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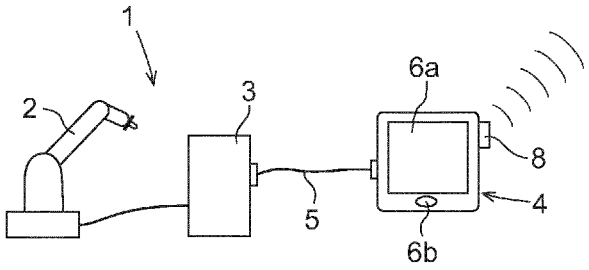

Fig. 1

(57) Abstract: The present invention relates to an industrial robot system comprising at least one robot (1) including a manipulator (2) movable about a plurality of axes, a robot controller (3) configured to control the motions of the manipulator, and a portable control unit (4) connected to the robot controller (3) through a wire (5). The portable control unit (4) has a user interface (6a- b) adapted to communicate with the robot controller (3) and to enable programming of the motions of the manipulator (2). The portable control unit (4) comprises a wireless communication device (8) for wireless connection to an external network. The portable control unit (4) is configured to receive data from the robot controller (3) and to transmit the received data to the external network by means of the wireless communication device (8). The invention also relates to a method for communication between at least one industrial robot and an external network.

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An industrial robot system and a method for communication between an industrial robot and an external network.

Field of the invention

The present invention relates to an industrial robot system comprising at least one robot. The present invention also relates to a method for communication between an industrial robot and an external network.

Background of the invention

An industrial robot typically comprises a manipulator movable about a plurality of axes, a robot controller configured to control the motions of the manipulator, and a portable control unit having a user interface adapted to communicate with the robot controller and to enable programming of the motions of the manipulator. The portable control unit can be connected to the robot controller wirelessly or through a wire. The portable control unit is generally denoted a Teach Pendant Unit (TPU).

WO14127822 discloses an industrial robot comprising a portable control device in the form of a general-purpose device adapted to communicate with the robot controller. The portable control device can be, for example, a smart phone or a tablet computer. The robot comprises a separate enabling unit including an enabling device that has to be activated to enable jogging of the robot.

It is well known to monitor a plurality of robots from a service center disposed at a remote location. The remote service center can perform monitoring of a large number of robots spread at a plurality of plants at different geographic locations. Extensive amount of service data is sent from the robots to the service center, which carries out diagnostics computations on the received data. The service center delivers service diagnostics to customers.

US2008/0247549 discloses a system of monitoring a plurality of robots, spread at different locations, by means of information exchange between individual robots and a remote service center. Each robot of the system is provided with a service box. The service box is connected to the robot controller and hosts internal GPRS/3G connectivity inside. The service box is in communication with a remote server unit at the remote service center. The service box comprises a service module configured to collect service data from the robot controller for monitoring and diagnostic purpose. The service box is provided with hardware and software to enable communication with the remote server unit and to enable transfer of service data to the remote server unit. For example, an access point can be provided at both the local site and remote site. This access point can take the form of a VPN router or other equipment allowing secure access to the remote service center. It is also proposed to use cheap communication lines, such as the Internet or GPRS. The connectivity to the Internet is today handled by the service box.

Due to the fact that each of the robots in the system must be provided with a service box, the cost for the system is increased when the robots are monitored from the remote service center. In order to reduce costs, it is desired to remove the service boxes. Further, in order to save costs, it is desired that the service data is sent from the robot controller to the remote service center via a cheap communication line, such as the Internet. However, there is a problem to provide the robot controller with access to the Internet. Connectivity to the Internet can be problematic to setup for the customer, leaving many robots unconnected. Problems range from the sheer lack of network connectivity (cables) within the workshop for small/medium size businesses, to issues with setting the correct proxy setting and opening up firewalls on larger corporate networks. Thus, implementing this functionality in the robot controller is costly and time consuming.

Object and summary of the invention

It is an object of the present invention to at least partly overcome the above problems. One object of the invention is to provide the robot controller with access to an external network, such as the Internet, in a simple and cost effective way.

This object is achieved by an industrial robot system as defined in claim 1.

