in a posture when performing a binding operation.

The binding device 6C is mounted on the distal end of the robotic arm 4. The binding device 6C includes a reinforcing bar binding machine 61C that performs binding at each of the intersections P of the reinforcing bars S constituting the workpiece B with the wires W, a slack forming unit 62C that draws the wires W from reels 63C and forms a slack in the wires W between the binding machine 61C and the reels 63C, and a control unit 64C that causes the reinforcing bar binding machine 61C to perform a binding operation and causes the slack forming unit 62C to perform a slack forming operation of the wires W according to operation commands from the control device 7D.

[0024] The reinforcing bar binding machine 61C has an entry portion 611C into which two wires W are fed from an outside of a case along a feed direction F illustrated in the drawing, and binds the reinforcing bars S with the wires W by winding the two wires W, that are fed from the entry portion 611C into an inside, around the reinforcing bars S, feeding the two wires W wound around the reinforcing bars S in a reverse feed direction R to wind the wires W on the reinforcing bars S, cutting off the wires W, and then twisting the wires W.

[0025] Therefore, the binding machine 61C includes a wire feed unit that feeds the wires W, a wire guide 612C that guides the wires W, a curl guide 613C and an inducing guide 614C that wind the wires W around the reinforcing bars S, a cut unit that cuts the wires W wound on the reinforcing bars S, and a binding unit that twists the wires W wound on the reinforcing bars S.

[0026] The wire guide 612C is provided in front of the entry portion 611C and guides the two wires W to enter the entry portion 611C along the feed direction F.

[0027] The wire feed unit is located inside the entry portion 611C and feeds the two wires W along the feed direction F while clamping the two wires W with a pair of feed gears. The wire feed unit includes a feeding motor 615C (see FIG. 2) as a driving source. The feeding motor 615C feeds the two wires W in the feed direction F by forward rotation driving, and thus the wires W can be wound around the reinforcing bars S by the curl guide 613C and the inducing guide 614C located ahead of the feeding motor 615C. Further, the feeding motor 615C feeds the two wires W in the reverse feed direction R by reverse rotation driving, and thus the reinforcing bars S can be tightened with the wires W.

[0028] The cut unit is located inside the entry portion 611C and on a further deeper side of the wire feed unit. The cut unit includes a movable blade and a fixed blade which are not illustrated, and shares a driving source of the movable blade with the binding unit. The movable blade can be moved toward the fixed blade by a twisting motor 616C (see FIG. 2),

which is a driving source of the binding unit, to cut the two wires.

The driving source of the cut unit may be separately provided.

[0029] The binding device 6C of FIG. 3 is supported by the end effector 43 on the distal end of the robotic arm 4, and performs the binding operation in a state where a turning axis Z_r of the end effector 43 is parallel to the Z direction (vertically upper-lower direction). Further, the binding device 6C is set such that a position at which binding of the reinforcing bars S with the wires W is performed is located on an axis of the turning axis Z_r , and the robotic arm 4 positions the binding device 6C during the binding such that each of the intersections P of the reinforcing bars S is on the axis of the turning axis Z_r .

[0030] The curl guide 613C and the inducing guide 614C are located at a distal end (a lower end during the binding operation) of the binding machine 61C, and are respectively disposed on both sides of the turning axis Z_r while sandwiching the turning axis Z_r .

A proximal end of the curl guide 613C is disposed ahead of the entry portion 611C in the feed direction F, and a guide path for curling the wires W in a process from the proximal end toward a distal end of the curl guide 613C is formed inside the curl guide 613C.

[0031] The inducing guide 614C is disposed to face the curl guide 613C, and a guide path for receiving the wires W curled by the curl guide 613C from a distal end and guiding the wires W toward a proximal end while maintaining the curled state is formed inside the inducing guide 614C.

By cooperation of the curl guide 613C and the inducing guide 614C, the wires W can be deformed into a loop shape and wound around the reinforcing bars S.

[0032] The binding unit includes a locking member that captures the wires W in a state of being wound around the reinforcing bars S between the proximal end of the inducing guide 614C and the proximal end of the curl guide 613C. The locking member is supported inside the binding machine 61C rotatably around a rotation axis concentric with the turning axis Z_r , and is applied with a torque for performing rotational driving from the twisting motor 616C. The locking member can be rotationally driven by the twisting motor 616C after the wires W are cut by the cut unit, and can twist both ends of the wires W to bind the reinforcing bars S.

[0033] Two reels 63C of the wires W are rotatably supported side by side on one side (an upper side during the binding operation) in a direction along the turning axis Z_r of the binding machine 61C. The two reels 63C are rotatable around an axis along a direction perpendicular to the page in FIG. 3 and are arranged side by side along the same direction.

[0034] As illustrated in FIG. 3, the slack forming unit 62C is disposed on one side in an

orthogonal direction X_w orthogonal to the turning axis Z_r with respect to the binding machine 61C and the two reels 63C.

The slack forming unit 62C includes a first slack forming unit 621C and a second slack forming unit 622C that perform mutual crossing operations, and a slack forming motor 623C that is a driving source of the mutual crossing operations.

[0035] The above-described feed direction F of the wires W is substantially parallel to a plane that is parallel to both the turning axis Z_r and the orthogonal direction X_w . Further, an upstream side of the feed direction F of the wires W is slightly inclined upward in the paper of FIG. 3 with respect to the orthogonal direction X_w .

Each of the first slack forming unit 621C and the second slack forming unit 622C holds a roller over which the two wires W are stretched.

[0036] Then, each of the first slack forming unit 621C and the second slack forming unit 622C performs the crossing operation substantially along the feed direction F , thus extending a path length of the wire W from the reel 63C to the entry portion 611C of the binding machine 61C and drawing out the wire W from the reel 63C. Further, each of the first slack forming unit 621C and the second slack forming unit 622C performs a restoration operation after the crossing operation, and thus a slack corresponding to an amount drawn out from the reel 63C can be applied to the wire W .

[0037] The two wires W are required to be fed to the entry portion 611C of the binding machine 61C from a direction close to the feed direction F , that is, at an incident angle close to the feed direction F . The feed direction F is a direction suitable for deforming the wires W into an appropriate loop shape by the curl guide 613C and the inducing guide 614C located ahead in an advance direction.

In order to supply the wires W to the entry portion 611C of the binding machine 61C along the feed direction F , the slack forming unit 62C is disposed such that a path from the second slack forming unit 622C on a downstream side to the entry portion 611C of the binding machine 61C is along the feed direction F . Then, during the crossing operation, the second slack forming unit 622C performs a separation movement in a direction away from the entry portion 611C of the binding machine 61C along the feed direction F .

[0038] Therefore, the binding device 6C is disposed such that the slack forming unit 62C largely protrudes on one side (a right side of the page in FIG. 3) in the orthogonal direction X_w with respect to the binding machine 61C (turning axis Z_r).

