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(54) **Title:** PROGRAM-CONTROLLED AUTOMATIC SOLDERING SYSTEM AND METHOD

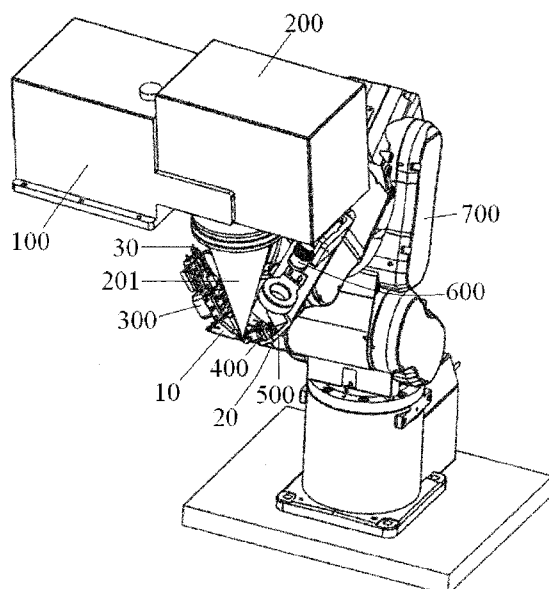


Fig.1

(57) **Abstract:** A program-controlled automatic soldering system, comprising: a laser source configured to emit a laser beam; a laser scan head configured to receive the laser beam from the laser source and focus the laser beam on a target position in a work area; a vision system; and a moving device configured to move products under a guidance of the vision system to a position where portions of the products to be soldered overlap the target position, so that the focused laser beam heats a solder material provided on the portions of the products to be soldered to solder the products together.



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PROGRAM-CONTROLLED AUTOMATIC SOLDERING SYSTEM AND METHOD**CROSS-REFERENCE TO RELATED APPLICATION**

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This application claims the benefit of Chinese Patent Application No. 201310378467.5 filed on August 27, 2013 in the State Intellectual Property Office of China, the whole disclosure of which is incorporated herein by reference.

10 **BACKGROUND OF THE INVENTION****Field of the Invention**

15 The present invention relates to a program-controlled automatic soldering system and a program-controlled automatic soldering method, more particularly, relates to a program-controlled automatic soldering system and a program-controlled automatic soldering method for soldering conducting wires on a circuit board.

Description of the Related Art

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In prior arts, a conventional soldering system generally comprises a soldering iron head mounted on a programmable moving device, for example, a multi-freedom robot. The soldering iron head is configured to move to a portion of a circuit board to be soldered under the guidance of a vision system and to heat a solder material to solder a conducting wire on the portion of the circuit board. Before soldering the conducting wire on the portion of the circuit board, it is necessary to pre-heat the soldering iron head to a predetermined temperature. However, the conventional soldering system has following disadvantages:

25 1) Since heat from the soldering iron head will be continuously diffused during soldering due to its thermal conduction property, it is difficult to control the soldering iron head at a stable desired temperature, and the soldering iron head will experience a great temperature fluctuation, thereby decreasing the soldering quality.

30 2) The soldering iron head has a large physical size (if the physical size becomes too small, the soldering iron head is likely oxidized), usually a tip diameter up to 0.5mm to 0.8mm. The large-sized soldering iron head may cause adjacent soldering spots to overlap with each other or interference with other fixture/devices needed during a small pitch, high precision soldering process.

35 3) The soldering iron head directly contacts the product to be soldered. Thereby, the soldering iron head is usually contaminated by soldering material after a definite number of

soldering cycles, which requires cleaning or deep cleaning of the soldering iron head. As a result, the soldering process can not be continued, and the soldering iron heat needs to be removed and cleaned, and then reinstalled on a soldering gun and calibrated in position after cleaning.

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SUMMARY OF THE INVENTION

The present invention has been made to overcome or alleviate at least one aspect of the above mentioned disadvantages.

10 According to an aspect of the present invention, there is provided a program-controlled automatic soldering system, comprising:

a laser source configured to emit a laser beam;

a laser scan head configured to receive the laser beam from the laser source and focus the laser beam on a target position in a work area;

15 a vision system; and

a moving device configured to move products under a guidance of the vision system to a position where portions of the products to be soldered overlap the target position, so that the focused laser beam heats a solder material provided on the portions of the products to be soldered to solder the products together.

20 According to an exemplary embodiment of the present invention, the program-controlled automatic soldering system may further comprise: a first gripper mounted on the moving device and configured to grip one of the products and hold it in position under the guidance of the vision system; and a second gripper mounted on the moving device and configured to grip another one of the products and hold it in position
25 under the guidance of the vision system.

According to another exemplary embodiment of the present invention, the solder material may comprises a conductive paste pre-printed on at least one of the products, a alloy solder pre-melt or fused on at least one of the products, or a solder wire supplied to the products during soldering the products.

30 According to another exemplary embodiment of the present invention, program-controlled automatic soldering system may be configured to solder the products together via the solder wire supplied to the products, may further comprises a wire feeder mounted on the moving device and configured to feed the solder wire to the portions of the products to be soldered under the guidance of the vision system.

35 According to another exemplary embodiment of the present invention, the products may be held to be stationary by the first gripper and the second gripper during heating the solder material with the focused laser beam.

According to another exemplary embodiment of the present invention, the

program-controlled automatic soldering system may further comprise: a tray configured to load at least one of the products thereon; and a conveying mechanism configured to convey the tray to the work area.

5 According to another exemplary embodiment of the present invention, the vision system may comprise at least one camera.

According to another exemplary embodiment of the present invention, the program-controlled automatic soldering system may further comprise a illumination unit configured to provide illumination for the vision system to facilitate image capturing.

10 According to another exemplary embodiment of the present invention, the illumination unit may be configured to be capable of automatically adjusting its optical properties according to geometries and/or dimensions of the products.

According to another exemplary embodiment of the present invention, the moving device may be configured to be a multi-freedom robot, the vision system, the illumination unit and the wire feeder may be mounted on an end arm of the robot; and the first gripper
15 may comprise a clamp for fixing one of the products in position.

According to another exemplary embodiment of the present invention, the laser scan head may be configured to be capable of adjusting an azimuth angle of a scanning galvanometer thereof with a closed loop control configuration under the guidance of the vision system, so that the laser beam is focused on the target position in the work area; or
20 the laser scan head may be configured to be stationary, and a scanning track of the focused laser beam may be controlled by an independent control system without the guidance of the vision system.