The second camera 51 and the illumination unit 53 of the individual imaging unit 5

are disposed on a left side of the page in FIG. 3 with respect to the binding machine 61C of the binding device 6C.

[0039] <Control Device>

The control device 7D is a computer that integrally controls the binding system 1D.
5 Specifically, the control device 7D includes an operation unit 72, a display unit 73, a storage unit 76D, and a control unit 77D.

The operation unit 72 is an operation unit by which a user performs various operations for operating the control device 7D, and includes, for example, a keyboard and a pointing device such as a mouse.

10 The display unit 73 includes, for example, a liquid crystal display, an organic EL display, or other displays, and displays various information based on a display signal from the control unit 77D. The display unit 73 may be a touch panel that also serves as a part of the operation unit 72, or may perform sound output.

[0040] The storage unit 76D is a memory including a random access memory (RAM), a read only memory (ROM), and the like, stores various programs and data, and also functions
15 as a work area of the control unit 77D.

The storage unit 76D serving as a recording apparatus stores image data 762D captured by the first camera 31 and the second camera 51, map data 763D in which information on the workpiece B is recorded, binding direction data 764D generated by a
20 binding direction determination process to be described later, device information data 766D indicating a three-dimensional position of an entire surface of the binding device 6C, and peripheral information data 767D indicating a three-dimensional position of an entire surface of an obstacle around the robotic arm 4 developed in a coordinate system of the robotic arm 4.

[0041] The control unit 77D includes, for example, a central processing unit (CPU), and
25 controls an operation of each unit of the control device 7D. Specifically, the control unit 77D causes each unit of the control device 7D to operate based on an operation content of the operation unit 72 or the like, loads programs stored in advance in the storage unit 76D, and executes various processes in cooperation with the loaded programs.

[0042] <Intersection Information Acquisition Process>

30 The control unit 77D executes a binding processing program 761D to acquire information on the intersections P at which the plurality of reinforcing bars S of the workpiece B intersect.

As described above, the control unit 77D controls the device body 10C to perform

binding with the wires W serving as the binding body at each of the intersections P at which the plurality of reinforcing bars S of the workpiece B intersect.

[0043] FIG. 4 is a schematic diagram of the workpiece B held by the support plate 211 of the holding table 21 of the workpiece holding unit 2 as viewed from above in the Z direction.

5 In this schematic diagram, the number of reinforcing bars S of the workpiece B is illustrated to be smaller than that in FIG. 1. In addition, a plurality of double circles in the drawing are marks indicating positions of the intersections P, and do not indicate an object existing on the actual workpiece B. Further, since the number of reinforcing bars S and intersections P in the drawing is large, only some of reinforcing bars S and intersections P are denoted by reference
10 numerals. The same applies to FIGS. 7 to 11 and 15.

[0044] The workpiece B has a grid pattern in which a plurality of reinforcing bars S along the Y direction are arranged on a plurality of reinforcing bars S along the X direction. The reinforcing bars S along the X direction and the reinforcing bars S along the Y direction may be upside down. Further, the plurality of reinforcing bars S along each direction are illustrated
15 in a state of being arranged at uniform intervals, or the inter-intervals between the reinforcing bars S may be non-uniform. In addition, the lengths may be non-uniform.

Positions where center lines of the plurality of reinforcing bars S along the X direction and the plurality of reinforcing bars S along the Y direction intersect when viewed from the Z direction are the intersections P, and the binding system 1D can set each of the
20 intersections P as a binding object.

[0045] For a binding operation control of the control unit 77D, the information on the intersections P for specifying the positions of the intersections P at which the reinforcing bars S of the workpiece B intersect is necessary.

Therefore, the control unit 77D performs an intersection information acquisition
25 process of acquiring the information on the intersections P for specifying the positions of all the intersections P of the workpiece B.

The intersection information acquisition process includes a first acquisition process of acquiring a position of each intersection P from the image data 762D captured by the first camera 31 or the second camera 51 functioning as an intersection information acquisition
30 unit, and a second acquisition process of acquiring the map data 763D from the outside of the binding system 1D.

[0046] The control unit 77D may be configured to perform only one of the first acquisition process and the second acquisition process.

For example, when the control unit 77D is configured to perform only the first acquisition process, the storage unit 76D may be configured not to hold the map data 763D.

[0047] In the first acquisition process performed by the control unit 77D, when the image data 762D of the workpiece B on the holding table 21 captured by the first camera 31 or the second camera 51 is two-dimensional planar image data, a position of a contour of each of the reinforcing bars S in the image is extracted by known image processing, a center line passing through a center of each reinforcing bar S is obtained, and a position at which the center lines of the reinforcing bars S intersect each other is specified, and is acquired as a position of the intersection P. Further, height information of the intersection P may be obtained by performing imaging two or more times while changing a relative position between the first camera 31 or the second camera 51 and the workpiece B on the holding table 21, and calculating a height of each position in the image by parallax. Since three-dimensional position data of all the intersections P of the reinforcing bars S of the workpiece B is obtained in this way, by developing the three-dimensional position data in the coordinate system of the robotic arm 4, the information on the intersections P for specifying the positions of the intersections P is acquired.

[0048] When the image data 762D of the first camera 31 or the second camera 51 is image data including three-dimensional position information, position information indicated by the image data is developed in the coordinate system of the robotic arm 4 to acquire the information on the intersections P for specifying the positions of the intersections P.

[0049] The control device 7D includes a communication device (not illustrated) that communicates with the outside of the binding system 1D, and the second acquisition process performed by the control unit 77D is a process of requesting and acquiring the map data 763D from another external information processing terminal via a communication network.

Further, the control device 7D may include a reading device (not illustrated) that reads a storage medium storing the map data 763D, and may acquire the map data 763D by reading from the storage medium.

[0050] The map data 763D records design information of the workpiece B and the like, and includes basic dimensions and three-dimensional position information of each reinforcing bar S and the three-dimensional position information of each intersection P.

Therefore, the control unit 77D that performs the second acquisition process develops the three-dimensional position information of the respective intersections P obtained from the map data 763D in the coordinate system of the robotic arm 4 to acquire the

information on the intersections P for specifying the positions of the intersections P.

[0051] <Binding Direction Determination Process>

The control unit 77D executes the binding processing program 761D to execute the binding direction determination process on the intersections P of the reinforcing bars S of the workpiece B.

The binding direction determination process on the intersections P of the workpiece B is executed for all the intersections P of the workpiece B, based on information related to the intersections P for specifying positions of all the intersections P of the workpiece B acquired by the intersection information acquisition process.

Hereinafter, a method for the control unit 77D to determine a binding direction for each of the intersections P of the reinforcing bars S of the workpiece B will be described.

[0052] Here, the "binding direction" for the intersection P of the workpiece B will be described with reference to FIGS. 5 and 6.

FIGS. 5 and 6 are plan views illustrating two types of binding directions for the intersection P. The wires W with which binding is performed at the intersection P of the reinforcing bar S in the X direction and the reinforcing bar S in the Y direction is in one of a direction illustrated in FIG. 5 and a direction illustrated in FIG. 6 inclined by approximately 45° with respect to both the X direction and the Y direction when viewed from above in the Z direction. Here, a binding direction along an upper right direction on the page of FIG. 5 is a first direction, and a binding direction along an upper left direction on the page of FIG. 6 is a second direction.

In the binding direction determination process, the control unit 77D determines either the first direction or the second direction as the "binding direction" for each of all the intersections P of the workpiece B.

The "binding direction" referred to here indicates a direction along which the wires W after binding extend, as viewed from a vertical direction of the planar workpiece B.

[0053] The binding device 6C of the binding system 1D has a specification of performing binding with two wires W by one binding operation, and the two wires W illustrated in FIGS. 5 and 6 illustrate a state after one binding operation. The same applies to the subsequent drawings.

Both ends of each wire W after binding are formed with a wound portion by a twisting operation, but the wound portion is not illustrated in FIG. 5 and the subsequent drawings.

[0054] In the binding direction determination process, the control unit 77D determines a binding direction for each intersection P according to the following binding direction conditions (1) to (5).

[Condition (1)] For each of all the intersections P of the workpiece B, one
 5 reinforcing bar S and another reinforcing bar S that form the intersection P are bound with the wires W along a direction different from that of at least one other intersection P in the one reinforcing bar S, which is different from the intersection P formed by the one reinforcing bar S and said another reinforcing bar S, and at least one other intersection P in said another reinforcing bar S, which is different from the intersection P formed by the one reinforcing bar
 10 S and said another reinforcing bar S.

[Condition (2)] Based on the condition (1), with respect to a direction for each of the intersections P located at corners of a work area of the workpiece B among all the intersections P within the work area, binding is performed with the wires W in a direction that is closer to parallel to a straight line connecting the intersection P and a center of the work
 15 area.

[Condition (3)] Based on the condition (2), with respect to a binding direction for at least one of two intersections P adjacent to the intersection P located at the corner of the work area of the workpiece B among all the intersections P in the work area, binding is performed with the wires W along the same direction as the intersection P located at the corner of the
 20 work area.

[Condition (4)] Based on the condition (2), with respect to a binding direction for each of the intersections P located on an outer edge of the work area of the workpiece B among all the intersections P within the work area, binding is performed with the wires W in a direction that is closer to parallel to a straight line connecting the intersection P and the center
 25 of the work area of the workpiece B.

[Condition (5)] Based on the condition (1), with respect to a direction for each of all the intersections P of the workpiece B, binding is performed with the wires W in a direction different from a direction at all other adjacent intersections P.

[0055] Here, when the binding direction for each intersection P is determined according to
 30 the binding direction conditions (1) to (5), the control unit 77D needs to specify the "intersection P located at the corner" and the "intersection P located on the outer edge" in the work area.

FIG. 7 is a diagram in which the "intersection P located at the corner" is indicated

by "A", the "intersection P located on the outer edge" is indicated by "B", and the other intersection P is indicated by "C".

[0056] First, the "work area" in the binding direction conditions (2) to (4) indicates the narrower one of an area of an outer edge of a movable range (range in which the binding device 6C can move) of the binding device 6C set when the robotic arm 4 holding the binding device 6C performs a binding work on the workpiece B in the binding system 1D and an outer edge of an area where all the intersections P of the workpiece B are present.

The movable range of the binding device 6C and the area where all the intersections P of the workpiece B are present may be assumed to be rectangular.

In the present embodiment, as illustrated in FIG. 4, a case where the inside of the support plates 211 on the four sides of the holding table 21 is a rectangular movable range and coincides with a rectangular area where all the intersections P of the workpiece B are present is exemplified. In this case, the inside of the support plates 211 on the four sides of the holding table 21 is a rectangular "work area".

[0057] In the above-described work area, as illustrated in FIG. 7, the control unit 77D specifies the intersection P having two other adjacent intersections P as the "intersection P located at the corner of the work area", such as the intersection P denoted by "A" in an area Ra surrounded by a two-dot chain line, at all the intersections P in the work area.

In FIG. 7, the control unit 77D specifies the intersection P having three or less other adjacent intersections P as the "intersection P located at the outer edge of the work area", such as the intersection P denoted by "B" in an area Rb surrounded by a two-dot chain line.

In FIG. 7, the control unit 77D specifies the intersection P having four other adjacent intersections P as the intersection P other than the "intersection P located at the corner of the work area" and the "intersection P located on the outer edge of the work area", such as the intersection P denoted by "C" in an area Rc surrounded by a two-dot chain line.

[0058] The "adjacent intersections P" indicate a case of being adjacent via the reinforcing bar S. That is, adjacent intersections P indicate adjacent intersections P in the X direction or the Y direction, and do not include adjacent intersections P in a direction oblique to both the X direction and the Y direction.

Since the "intersection P located on the outer edge of the work area" is an intersection having three or less other adjacent intersections P, the "intersection P located at the corner of the work area" having two other adjacent intersections P is also included.

[0059] The above-described condition (1) will be described with reference to FIG. 8.

As illustrated, one reinforcing bar S and the other reinforcing bar S that form the intersection P are defined as S_x and S_y , respectively, and the intersection P is defined as P_o .

In this condition (1), with respect to a binding direction with the wires W, it is required that at least one of the intersections P other than the intersection P_o in one reinforcing bar S_x is in a direction different from the intersection P_o , and at least one of the intersections P other than the intersection P_o in the other reinforcing bar S_y is in a direction different from the intersection P_o .

Since the binding direction with the wires W is only one of the first direction and the second direction described above, and "the binding directions are different" means that one intersection P is the first direction and the other intersection P is the second direction.

[0060] In the condition (1), when the binding is performed along the second direction at the intersection P_o , the reinforcing bar S_x is required to be bound with the wires W along the first direction at any intersection P other than the intersection P_o . Similarly, the reinforcing bar S_y is also required to be bound with the wires W along the first direction at any other intersection P than the intersection P_o .

All the intersections P of the workpiece B are required to be the same as the intersection P_o .

In the present embodiment, as the condition (1), a case where all the intersections P of the workpiece B are required to be the same as the intersection P_o is exemplified, but the present invention is not limited thereto. For example, as the condition (1), only one intersection P or some of the intersections P of the workpiece B may be required to be the same as the intersection P_o .

[0061] The above-described condition (2) will be described with reference to FIGS. 9 and 12. The condition (2) is based on the premise that the condition (1) is satisfied.

Here, as illustrated, among all the intersections P in a work area U of the workpiece B, an intersection located at a corner of the work area U is defined as P_c .