According to another exemplary embodiment of the present invention, the one of the products gripped and held by the first gripper may comprise a circuit board, and the another
25 one of the products gripped and held by the second gripper may comprise a conducting wire to be soldered on the circuit board.

According to another exemplary embodiment of the present invention, the second gripper may be configured to grip the conducting wire and hold the conducting wire in position on the circuit board after the first gripper grips and holds the circuit board in
30 position.

According to another exemplary embodiment of the present invention, the program-controlled automatic soldering system may be adapted to solder various kinds of products.

35 According to another exemplary embodiment of the present invention, the program-controlled automatic soldering system may comprise various kinds of grippers for gripping and holding the various kinds of products.

According to another aspect of the present invention, there is provided a program-controlled automatic soldering method, comprising steps of:

S100: providing a program-controlled automatic soldering system according to any one of the above exemplary embodiments;

5 S200: moving products under a guidance of the vision system to a position where portions of the products to be soldered overlap the target position, and holding the products to be stationary;

S300: turning on the laser source to heat a solder material provided on the portions of the products to be soldered to solder the products together; and

S400: turning off the laser source.

10 According to an exemplary embodiment of the present invention, before the step S200, the method further comprises a step of:

S110: adjusting an azimuth angle of a scanning galvanometer of the laser scan head with a closed loop control configuration under the guidance of the vision system, so that the laser beam is focused on the target position in the work area.

15 According to another exemplary embodiment of the present invention, the step S200 may comprise:

gripping one of the products and holding it in position under the guidance of the vision system, and gripping another of the products and holding it in position under the guidance of the vision system.

20 According to another exemplary embodiment of the present invention, the one of the products gripped and held by the first gripper may comprise a circuit board, and the another one of the products gripped and held by the second gripper may comprise a conducting wire to be soldered on the circuit board.

According to another exemplary embodiment of the present invention, the method may further comprise steps of:

25 S500: loosing the second gripper from the soldered conducting wire, and moving the circuit board to a position where a next portion of the circuit board to be soldered overlaps the target position;

30 S600: gripping a new conducting wire and placing a portion of the new conducting wire to be soldered on the next portion of the circuit board to be soldered by the second gripper under the guidance of the vision system, and holding the circuit board and the new conducting wire to be stationary;

S700: turning on the laser source to heat a solder material provided on the portion of the circuit board to be soldered to solder the circuit board and the new conducting wire together;

35 S800: turning off the laser source; and

S900: repeating step 500 to step 800 until completing the entire soldering operation on the circuit board.

According to another exemplary embodiment of the present invention, the solder

material may comprise a conductive paste pre-printed on at least one of the products, a alloy solder pre-melt or fused on at least one of the products, or a solder wire supplied to the products during soldering the products.

5 According to another exemplary embodiment of the present invention, the products may be soldered together via the solder wire supplied to the products, and the program-controlled automatic soldering system may further comprise a wire feeder mounted on the moving device and configured to feed the solder wire to the portions of the products to be soldered under the guidance of the vision system.

10 According to another exemplary embodiment of the present invention, the products may be held to be stationary by the first gripper and the second gripper during heating the solder material with the focused laser beam.

15 According to another exemplary embodiment of the present invention, the program-controlled automatic soldering system may further comprise: a tray configured to load at least one of the products thereon; and a conveying mechanism configured to convey the tray to the work area.

According to another exemplary embodiment of the present invention, the vision system may comprise at least one camera.

20 According to another exemplary embodiment of the present invention, the program-controlled automatic soldering system may further comprise a illumination unit configured to provide illumination for the vision system to facilitate image capturing.

According to another exemplary embodiment of the present invention, the illumination unit may be configured to be capable of automatically adjusting its optical properties according to geometries and/or dimensions of the products.

25 According to another exemplary embodiment of the present invention, the moving device may be configured to be a multi-freedom robot, and the vision system, the illumination unit and the wire feeder may be mounted on an end arm of the robot.

According to another exemplary embodiment of the present invention, after the first gripper grips and holds the circuit board in position, the second gripper is moved to grip the conducting wire and hold the conducting wire in position on the circuit board.

30 According to another exemplary embodiment of the present invention, the program-controlled automatic soldering system may be adapted to solder various kinds of products.

35 According to another exemplary embodiment of the present invention, the program-controlled automatic soldering system may comprise various kinds of grippers for gripping and holding the various kinds of products.

In the above various exemplary embodiments of the present invention, the laser scan head is used to replace the conventional soldering iron head. Thereby, the solder spot formed by the laser scan head can be controlled to be smaller in size than that formed by the

conventional soldering iron head, thereby improving the soldering accuracy. Furthermore, the conventional soldering iron head needs to physically contact the solder material, while the laser scan head needs not to directly contact the solder material, therefore, the present invention avoids the problem that the soldering iron head is adhered by solder material and must be cleaned periodically, thereby increasing the soldering efficiency and saving the solder material.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the accompanying drawings, in which:

Fig.1 is an illustrative perspective view of a program-controlled automatic soldering system according to an exemplary embodiment of the present invention;

Fig.2 is an illustrative locally enlarged view of the program-controlled automatic soldering system of Fig.1;

Fig.3 is an illustrative main work flow chart of the program-controlled automatic soldering system according to an exemplary embodiment of the present invention;

Fig.4 is an illustrative sub work flow chart of the main work flow chart of Fig.3, for pre-programming the soldering system to solder various kinds of products; and

Fig.5 is an illustrative sub work flow chart of the main work flow chart of Fig.3, for visually checking solder joints.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Exemplary embodiments of the present disclosure will be described hereinafter in detail with reference to the attached drawings, wherein the like reference numerals refer to the like elements. The present disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiment set forth herein; rather, these embodiments are provided so that the present disclosure will be thorough and complete, and will fully convey the concept of the disclosure to those skilled in the art.

In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

According to a general concept of the present invention, there is provided a

program-controlled automatic soldering system, comprising: a laser source configured to emit a laser beam; a laser scan head configured to receive the laser beam from the laser source and focus the laser beam on a target position in a work area; a vision system; and a moving device configured to move products to be soldered under a guidance of the vision system to a position where portions of the products to be soldered overlap the target position, so that the focused laser beam heats a solder material provided on the portions of the products to be soldered to solder the products together.

Fig.1 is an illustrative perspective view of a program-controlled automatic soldering system according to an exemplary embodiment of the present invention; Fig.2 is an illustrative local enlarged view of the program-controlled automatic soldering system of Fig.1.