The control unit 77D can specify the work area U according to the definition described above, and can obtain a center C of the work area U. The center C of the work area U can be obtained from the center of gravity (centroid) of the work area U, for example.

Further, the control unit 77D can specify all the intersections P located at the corners of the work area U according to the definition in FIG. 7 described above. In the case of the example of FIG. 9, the intersections P at which reinforcing bars S1 and S2 located at both ends of the work area U in the Y direction and reinforcing bars S3 and S4 located at both

ends of the work area U in the X direction intersect are four intersections Pc located at corners of the work area U.

As illustrated in FIG. 9, straight lines Lc passing through the center C and the intersections Pc located at the corners can be specified.

5 As illustrated in FIG. 12, a cross angle between the wires W facing the first direction at the intersection Pc located at the corner and the straight line Lc and a cross angle between the wires W facing the second direction at the same intersection Pc and the straight line Lc are obtained, and a direction in which the cross angle in the first direction or the second direction is smaller is determined as a "direction closer to parallel" to the straight line
10 Lc, and is determined as a binding direction at the intersection Pc. In any case, it is assumed that the line of sight is from the Z direction.

In the above case, the cross angle between the wires W and the straight line Lc includes an acute cross angle and an obtuse cross angle, and the acute cross angle is compared.

15 Depending on a shape of the work area, the cross angle between the wires W facing in the first direction and the straight line Lc may be equal to the cross angle between the wires W facing in the second direction and the straight line Lc.

In such a case, the control unit 77D may select either the first direction or the second direction for the intersection Pc. In this case, the control unit 77D may determine in
20 advance either the "first direction" or the "second direction".

[0062] The above-described condition (3) will be described with reference to FIG. 10. The condition (3) is based on the premise that the condition (2) is satisfied.

Here, as illustrated, an intersection adjacent to the intersection Pc located at the corner of the work area U on one side is defined as Pn.

25 Binding at the intersections Pn adjacent to the four intersections Pc located at the corners of the work area U are required to be performed with the wires W in the same direction as the intersections Pc.

Therefore, in the case of FIG. 10, binding is performed with the wires W along the second direction at the intersection Pn adjacent to the intersection Pc located at an upper left
30 corner in the drawing, binding is performed with the wires W along the first direction at the intersection Pn adjacent to the intersection Pc located at an upper right corner in the drawing, binding is performed with the wires W along the first direction at the intersection Pn adjacent to the intersection Pc located at a lower left corner in the drawing, and binding is performed

with the wires W along the second direction at the intersection P_n adjacent to the intersection P_c located at a lower right corner in the drawing.

The intersection P_c located at the corner of the work area U has two adjacent intersections P, but binding may be performed at both of these intersections P in the same direction as the intersection P_c located at the corner.

[0063] The above-described condition (4) will be described with reference to FIGS. 11 and 12. This condition (4) is based on the premise that the condition (2) is satisfied.

Since the control unit 77D can specify all the intersections P located at the center C of the work area U and located on the outer edges of the work area U according to the definition described above, the control unit 77D can specify the straight lines L_c passing through the center C and the intersections P located on the outer edges as illustrated in FIG. 11.

As illustrated in FIG. 12, a cross angle between the wires W facing the first direction at the intersection P located on the outer edge and the straight line L_c and a cross angle between the wires W facing the second direction at the same intersection P and the straight line L_c are obtained, and a direction in which the cross angle in the first direction or the second direction is smaller is determined as a "direction closer to parallel" to the straight line L_c, and is determined as a binding direction at the intersection P. In any case, it is assumed that the line of sight is from the Z direction.

[0064] In the above case, the cross angle between the wires W and the straight line L_c includes an acute cross angle and an obtuse cross angle, and the acute cross angle is compared.

The cross angle between the wires W facing the first direction and the straight line L_c may be equal to the cross angle between the wires W facing the second direction and the straight line L_c. For example, a cross angle in the first direction and a cross angle in the second direction are equal to each other for the wires W with which binding is performed at the intersection P located on the outer edge on the reinforcing bar S that passes through the center C of the work area U and is parallel to the X direction, or the wires W with which binding is performed at the intersection P located on the outer edge on the reinforcing bar S that passes through the center C of the work area U and is parallel to the Y direction.

In such a case, the control unit 77D may select either the first direction or the second direction for the intersection P. In this case, the control unit 77D may determine in advance either the "first direction" or the "second direction".

[0065] The above-described condition (5) will be described with reference to FIG. 13. This condition (5) is based on the premise that the condition (1) is satisfied.

Under this condition (5), the direction in which binding with the wires W is performed at each of all the intersections P of the workpiece B is different from the direction in which binding with the wires W is performed at all other adjacent intersections P. Therefore, as illustrated in FIG. 13, the wires W with which binding is performed at the respective intersections P have a so-called staggered arrangement in which the first direction and the second direction are alternately arranged in all rows of the intersections arranged in the X direction, and the first direction and the second direction are alternately arranged in all rows of the intersections arranged in the Y direction.

[0066] With respect to the binding direction for each intersection P that satisfies the condition (5), there are a case illustrated in the example of FIG. 13 and a case where the binding direction with the wires W is reversed between the first direction and the second direction for all the intersections P in FIG. 13.

Therefore, it is preferable that the control unit 77D determines a condition for selecting one of a pattern in FIG. 13 and a pattern opposite to FIG. 13 for each of the intersections P of the workpiece B.

For example, it is preferable to determine a condition that the binding direction with the wires W is the first direction (or the second direction) at the intersection P at a specific position of the workpiece B (for example, the intersection P located at a specific corner).

Thus, the control unit 77D can uniquely determine the binding direction with the wires W for each of all the intersections P of the workpiece B.

In the present embodiment, as the condition (5), a case where binding with the wires W at all the intersections P of the workpiece B are required to be performed in a direction different from those of all the other adjacent intersections P is exemplified, but the present embodiment is not limited thereto. For example, as the condition (5), a direction in which binding with the wires W is performed at only one intersection P or some intersections P of the workpiece B may be required to be different from the direction in which binding with the wires W is performed at all other adjacent intersections P.

[0067] The binding system 1D may be implemented such that the user can select some or all of the conditions (1) to (5) described above from, for example, the operation unit 72. In this case, the control unit 77D determines a direction in which binding with the wires W is performed at all the intersections P of the workpiece B based on any of the conditions (1) to

(5) selected by the user.

In addition, in the binding system 1D, the control unit 77D may be configured to determine the direction in which the binding with the wires W is performed at all the intersections P of the workpiece B based on only one of the conditions (1) to (5).

5 [0068] Here, the usefulness of the binding direction with the wires W for the intersection P of the workpiece B based on each of the conditions (1) to (5) will be described.