As shown in Figs.1-2, in the illustrated embodiments, the program-controlled automatic soldering system is configured to solder various kinds of products. Various kinds of control programs corresponding to the various kinds of products are pre-programmed and stored in a controller. In an exemplary embodiment, the controller for controlling the soldering system may be but not limited to Programmable Logic Controller, Industrial Control Computer, or combination thereof.

As shown in Fig.1, in an exemplary embodiment of the present invention, the program-controlled automatic soldering system mainly comprises a laser source 100, a laser scan head 200, a vision system 600 and a moving device 700.

As shown in Figs.1-2, the laser source 100 is configured to emit a laser beam and transmit the laser beam to the laser scan head 200 through, for example, an optical fiber.

Referring to Figs.1-2, the laser scan head 200 is configured to receive the laser beam from the laser source 100 and focus the laser beam on a target position in a work area.

Referring to Figs.1-2 again, the moving device 700 is configured to move a first product 10 and a second product 20 under a guidance of the vision system 600 to a position where portions of the products 10, 20 to be soldered overlap the target position, so that the focused laser beam 201 heats a solder material provided on the portions of the products 10, 20 to be soldered to solder the products 10, 20 together.

In an exemplary embodiment of the present invention, the first product is a circuit board 10, and the second product is a conducting wire 20 to be soldered on the circuit board 10. But the present invention is not limited to the illustrated embodiments, and the first and second products may be other kinds of products to be soldered together. In an exemplary embodiment of the present invention, the program-controlled automatic soldering system is adapted to solder various kinds of products by re-programming the soldering system only.

In the illustrated embodiments, as shown in Figs.1-2, the moving device 700 may be a multi-freedom robot, for example, a 6-axis robot.

Referring to Figs.1-2, the program-controlled automatic soldering system further

comprises a first gripper (not shown) and a second gripper 400 both mounted on an end arm 500 of the robot 700.

Although it is not shown, the program-controlled automatic soldering system may further comprise at least one tray for loading the circuit board 10 and the conducting wires 20 thereon and a conveying mechanism for conveying the tray to the work area.

As shown in Figs.1-2, after the circuit board 10 is conveyed to the work area, the robot 700 moves a first gripper to the circuit board 10 under the guidance of the vision system 600, then the first gripper grips the circuit board 10, and places and holds the circuit board 10 in position under the guidance of the vision system 600.

As shown in Figs.1-2, after the circuit board 10 is placed in position by the first gripper, the robot 700 moves the second gripper 400 to the conducting wire 20 under the guidance of the vision system 600, then the second gripper 400 grips the conducting wire 20, and places and holds the portion of the conducting wire 20 to be soldered on the portion of the circuit board 10 to be soldered under the guidance of the vision system 600.

In the illuminated embodiment, as shown in Figs.1-2, the solder material is a solder wire 30 supplied to the products 10, 20 during soldering the products 10, 20. But the present invention is not limited to this, and the solder material may be a conductive paste pre-printed on the circuit board 10 or an alloy solder pre-melt or fused on the circuit board 10.

As shown in Figs.1-2, in an exemplary embodiment, the program-controlled automatic soldering system further comprises a wire feeder 300 mounted on the moving device 700 and configured to accurately feed the solder wire 30 to the portions of the products 10, 20 to be soldered under the guidance of the vision system 600.

In order to ensure a positional accuracy of solder spots between the circuit board 10 and the conducting wire 20, in an exemplary embodiment as shown in Figs.1-2, the circuit board 10 and the conducting wire 20 are held to be stationary by the first gripper and the second gripper 400 during heating the solder material with the focused laser beam 201.

As shown in Figs.1-2, in an exemplary embodiment, the vision system 600 comprises at least one camera. The camera is also mounted on the end arm 500 of the robot 700. In this way, since the vision system 600, the wire feeder 300, the first gripper and the second gripper 400 are all mounted on the end arm 500 of the robot 700, the relative position relation among them is constant, and coordinate transformations among them are not needed, increasing the calculation speed and the soldering efficiency.

As shown in Figs.1-2, in an exemplary embodiment, the program-controlled automatic soldering system may further comprise an illumination unit 800 configured to provide illumination for the vision system 600 to facilitate image capturing.

In order to improve the image capturing effect of the camera 600, in an exemplary embodiment of the present invention, the illumination unit 800 may be configured to be capable of automatically adjusting its optical properties according to geometries and/or

dimensions of the products to be soldered.

In an exemplary embodiment, the illumination unit 800 is also mounted on the end arm 500 of the robot 700, and in the front of the camera 600. In another exemplary embodiment of the present invention, the illumination unit 800 may be integrated with at least one lens to
5 change the magnification or focal distance of the camera 600.

In an exemplary embodiment of the present invention, an azimuth angle of a scanning galvanometer of the laser scan head 200 can be adjusted through a closed loop control configuration under the guidance of the vision system 600, so that the laser beam 201 can be accurately focused on the target position in the work area.

10 In an exemplary embodiment of the present invention, the laser scan head 200 may be stationary, and a scanning track of the laser beam 201 may be controlled by an independent control system without the guidance of the vision system 600.

In the illuminated embodiments, although only the first gripper for gripping the circuit board 10 and the second gripper 400 for gripping the conducting wire 20 are shown, the
15 present invention is not limited to this, and the program-controlled automatic soldering system may have other kinds of grippers adapted to grip various kinds of products other than the circuit board 10 and the conducting wire 20.

In an exemplary embodiment of the present invention, the first gripper may be a clamp for fixing the circuit board 10 in position.

20 Hereafter, the soldering process of the soldering system of Figs.1-2 will be described in detail with reference to Figs.3-5.

Fig.3 is an illustrative main work flow chart of the program-controlled automatic soldering system according to an exemplary embodiment of the present invention.

As shown in Fig.3, firstly, the soldering system is preprogrammed for various products
25 to be soldered (please see the sub work flow chart of Fig.4, which will be described later); Then, products are selected and fed to the soldering system; Then, a machine vision program is run for selected products to capture images of the selected products and process the captured images; Then, features of the captured images are identified, and it is determined whether or not the identified features conform to features of the to-be-soldered products
30 pre-stored in a control system, if not, an error is reported to alarm that the selected product is not a produce to be soldered, and if yes, a motion plan is generated and performed by the soldering system, so that a first product (for example, a circuit board) is gripped and held by the first gripper and a second product (for example, a conducting wire) is gripped and held by the second gripper; after portions of the first and second products to be soldered have
35 been moved to the target position, it is determined whether or not there is an alloy solder pre-provided on the first product, if yes, the laser source is turned on to heat the alloy solder by scanning the laser beam, and if not, it is determined whether or not there is a conductive paste pre-printed on the first product, if yes, the laser source is turned on to heat the

conductive paste by scanning the laser beam, and if not, the solder wire is fed to the portions to be soldered, and the laser source is turned on to heat the solder wire by scanning the laser beam; Then, after heating and scanning, a machine vision inspection is made to inspect solder joints (please see the sub work flow chart of Fig.5, which will be described later);

5 Then, it is determined whether or not there are other joints to be soldered on the first product, if yes, the second product is moved so that a next joint on the first product is soldered, and if not, the soldering process is finished.