In the case of the condition (1), when the control unit 77D determines a binding direction with the wires W for each intersection P to satisfy this condition, all the intersections P of all the reinforcing bars S constituting the workpiece B are not bound in the same
10 direction. When binding is performed at all intersections on a certain reinforcing bar S with another reinforcing bar S in the same binding direction, stress is received from each intersection P in the same direction, so that a gap between the reinforcing bars S is likely to be generated, and the binding strength can be reduced. However, when a binding direction for each intersection P of the workpiece B is determined according to the condition (1), it is
15 possible to perform strong binding to the workpiece B while avoiding a reduction in binding strength.

[0069] In the case of the condition (5), when the control unit 77D determines the binding direction with the wires W for each intersection P to satisfy this condition, the binding is performed alternately in the first direction and the second direction for the plurality of
20 intersections P in one reinforcing bar S. Therefore, since a direction of the stress is dispersed for each of the intersections P arranged along the reinforcing bars S, it is possible to further reduce the gap between the reinforcing bars S and to more effectively perform strong binding to the workpiece B.

[0070] The cases of the conditions (2) to (4) will be described with reference to FIGS. 14
25 and 15 in addition to FIGS. 3 and 11 described above.

FIG. 14 is a plan view of the binding device 6C in FIG. 3 viewed from one side of the turning axis Zr (for example, an upper side in the binding operation), and FIG. 15 is a plan view in which a configuration of a part of the device body 10C is omitted.

[0071] As described above, the binding device 6C has a structure in which the slack
30 forming unit 62C is disposed on one side of the reinforcing bar binding machine 61C in the orthogonal direction Xw, which is an arrangement direction of the curl guide 613C and the inducing guide 614C, to deform the wire W into an appropriate loop shape by the curl guide 613C and the inducing guide 614C.

As illustrated in FIG. 14, the binding device 6C protrudes most toward one side in the orthogonal direction X_w , which is a slack forming unit 62C side, around the turning axis Z_r .

When the binding with the wires W is performed in the determined binding direction, the robotic arm body 40 turns the binding device 6C around the turning axis Z_r . In this case, when there is a portion protruding toward one side in the orthogonal direction X_w around the turning axis Z_r , there is a concern that the portion may come into contact with an object standing in the Z direction around the binding device 6C or an object at a position higher than the workpiece B in the Z direction.

As illustrated in FIG. 15, in the device body 10C, there is a concern that each support column 12 of the gantry 11 may come into contact with the binding device 6C. Although only one support column 12 is provided at each of the four corners of the device body 10C, if the total weight of the device body 10C increases, more support columns 12 may be provided along each beam 13.

Further, depending on the installation environment of the device body 10C, an obstacle other than the support column may occur.

[0072] Therefore, when the binding operation with the wires W is performed on the workpiece B, it is preferable that a protruding portion of the binding device 6C, particularly, the slack forming unit 62C does not protrude to the outside of the work area U.

In FIG. 11, a silhouette of the binding device 6C in a plan view when the turning axis Z_r at a binding position of the binding device 6C is positioned with respect to the plurality of intersections P is indicated by a two-dot chain line. In the silhouette of the binding device 6C in a plan view, an end having a semicircular shape in a longitudinal direction is an end on an individual imaging unit 5 side in the orthogonal direction X_w , and an end having a rectangular shape in the longitudinal direction is an end on the slack forming unit 62C side.

[0073] For example, as illustrated in FIG. 11, in a case where the conditions (2) to (4) are satisfied, for example, a binding direction intersecting with the outer edge of the work area U at the intersection P which is at a corner in the work area U is selected, so that the binding operation can be performed in a state where the slack forming unit 62C, which is the most protruding portion of the binding device 6C, faces the inside of the work area U, and it is possible to reduce the possibility of contact between an obstacle around the work area U and the slack forming unit 62C which is the most protruding portion of the binding device 6C.

If a direction that does not satisfy the conditions (2) to (4) is selected at the

intersection P at the corner, for example, if the first direction is selected at the intersection P at the upper left corner of the page of FIG. 11, the slack forming unit 62C protrudes to the left side or the upper side of the page of FIG. 11 toward the outside of the work area U, and the possibility of contact with the obstacle around the work area U occurs.

5 In a case where the conditions (2) to (4) are satisfied, it is possible to exclude the selection of the binding direction in which there is a possibility that the slack forming unit 62C protrudes to the outside of the work area U, and it is possible to reduce the possibility of contact between the slack forming unit 62C and an obstacle.

[0074] In the case of the condition (3), the binding operation is also performed at the
10 intersection P adjacent to the intersection P at the corner in the same direction as the intersection P at the corner. In the case of the intersection P in the vicinity of the corner, if the binding direction is not appropriately selected, there is a possibility that the slack forming unit 62C protrudes to the outside of the work area U similarly to that at the corner. Therefore, it is possible to reduce the possibility of contact between the slack forming unit 62C and an
15 obstacle even in the case of the condition (3).

Further, since the binding operation is performed at the intersection P adjacent to the intersection P at the corner in the same direction as the intersection P at the corner, it is possible to reduce the frequency of a turning operation of the binding device 6C and to accelerate the binding operation.

20 [0075] In the case of the condition (4), since a direction closer to parallel to a straight line connecting the center C of the work area U and the intersections P is selected as the binding direction at the intersection P located on the outer edge including the corner, the binding operation can be performed in a state where the slack forming unit 62C, which is the most protruding portion of the binding device 6C, faces the inside of the work area U, and the
25 possibility of contact between the obstacle outside the work area U and the slack forming unit 62C can be reduced.

In particular, among the intersections P located on the outer edge, the intersection P closer to the corner may have a binding direction in which the slack forming unit 62C cannot be prevented from protruding to the outside of the work area U. However, in a case where the
30 condition (4) is satisfied, the possibility of protruding to the outside can be reduced, and the possibility of contact between the slack forming unit 62C and the obstacle can be reduced.

[0076] In a case where the binding directions for all the intersections P of the workpiece B are determined according to only the condition (1), since the number of combinations thereof

is very large, it is preferable to determine a filtering condition in advance.

The filtering condition includes, for example, a ratio of the number of intersections P in the first direction and the number of intersections P in the second direction in each reinforcing bar S, a lower limit value of the number of intersections P in the first direction or a lower limit value of the number of intersections P in the second direction in each reinforcing bar S, a ratio of the number of intersections P in the first direction and the number of intersections P in the second direction in all the intersections P of the workpiece B, and a degree of dispersion of the intersections P in the first direction and the intersections P in the second direction in the arrangement of all the intersections P of the workpiece B (for example, the area where all the intersections P of the workpiece B are present is divided into a plurality of areas, and the number of intersections P in the first direction and the number of intersections P in the second direction in each divided area are made close to equal).

In addition, for the intersections P for which the binding direction cannot be determined even in consideration of the condition (1) and the filtering condition, it is more preferable to determine in advance that all of the intersections P are set to the first direction, all of the intersections P are set to the second direction, a ratio between the first direction and the second direction is more uniform, or the like.

[0077] In a case where the binding directions of all the intersections P of the workpiece B are determined according to only the condition (2), since the number of combinations thereof is very large, it is preferable to determine a filtering condition in advance.

For example, in the work area U, the intersections P other than the intersections P located at the corners are set to the same binding direction as the intersection P located at the closest corner. In addition, the same filtering condition as the condition (1) may be added.

In addition, for the intersections P for which the binding direction cannot be determined even in consideration of the condition (2) and the filtering condition, it is more preferable to determine in advance that all of the intersections P are set to the first direction, all of the intersections P are set to the second direction, a ratio between the first direction and the second direction is more uniform, or the like.

[0078] In a case where the binding directions of all the intersections P of the workpiece B are determined according to only the condition (3), since the number of combinations thereof is very large, it is preferable to determine a filtering condition in advance.

For example, in the work area U, the intersections P other than the intersections P located at the corners and the intersections P adjacent thereto are set to the same binding

direction as the intersection P located at the closest corner. In addition, the same filtering condition as the condition (1) may be added.

In addition, for the intersections P for which the binding direction cannot be determined even in consideration of the condition (3) and the filtering condition, it is more preferable to determine in advance that all of the intersections P are set to the first direction, all of the intersections P are set to the second direction, a ratio between the first direction and the second direction is more uniform, or the like.

[0079] In a case where the binding directions for all the intersections P of the workpiece B are determined according to only the condition (4), since the number of combinations thereof is very large, it is preferable to determine a filtering condition in advance.

For example, in the work area U, the intersections P other than the intersections P located at the corners and the intersections P located on the outer edges are set to the same binding direction as the intersection P located at the closest corner or the intersections P located on the outer edges. In addition, the same filtering condition as the condition (1) may be added.

In addition, for the intersections P for which the binding direction cannot be determined even in consideration of the condition (4) and the filtering condition, it is more preferable to determine in advance that all of the intersections P are set to the first direction, all of the intersections P are set to the second direction, a ratio between the first direction and the second direction is more uniform, or the like.

[0080] In a case where the binding directions for all the intersections P of the workpiece B are determined according to only the condition (5), since there are only two types of combinations thereof, as described above, the first direction or the second direction may be determined in advance for a specific intersection P.

[0081] <Operation of Binding System>

Subsequently, an operation of the binding system 1D will be described.

FIG. 16 is a flow chart illustrating a procedure when the binding system 1D performs a binding process.

The CPU of the control unit 77D of the control device 7D performs the following binding process according to the binding processing program 761D.

[0082] By executing the binding processing program 761D, the control unit 77D performs the intersection information acquisition process, and performs a process of acquiring information on the intersection P at which the plurality of reinforcing bars S of the workpiece

B intersect.

In this case, the control unit 77D determines whether the use of the map data 763D is selected by the user through the operation unit 72, for example (step S201).

[0083] When the use of the map data 763D is selected, the control unit 77D reads the map data 763D from the storage unit 76D (step S203). At this time, when the map data 763D is not prepared in the storage unit 76D, the map data 763D is acquired by communicating with the outside or reading a recording medium.

[0084] On the other hand, when the use of the map data 763D is not selected, the control unit 77D causes the first camera 31 of the entire imaging unit 3 to image the entire workpiece B on the holding table 21 of the workpiece holding unit 2 disposed in the imaging area E1 of the gantry 11 (step S205).

[0085] When the map data 763D is read or the workpiece B is imaged by the first camera 31, the control unit 77D acquires three-dimensional position data of all the intersections P of the reinforcing bars S of the workpiece B based on the map data 763D or the image data 762D, and develops the three-dimensional position data in the coordinate system of the robotic arm 4. Accordingly, positions of all the intersections P can be specified (step S207).

Therefore, the control unit 77D functions as an intersection specifying unit.

[0086] Next, the control unit 77D drives the driving motor 23 of the workpiece holding unit 2 to cause the holding table 21 and the workpiece B to move to the binding area E2 (step S209).

[0087] Next, the control unit 77D determines a binding direction for all the intersections P in the workpiece B or the work area U based on the determined binding direction determination condition (any one of the above-described conditions (1) to (5)). In this case, the filtering conditions described above for the conditions (1) to (5) may also be considered (step S211).

When the binding direction for all the intersections P in the workpiece B or the work area U is determined, the control unit 77D generates and records the binding direction data 764D in the storage unit 76D. The binding direction data 764D may be used by omitting the process of step S211 when the binding operation is performed on another workpiece B having the same design condition.

[0088] The control unit 77D controls the robotic arm 4 to position the second camera 51 at an imaging position of the intersection P at which the binding is first performed, and moves the second camera 51 closer to the intersection P by driving the elevator motor 52 (step S213).

The binding order for each intersection P is determined according to a predetermined operation condition or the like.

[0089] Next, the control unit 77D images the intersection P by the second camera 51 (step S215).

5 The second camera 51 can obtain a position of the intersection P with higher accuracy based on the image data 762D by imaging the intersection P closer to the intersection P than the first camera 31.

[0090] Therefore, the control unit 77D newly calculates a position of the intersection P based on the image data 762D obtained by the second camera 51 (step S217), and positions
10 the binding position of the binding device 6C closer to the newly obtained position of the intersection P (step S219).

At this time, the control unit 77D determines an orientation of the binding device 6C around the shaft along the Z direction according to the binding direction determined in step S211 for the intersection P.

15 [0091] The control unit 77D operates the binding device 6C to perform binding with the wires W at the intersection P (step S221).

Thereafter, the control unit 77D controls the robotic arm 4 again to position the second camera 51 at the imaging position of the intersection P, moves the second camera 51 closer to the intersection P by driving the elevator motor 52 (step S223), and images the
20 intersection P (step S225).

[0092] The control unit 77D determines whether the binding is performed in the binding direction determined in step S211 based on the image data 762D obtained by the imaging (step S227).

25 As a result, when the binding direction is not the binding direction determined in step S211, the occurrence of an error is notified (step S229), and the binding operation is ended.

As a method of notifying the occurrence of the error, a dedicated notification device such as a notification lamp or a buzzer may be prepared and operated, or the notification may be displayed on the display unit 73. When the control device 7D includes a communication
30 device with the outside, the notification may be provided to the outside through communication.

[0093] On the other hand, in step S227, when it is determined that the binding is performed in the binding direction determined in step S211, the control unit 77D determines whether the

intersection P at which the binding is performed is the last intersection P based on information on the intersection P for specifying the position of the intersection P acquired in step S207 (step S231).

5 Thereby, when the intersection P at which the binding has been performed is not the last intersection P, the control unit 77D specifies the intersection P at which binding is to be performed next (step S233), and repeats the processes from step S213 to step S233.

On the other hand, when the intersection P at which the binding has been performed is the last intersection P, the control unit 77D ends the binding process on the workpiece B.