Fig.4 is an illustrative sub work flow chart of the main work flow chart of Fig.3, for pre-programming the soldering system to solder various kinds of products.

10 As shown in Fig.4, firstly, product information is obtained; Then, it is determined whether or not the illumination unit is capable of be program controlled, if yes, the spectrum, intensity, strobe control and the like are programmed for the illumination unit, and if not, a light source is selected for the specific product to be soldered; Then, it is determined whether or not the lens of the vision system is capable of being servo-controlled, if yes,

15 magnification and focus length of the lens are programmed, and if not, a camera lens is adjusted to focus on the target plane; Then, a vision controller is programmed for identifying features of the products to be soldered. Furthermore, referring to Fig.4 again, after the product information is obtained, parameters of the soldering process are defined based on the product information. After the parameters of the soldering process are defined, a laser

20 power sequence is programmed and then a laser scanning pattern is programmed. In addition, referring to Fig.4 again, after the parameters of the soldering process are defined, the type of the first gripper and/ or the type of the second gripper are defined based on the product information, opening and closing sequences of the first gripper and/ or the second gripper is programmed, then the moving device is program-controlled so that the first product and/ or

25 the second product can be gripped and held, and finally all control programs are stored in the control system.

Fig.5 is an illustrative sub work flow chart of the main work flow chart of Fig.3, for visually checking solder joints.

As shown in Fig.5, firstly, an image of a solder joint is captured, then a joint

30 dimensioning algorithm is performed to obtain dimensions of the solder joint; then it is determined whether or not the second product is a conducting wire, if yes, a wire agitation motion is performed to cause a solder bump to be cold quickly; a detection algorithm is performed to detect the cold solder joint so as to obtain a detection result, then an appearance inspection is performed on the solder joint to obtain an appearance inspection

35 result of the solder joint; then the results are checked and compared with standard values of the solder joint; and finally all the results are stored in a manufacturing information system.

Noted that Figs. 3-5 only illustrate an exemplary embodiment of the flow chart of the soldering system, and the present invention is not limited to this.

In another exemplary embodiment of the present invention, there is provided a program-controlled automatic soldering method, comprising steps of:

S100: providing a program-controlled automatic soldering system as described above;

S200: moving products 10, 20 to be soldered under the guidance of the vision system 600 to a position where portions of the products to be soldered overlap the target position, and held the products 10, 20 to be stationary;

S300: turning on the laser source 100 to heat a solder material provided on the portions of the products 10, 20 to be soldered to solder the products 10, 20 together; and

S400: turning off the laser source 100.

In an exemplary embodiment of the present invention, before the step S200, the above method may further comprise a step of:

S110: adjusting an azimuth angle of a scanning galvanometer of the laser scan head 200 with a closed loop control configuration under the guidance of the vision system 600, so that the laser beam 201 is focused on the target position in the work area.

In an exemplary embodiment of the present invention, the step S200 may comprise steps of: gripping one of the products 10, 20 and placing it in position by a first gripper under the guidance of the vision system 600, and gripping the other of the products 10, 20 and placing it in position by a second gripper 400 under the guidance of the vision system 600.

In an exemplary embodiment of the present invention, one of the products 10, 20 grabbed and held by the first gripper comprises a circuit board 10; and the other of the products 10, 20 grabbed and held by the second gripper 400 comprises a conducting wire 20 to be soldered on the circuit board 10.

In another exemplary embodiment of the present invention in which the one product 10 gripped by the first gripper is a circuit board while the other product 20 gripped by the second gripper 40 is a conducting wire to be soldered on the circuit board, after the above step 400, the above method may further comprising steps of:

S500: loosing the second gripper 400 from the soldered conducting wire 20, and moving the circuit board 10 to a position where a next portion of the circuit board 10 to be soldered overlaps the target position;

S600: gripping a new conducting wire 20 and placing a portion of the new conducting wire 20 to be soldered on the next portion of the circuit board 10 to be soldered by the second gripper 400 under the guidance of the vision system 600, and holding the circuit board 10 and the new conducting wire 20 to be stationary;

S700: turning on the laser source 100 to heat a solder material provided on the portion of the circuit board 10 to be soldered to solder the circuit board 10 and the new conducting wire 20 together;

S800: turning off the laser source 100; and

S900: repeating step 500 to step 800 until completing the entire soldering operation on the circuit board 10.

In the above various exemplary embodiments of the present invention, by replacing the conventional soldering iron head with the laser scan head, and by incorporating guiding functions of the machine vision system, the program-controlled automatic soldering system of the present invention has at least following advantages of:

1) The solder spot formed by the laser scan head is very small, for example, the diameter of the solder spot may be less than 0.1mm, thereby enabling a small pitch, high precision soldering process;

2) A better and a stable heating energy control can be achieved by quickly opening and closing the laser source;

3) The laser scan head needs not to directly contact the solder material, thereby avoiding the problem of cleaning the adhered solder material periodically, increasing the soldering efficiency and saving the solder material;

4) The products can be held to be stationary by the grippers to prevent the products from being accidentally displaced during soldering, ensuring the soldering accuracy;

5) The azimuth angle of the scanning galvanometer of the laser scan head can be controlled with a closed loop control configuration under the guidance of the vision system, so that the laser beam can be accurately focused on the target position, increasing the soldering accuracy;

6) The solder spot formed by the focused laser beam can be controlled to be suitable for different products to be soldered, therefore, the soldering system can solder various kinds of products with the same one laser scan head, without changing different laser scan heads as in prior arts.

It should be appreciated for those skilled in this art that the above embodiments are intended to be illustrated, and not restrictive. For example, many modifications may be made to the above embodiments by those skilled in this art, and various features described in different embodiments may be freely combined with each other without conflicting in configuration or principle.

Although several exemplary embodiments have been shown and described, it would be appreciated by those skilled in the art that various changes or modifications may be made in these embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents.

As used herein, an element recited in the singular and proceeded with the word "a" or "an" should be understood as not excluding plural of said elements or steps, unless such exclusion is explicitly stated. Furthermore, references to "one embodiment" of the present invention are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Moreover, unless explicitly stated to

the contrary, embodiments "comprising" or "having" an element or a plurality of elements having a particular property may include additional such elements not having that property.

What is claimed is,

1. A program-controlled automatic soldering system, comprising:

a laser source (100) configured to emit a laser beam;

5 a laser scan head (200) configured to receive the laser beam from the laser source (100) and focus the laser beam on a target position in a work area;

a vision system (600); and

a moving device (700) configured to move products (10, 20) to be soldered under a guidance of the vision system (600) to a position where portions of the products to be
10 soldered overlap the target position, so that the focused laser beam (201) heats a solder material provided on the portions of the products (10, 20) to be soldered to solder the products (10, 20) together.

2. The program-controlled automatic soldering system according to claim 1, further
15 comprising:

a first gripper mounted on the moving device (700) and configured to grip one of the products (10, 20) and hold it in position under the guidance of the vision system (600); and

a second gripper (400) mounted on the moving device (700) and configured to grip
20 another one of the products (10, 20) and hold it in position under the guidance of the vision system (600).

3. The program-controlled automatic soldering system according to claim 2,

wherein the solder material comprises a conductive paste pre-printed on at least one of the products (10, 20), a alloy solder pre-melt or fused on at least one of the products (10, 20),
25 or a solder wire (30) supplied to the products (10, 20) during soldering the products (10, 20).

4. The program-controlled automatic soldering system according to claim 3,

wherein the program-controlled automatic soldering system is configured to solder the products (10, 20) together via the solder wire (30) supplied to the products (10, 20); and

30 wherein the program-controlled automatic soldering system further comprises a wire feeder (300) mounted on the moving device (700) and configured to feed the solder wire (30) to the portions of the products (10, 20) to be soldered under the guidance of the vision system (600).

5. The program-controlled automatic soldering system according to claim 4,

35 wherein the products (10, 20) are held to be stationary by the first gripper and the second gripper (400) during heating the solder material with the focused laser beam (201).

6. The program-controlled automatic soldering system according to claim 5, further comprising:

a tray configured to load at least one of the products (10, 20) thereon; and
a conveying mechanism configured to convey the tray to the work area.

5

7. The program-controlled automatic soldering system according to claim 5, wherein the vision system (600) comprises at least one camera.

8. The program-controlled automatic soldering system according to claim 7, further comprising:

an illumination unit (800) configured to provide illumination for the vision system (600) to facilitate image capturing.

9. The program-controlled automatic soldering system according to claim 8,
wherein the illumination unit (800) is configured to be capable of automatically adjusting its optical properties according to geometries and/or dimensions of the products (10, 20).

10. The program-controlled automatic soldering system according to claim 9,
wherein the moving device (700) is configured to be a multi-freedom robot;
wherein the vision system (600), the illumination unit (800) and the wire feeder (300) are mounted on an end arm (500) of the robot; and
wherein the first gripper comprises a clamp for fixing one of the products (10, 20) in position.

25

11. The program-controlled automatic soldering system according to claim 1,
wherein the laser scan head (200) is configured to be capable of adjusting an azimuth angle of a scanning galvanometer thereof with a closed loop control configuration under the guidance of the vision system (600), so that the laser beam (201) is focused on the target position in the work area; or

30

wherein the laser scan head (200) is configured to be stationary, and a scanning track of the laser beam (201) is controlled by an independent control system without the guidance of the vision system (600).

12. The program-controlled automatic soldering system according to claim 10,
wherein the one of the products (10, 20) gripped and held by the first gripper comprises a circuit board (10); and

35

wherein the another one of the products (10, 20) gripped and held by the second

gripper (400) comprises a conducting wire (20) to be soldered on the circuit board (10).

13. The program-controlled automatic soldering system according to claim 12,
wherein the second gripper (400) is configured to grip the conducting wire (20) and
5 hold the conducting wire (20) in position on the circuit board (10) after the first gripper grips
and holds the circuit board (10) in position.

14. The program-controlled automatic soldering system according to claim 1,
wherein the program-controlled automatic soldering system is adapted to solder
10 various kinds of products.

15. The program-controlled automatic soldering system according to claim 14,
wherein the program-controlled automatic soldering system comprises various kinds of
grippers for gripping and holding the various kinds of products.

16. A program-controlled automatic soldering method, comprising steps of:
S100: providing a program-controlled automatic soldering system according to claim
1;
S200: moving products (10, 20) under a guidance of the vision system (600) to a
20 position where portions of the products to be soldered overlap the target position, and
holding the products (10, 20) to be stationary;
S300: turning on the laser source (100) to heat a solder material provided on the
portions of the products (10, 20) to be soldered to solder the products (10, 20) together; and
S400: turning off the laser source (100).

25 17. The method according to claim 16, before the step S200, the method further
comprising a step of:

S110: adjusting an azimuth angle of a scanning galvanometer of the laser scan head
(200) with a closed loop control configuration under the guidance of the vision system (600),
30 so that the laser beam (201) is focused on the target position in the work area.

18. The method according to claim 17, the step S200 comprising:
gripping one of the products (10, 20) and holding it in position under the guidance of
the vision system (600), and gripping another one of the products (10, 20) and holding it in
35 position under the guidance of the vision system (600).

19. The method according to claim 18,
wherein the one of the products (10, 20) gripped and held by the first gripper comprises

a circuit board (10); and

wherein the another one of the products (10, 20) gripped and held by the second gripper (400) comprises a conducting wire (20) to be soldered on the circuit board (10).

5 20. The method according to claim 19, further comprising step of:

S500: loosing the second gripper (400) from the soldered conducting wire (20), and moving the circuit board (10) to a position where a next portion of the circuit board (10) to be soldered overlaps the target position and holding the circuit board (10) in position under the guidance of the vision system (600);

10 S600: gripping a new conducting wire (20) and placing it on the next portion of the circuit board (10) to be soldered by the second gripper (400) under the guidance of the vision system (600), and holding the circuit board (10) and the new conducting wire (20) to be stationary;

15 S700: turning on the laser source (100) to heat a solder material provided on the portion of the circuit board (10) to be soldered to solder the circuit board (10) and the new conducting wire (20) together;

S800: turning off the laser source (100); and

S900: repeating the step 500 to the step 800 until completing the entire soldering operation on the circuit board (10).

20

21. The method according to claim 20,

wherein the solder material comprises a conductive paste pre-printed on at least one of the products (10, 20), a alloy solder pre-melt or fused on at least one of the products (10, 20), or a solder wire (30) supplied to the products (10, 20) during soldering the products (10, 20).