[0094] As illustrated in step S229, the process of notifying the occurrence of the error and
10 ending the binding operation in a case where the binding direction is not the determined binding direction has been exemplified, but the occurrence of the error may be notified, the error content may be further recorded, the process may proceed to step S231, and the binding operation for the subsequent intersection P may be continued.

[0095] <Technical Effect of Embodiment of Invention>

15 The control device 7D of the binding system 1D includes the control unit 77D that binds one reinforcing bar S and another reinforcing bar S that form the intersection P with the wires W along a direction different from that of at least one other intersection P in the one reinforcing bar S, which is different from the intersection P formed by the one reinforcing bar S and said another reinforcing bar S, and at least one other intersection P in said another
20 reinforcing bar S, which is different from the intersection P formed by the one reinforcing bar S and said another reinforcing bar S.

Therefore, it is possible to reduce the gap between the reinforcing bars S constituting the workpiece B and to perform strong binding to the workpiece B.

[0096] The control unit 77D performs binding with the wires W along a direction closer to
25 parallel to the straight line Lc connecting the intersection P and the center C of the work area U at the intersection P located at the corner among all the intersections P within the work area U of the workpiece B. Therefore, it is possible to reduce the possibility of contact between the slack forming unit 62C, which is a protruding portion of the binding device 6C, and an obstacle outside the work area U during the binding operation at the intersection P located at
30 the corner.

[0097] The control unit 77D performs binding with the wires W at least one intersection P adjacent to the intersection P located at the corner of the work area U among the plurality of intersections P in the work area U of the workpiece B along the same direction as the

intersection P located at the corner. Therefore, it is possible to reduce the possibility of contact between the slack forming unit 62C, which is a protruding portion of the binding device 6C, and an obstacle outside the work area U during the binding operation at the intersection P adjacent to the intersection P located at the corner.

5 Furthermore, it is possible to reduce the frequency of the turning operation of the binding device 6C and to accelerate the binding operation.

[0098] The control unit 77D performs binding with the wires W at the intersection P located on the outer edge of the work area U in a direction closer to parallel to the straight line Lc connecting the intersection P and the center of the work area U. Therefore, it is possible to
10 reduce the possibility of contact between the slack forming unit 62C, which is a protruding portion of the binding device 6C, and the obstacle outside the work area U during the binding operation at the intersection P located on the outer edge.

[0099] Further, the control unit 77D performs binding with the wires W at each of all the intersections P of the workpiece B in a direction different from those of all the other adjacent
15 intersections P. Therefore, since a direction of the stress is dispersed for each of the intersections P arranged along the reinforcing bars S, it is possible to further reduce the gap between the reinforcing bars S and to more effectively perform strong binding to the workpiece B.

[0100] Since the binding system 1D includes the second camera 51 as the intersection
20 information acquisition unit that is provided together with the binding device 6C and acquires information on the intersection P, it is possible to determine whether the binding direction with the bound wires W is appropriate during the binding operation, and it is possible to detect the occurrence of inappropriate binding.

[0101] Since the control unit 77D of the control device 7D executes the binding processing
25 program 761D to realize a function of controlling binding with the wires W along a predetermined binding direction at the intersection P of the workpiece B, it is possible to obtain the function from the existing binding system without increasing new hardware resources, and it is possible to reduce a development burden of hardware resources or a manufacturing cost of the system.

30 [0102] <Use of Device Information Data and Peripheral Information Data>

The storage unit 76D of the control device 7D of the binding system 1D stores the device information data 766D indicating a three-dimensional position of the entire surface of the binding device 6C and the peripheral information data 767D indicating a three-

dimensional position of the entire surface of an obstacle around the robotic arm 4.

The control unit 77D may determine whether the "binding direction" determined for each intersection P of the workpiece B can be determined using these data 766D and 767D.

[0103] That is, since the device information data 766D includes three-dimensional position data of the entire device surface of the binding device 6C, it is possible to acquire each position of a surface of the binding device 6C in a state where the binding device 6C is supported by the end effector 43 of the robotic arm 4.

In the binding operation of the binding device 6C, when the binding device 6C is rotated around the turning axis Zr according to the determination of the "binding direction", the possibility of interference between the binding device 6C and the obstacle can be determined based on each position on the surface of the binding device 6C and the peripheral information data 767D indicating the three-dimensional position of the entire surface of the obstacle around the robotic arm 4.

Therefore, when the control unit 77D determines the "binding direction", the control unit 77D may determine the possibility of interference between the binding device 6C and the obstacle, and when there is the possibility of interference, the control unit 77D may perform a process of notifying that there is the possibility of interference through the display unit 73 or the like, a process of automatically changing the current determination of the "binding direction", or the like.

[0104] <Other Matters in Present Embodiment>

The embodiments of the present invention have been described above. However, the present invention is not limited to the above-described embodiments. For example, in the embodiments, a component integrally formed of a single member may be replaced with a component divided into a plurality of members and coupled or fixed to each other. A component formed by coupling a plurality of members may be replaced with a component formed integrally with a single member. In addition, the details described in the embodiments can be appropriately changed without departing from the gist of the invention.

[0105] For example, the control unit 77D performs a process of determining a binding direction for each intersection P of the workpiece B, but in addition to the determination of the binding direction, the control unit 77D may determine which direction the slack forming unit 62C, which is a protruding portion of the binding device 6C, faces with respect to the turning axis Zr. In this case, it is preferable that the slack forming unit 62C, which is a protruding portion of the binding device 6C, is determined to face the inside of the work area

U (opposite side to the outer edge of the work area U) with respect to the turning axis Zr.

[0106] In the above embodiments, when each of the conditions (1) to (5) for the control unit 77D to determine the binding direction is described, a case where the work area U is a rectangular area without a defective portion has been exemplified, but the binding direction can be effectively determined even when the work area U has another shape.

For example, even in a case where the work area U has a shape in which there is a defective portion in each portion with respect to a rectangle, a binding direction for each intersection P can be determined according to each of the conditions (1) to (5) by specifying the "intersection P located at the corner" and the "intersection P located on the outer edge" according to the definition illustrated in FIG. 7.

Further, when there is a defective portion such as a hole inside the work area U, the periphery of the hole is also recognized as the outer edge of the work area U, and the binding direction for each intersection P can be determined according to each of the conditions (1) to (5).

[0107] With respect to the irregular work area U as described above, it is possible to determine in which direction the slack forming unit 62C, which is a protruding portion of the binding device 6C, faces with respect to the turning axis Zr.

For example, in the case of the work area U having a defective portion such as a hole, the slack forming unit 62C may be determined to face the opposite side to the outer edge of the work area U around the hole where the intersection P is closest to the turning axis Zr.

[0108] In the present embodiment, a case where the outer edge of the movable range of the binding device 6C set when the robotic arm 4 performs the binding work on the workpiece B coincides with the outer edge of the area where all the intersections P of the workpiece B are present has been exemplified, but these outer edges may not coincide with each other. For example, when the area where all the intersections P of the workpiece B are present is larger than the movable range of the binding device 6C, the area where all the intersections P of the workpiece B are present may be divided into a plurality of areas, and the robotic arm 4 and the workpiece B may be assumed to be moved to perform the binding operation for each divided area.

[0109] In the present embodiment, in the binding system 1D, the control unit 77D performs the binding direction determination process of the wire W with respect to each intersection P of the workpiece B, but the present invention is not limited thereto.

For example, the control unit 77D may use binding direction data created by the

user by determining a binding direction for each intersection P of the workpiece B to satisfy any one of the above-described binding direction conditions (1) to (5) from the operation unit 72, and the control unit 77D may perform the binding operation according to the binding direction data without performing the determination of determining the binding direction of the wire W for each intersection P of the workpiece B. Alternatively, the control unit 77D may acquire, from the outside of the binding system 1D, binding direction data in which the binding direction for each intersection P of the workpiece B is determined to satisfy any one of the above-described binding direction conditions (1) to (5), and perform the binding operation according to the binding direction data.

In addition, a recording medium on which the binding direction data in which the binding direction for each intersection P of the workpiece B is determined to satisfy any one of the binding direction conditions (1) to (5) is recorded by an information processing terminal or the like not included in the binding system 1D may be read by a reading device of the recording medium, and the control unit 77D may perform the binding operation according to the binding direction data.

[0110] The binding system 1D may be configured to acquire information on the intersection P for specifying each intersection P of the workpiece B only from the map data 763D. In that case, in the binding system 1D, the first camera 31 and the second camera 51 are not essential.

However, since the binding device 6C can be more accurately positioned with respect to the intersection P by the second camera 51, only the first camera 31 may be omitted, and the second camera 51 may be provided.

When the first camera 31 is omitted from the configuration of the binding system 1D, the movement mechanism 32 that causes the first camera 31 to move between the imaging area E1 and the binding area E2 can also be omitted.

[0111] In the binding system 1D according to the present embodiment, the binding device 6C that binds the reinforcing bars S with two wires W has been exemplified, but the present invention is not limited thereto, and a binding device that binds the reinforcing bars S with one or three or more wires W may be used.

[0112] In the binding system 1D, a configuration in which the binding device 6C and the individual imaging unit 5 are moved by the robotic arm 4 has been exemplified, but the present invention is not limited thereto. For example, the binding device 6C and the individual imaging unit 5 may be mounted on a head of a gantry type mobile apparatus in the X-Y

direction, and the binding device 6C and the individual imaging unit 5 may be raised and lowered along the Z direction from the head and may be turned around an axis along the Z direction.

Alternatively, the binding device 6C and the individual imaging unit 5 may be mounted on a self-propelled mobile apparatus that moves the workpiece B held in a grid pattern.

[0113] In addition, the binding system 1D according to the present embodiment is a stationary binding system disposed or fixedly installed in an indoor work space. Therefore, it is possible to perform the binding work without being affected by the weather or the outdoor environment as in an outdoor work type binding system. By eliminating the need for a device having measures against water, dust, high temperature, low temperature, and the like, which is durable in a severe outdoor environment, it is possible to mount a device that performs a precise work indoors, and to perform a precise binding work on the workpiece B.

However, by excluding these advantages, it is also possible to configure a binding system having features in the present embodiment with respect to an outdoor use type binding system.

[0114] The present application is based on Japanese Patent Application No. 2024-013045 filed on January 31, 2024, the contents of which are incorporated herein by reference.

INDUSTRIAL APPLICABILITY

[0115] It is possible to prevent a plurality of intersections in reinforcing bars constituting a workpiece from being bound with a binding body only in the same direction, to reduce a gap between the reinforcing bars to realize strong binding.

REFERENCE SIGNS LIST

[0116] 1D binding system

31 first camera (intersection information acquisition unit)

51 second camera (intersection information acquisition unit)

6C binding device

7D control device

72 operation unit

76D storage unit

761D binding processing program

77D control unit

P intersection

S reinforcing bar

B workpiece

5

W wire (binding body)

CLAIMS

[Claim 1]

A binding system for binding a workpiece, in which a plurality of reinforcing bars intersect to form a plurality of intersections, with a binding body by a moving binding device
5 at each of the plurality of intersections, the binding system comprising:

a control unit configured such that, with respect to one reinforcing bar and another reinforcing bar that form the intersection, at least one other intersection in the one reinforcing bar, which is different from the intersection formed by the one reinforcing bar and the other reinforcing bar, and at least one other intersection in the other reinforcing bar, which is
10 different from the intersection formed by the one reinforcing bar and the other reinforcing bar, are bound with the binding body along a direction different from a direction in which the intersection formed by the one reinforcing bar and the other reinforcing bar is bound with the binding body.

15 [Claim 2]

The binding system according to claim 1, wherein

when an intersection having two other adjacent intersections among all the intersections in a work area in which the binding device is movable is set as an intersection located at a corner of the work area, the control unit performs binding with the binding body
20 at the intersection located at the corner along a direction closer to parallel to a straight line connecting the intersection located at the corner and a center of the work area.

[Claim 3]

The binding system according to claim 2, wherein

25 the control unit performs binding with the binding body at at least one of two intersections adjacent to the intersection located at the corner of the work area among the plurality of intersections in the work area of the workpiece along the same direction as the intersection located at the corner of the work area.

30 [Claim 4]

The binding system according to claim 2, wherein

when an intersection having three or less other adjacent intersections among the plurality of intersections in the work area of the workpiece is set as an intersection located on

an outer edge of the work area, the control unit performs binding with the binding body at the intersection located on the outer edge of the work area in a direction closer to parallel to a straight line connecting the intersection and the center of the work area.

5 [Claim 5]

The binding system according to claim 1, wherein

the control unit performs binding with the binding body at the intersection in a direction different from a direction in which all other adjacent intersections are bound with the binding body.

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[Claim 6]

The binding system according to claim 1, further comprising:

a binding device configured to perform binding with the binding body at the intersection; and

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an intersection information acquisition unit provided together with the binding device and configured to acquire information on the intersection.

[Claim 7]

20 A binding processing program for causing a computer that controls a binding system for binding a workpiece, in which a plurality of reinforcing bars intersect to form a plurality of intersections, with a binding body by a moving binding device at each of the plurality of intersections, to realize a function of performing control of

binding, with respect to one reinforcing bar and another reinforcing bar that form the intersection, at least one other intersection in the one reinforcing bar, which is different from the intersection formed by the one reinforcing bar and the other reinforcing bar, and at least one other intersection in the other reinforcing bar, which is different from the intersection formed by the one reinforcing bar and the other reinforcing bar, with the binding body along a direction different from a direction in which the intersection formed by the one reinforcing bar and the other reinforcing bar is bound with the binding body.

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