25

22. The method according to claim 21,

wherein the products (10, 20) are soldered together via the solder wire (30) supplied to the products (10, 20); and

30 wherein the program-controlled automatic soldering system further comprises a wire feeder (300) mounted on the moving device (700) and configured to feed the solder wire (30) to the portions of the products (10, 20) to be soldered under the guidance of the vision system (600).

23. The method according to claim 22,

35 wherein the products (10, 20) are held to be stationary by the first gripper and the second gripper (400) during heating the solder material with the focused laser beam (201).

24. The method according to claim 21,

wherein the program-controlled automatic soldering system further comprising:
a tray configured to load at least one of the products (10, 20) thereon; and
a conveying mechanism configured to convey the tray to the work area.

5 25. The method according to claim 24, wherein the vision system (600) comprises at least one camera.

26. The method according to claim 25, wherein the program-controlled automatic soldering system further comprising:

10 an illumination unit (800) configured to provide illumination for the vision system (600) to facilitate image capturing.

27. The method according to claim 26,

15 wherein the illumination unit (800) is configured to be capable of automatically adjusting its optical properties according to geometries and/or dimensions of the products (10, 20).

28. The method according to claim 27,

wherein the moving device (700) is configured to be a multi-freedom robot; and

20 wherein the vision system (600), the illumination unit (800) and the wire feeder (300) are mounted on an end arm (500) of the robot.

29. The method according to claim 19,

25 wherein after the first gripper grips and holds the circuit board (10) in position, the second gripper (400) is moved to grip the conducting wire (20) and hold the conducting wire (20) in position on the circuit board (10).

30. The method according to claim 16,

30 wherein the program-controlled automatic soldering system is adapted to solder various kinds of products.

31. The method according to claim 30,

wherein the program-controlled automatic soldering system comprises various kinds of grippers for gripping and holding the various kinds of products.

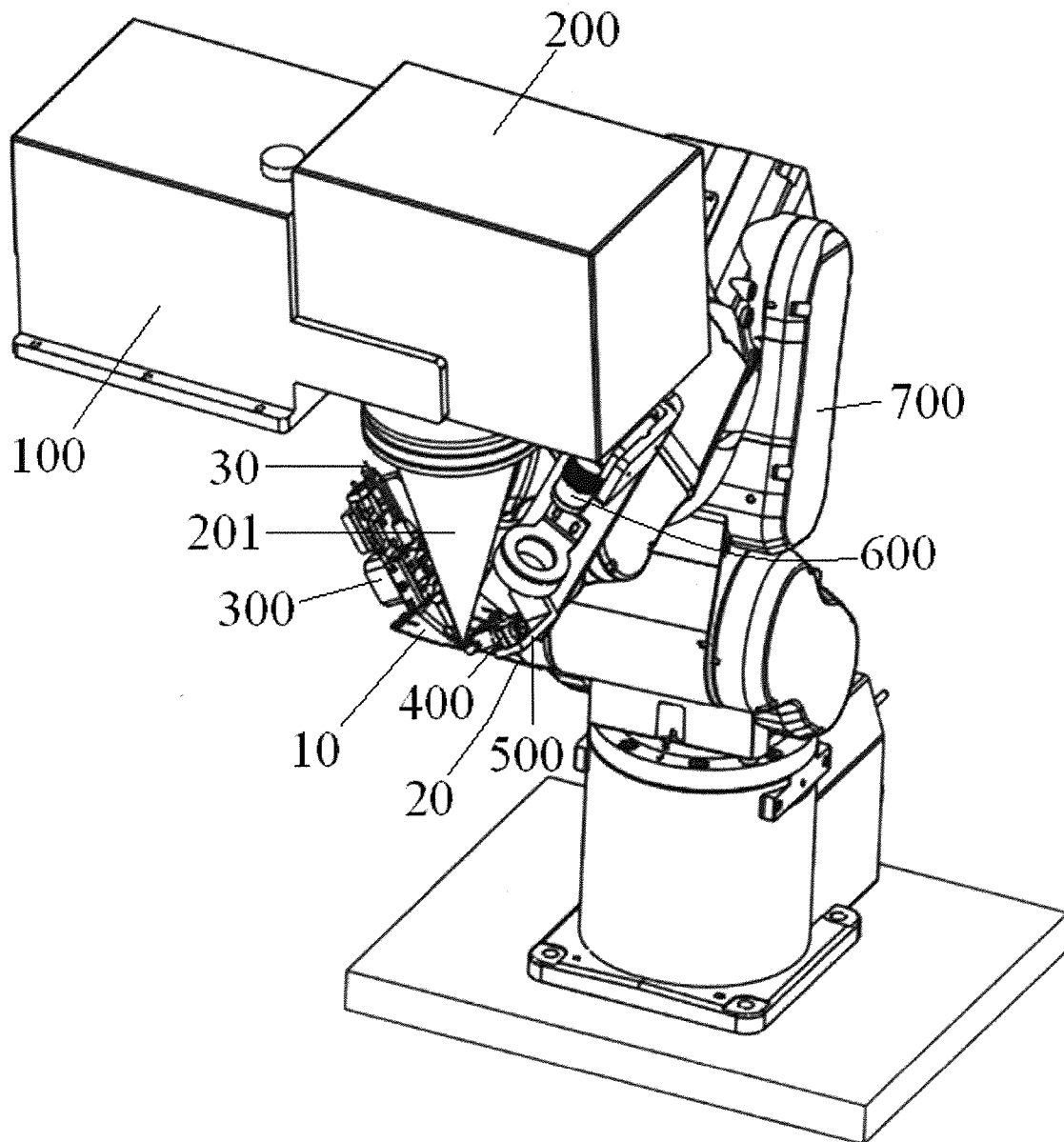


Fig.1

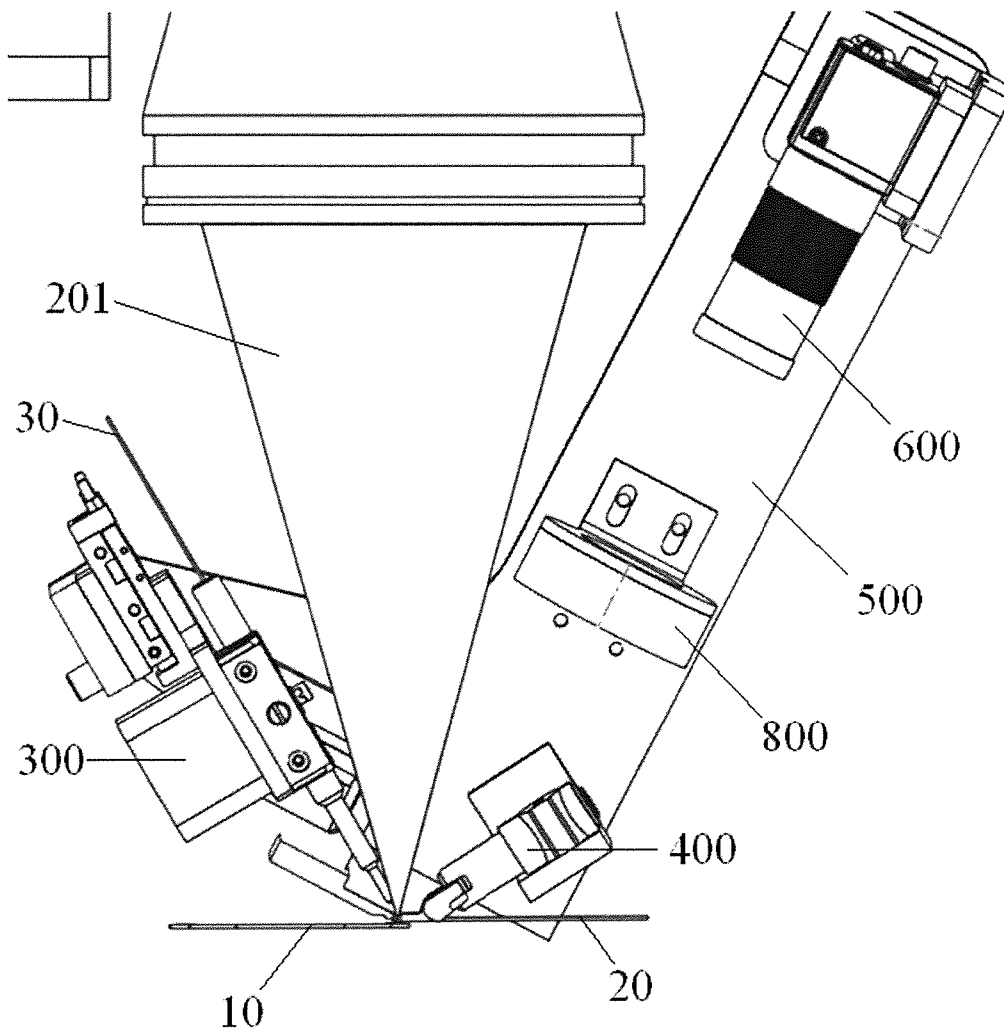


Fig.2

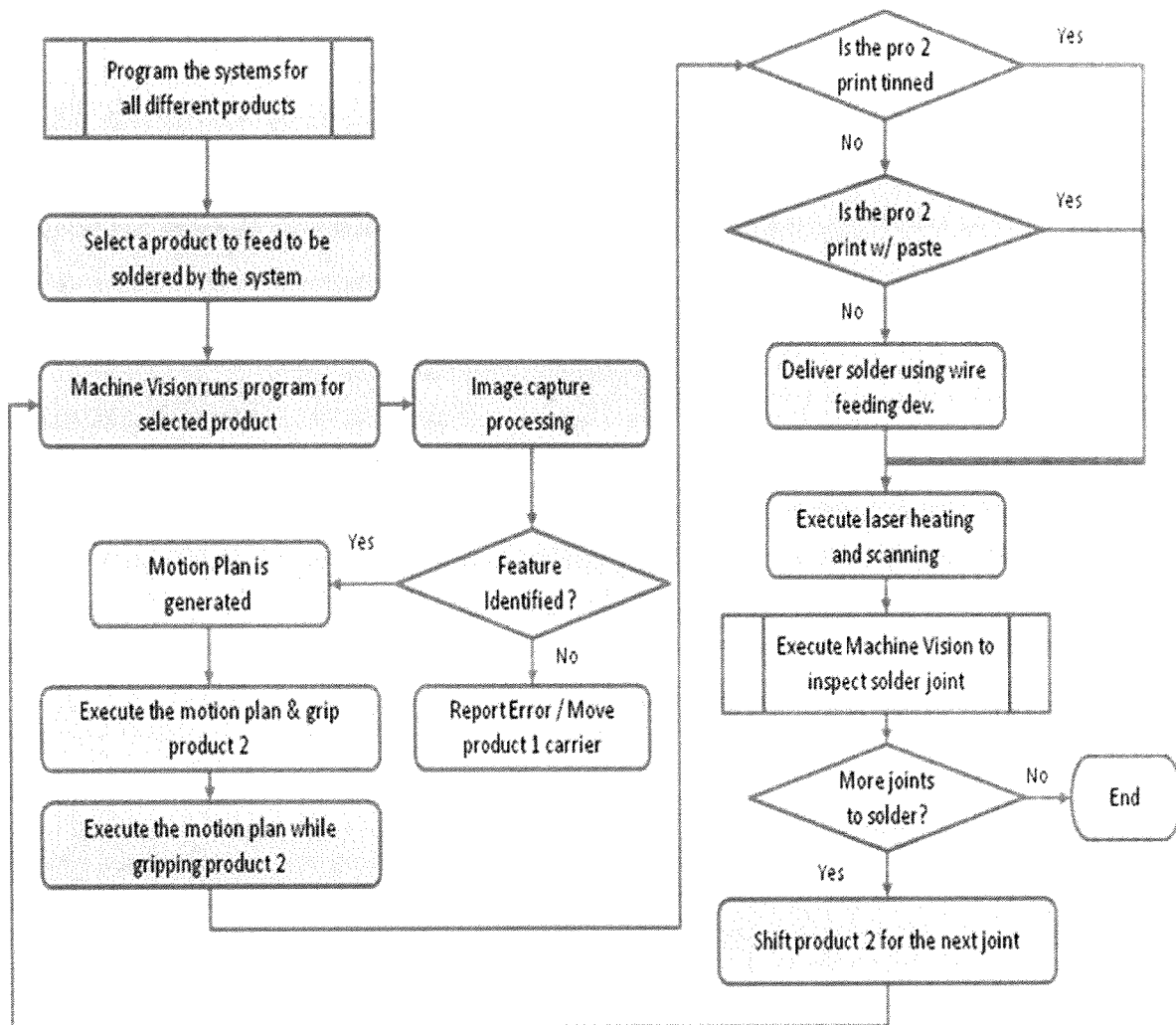


Fig.3

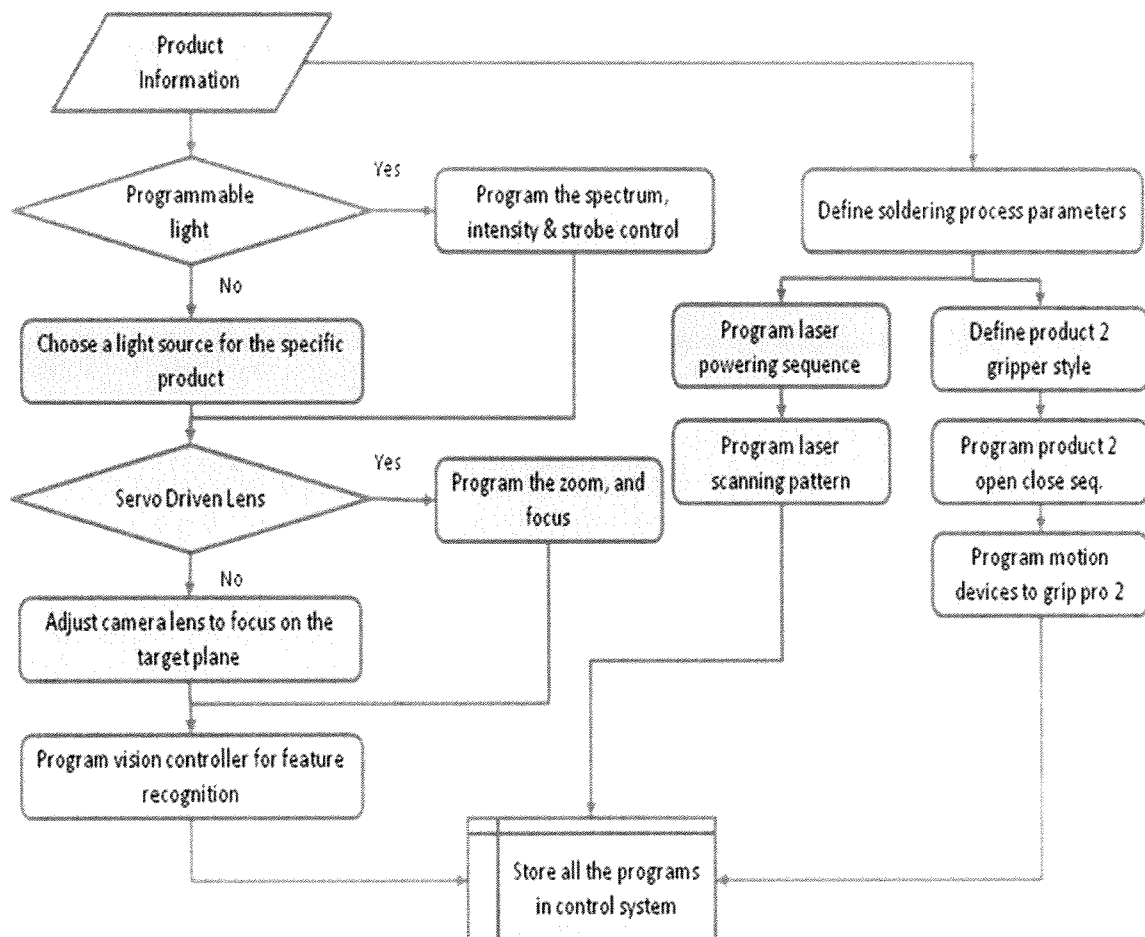


Fig.4

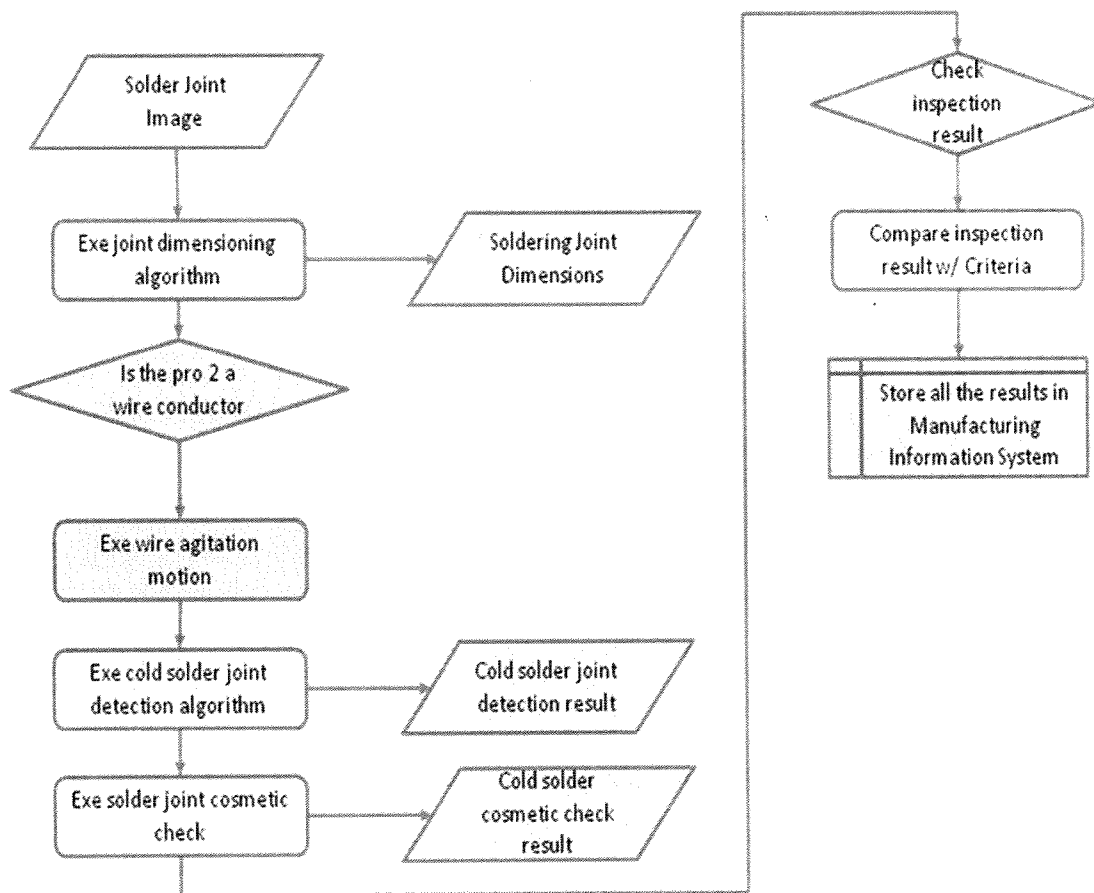


Fig.5