The industrial robot system comprises at least one robot including a manipulator movable about a plurality of axes, a robot controller configured to control the motions of the manipulator, and a portable control unit connected to the robot controller through a wire and having a user interface adapted to communicate with the robot controller and to enable programming of the motions of the manipulator. According to the invention, the portable control unit comprises a wireless communication device for wireless connection to an external network, and the portable control unit is configured to receive data from robot controller and to transmit the received data to the external network by means of the wireless communication device.

By a wireless communication device is meant a device comprising the necessary hardware and software for enabling wireless communication with another communication device. The wireless communication device can be configured to provide direct access to the external network, or to provide indirect access to the external network via a local access point. Thus, the other communication device can be a local device, such as a router or a modem, providing indirect access to the external network, or a telecommunication device on the external network. The wireless communication device comprises an antenna, a transmitter, and software for handling transmission of wireless data. Preferably, the wireless communication device also comprises a receiver, and software for handling received wireless data.

The present invention is based on the realization that the portable control unit can be used as an Internet gateway for the robot controller. Thus, the above-mentioned problems with providing the robot controller with access to the Internet are avoided. The portable control unit is used as an Internet Gateway for the controller and can use the state of the art operating

system and hardware in the portable control unit, instead of implementing this functionality in the robot controller, which would be much more costly and time consuming to develop. The invention makes it possible to remove the service boxes, which will save costs.

The portable control unit is connected to the robot controller via a wire, which makes it easy for the robot controller to transmit data to the portable control unit. The portable control unit can be an external computer, and accordingly it is easier and less costly to provide the portable control unit with access to the Internet, than implementing this functionality in the robot controller. The portable control unit can easily be provided with commercially available drivers for wireless communication. The present invention enables the robot controller access to an external network, such as the Internet, without the need of any addition hardware or software in the robot controller.

According to an embodiment of the invention, the robot is located at a local site, the robot controller comprises an embedded service module configured to collect service data from the robot controller for monitoring and diagnostic purpose, and the system comprises a remote server unit located at a remote site, connected to the external network, and adapted to receive service data from the robot controller and to perform remote monitoring and service of the robot based on the received service data, the robot controller is configured to send the service data to the portable control unit, and the portable control unit is configured to transmit the service data to the remote server unit via said wireless communication device.

This embodiment makes it possible to omit the service box and accordingly lowers the costs for the customer to connect their robots to the remote server unit. Instead of providing the robot with a separate service box in communication with the remote server unit, an embedded service module is provided on the robot controller and the service data is sent from the robot controller to the remote server unit via the portable control unit. This embodiment makes it easier for the customer to connect the embedded service module to the Internet, thus lowering the technological complexity barrier preventing some customers from connecting their robots.

According to an embodiment of the invention, the system comprises a local access point, which has the ability to communicate with the external network, said wireless communication device is configured to wirelessly communicate with the local access point, and to transmit the received data to the local access point. The local access point is provided with a communication device, for example, a router. The communication device providing the local access point can be a wireless communication device for wireless communication with the external network. However, it can also be connected to the external network through a wire.

According to an embodiment of the invention, the portable control unit is a general-purpose device configured to communicate with the robot controller and including a user interface adapted to allow jogging of the manipulator. The general-purpose device is, for example, a

portable mobile computer, a tablet computer, or a smart phone. A general-purpose device is a device that can be used in a large number of applications and is not designed for a special purpose. The general-purpose devices have the ability to receive and evaluate inputs from a user. Further, the general-purpose devices possess the possibility to add functionality, for example, to download software modules, such as apps. The functionality that has to be added to the general-purpose device in order to configure it as a portable control device for an industrial robot is the ability to request authorization to take over control of the robot during manual mode and to jog the manipulator. It is an advantage to use a general-purpose device as portable control device since it is often provided with wireless communication unit from its supplier, or is designed so that it can easily be provided with the ability to communicate wirelessly. A general-purpose device is usually provided with a general-purpose operating system.

According to an embodiment of the invention, the portable control unit comprises a general-purpose operating system designed for handling wireless communication. By a general-purpose operating system is meant an operating system that can be used in a large number of applications and is not designed for a special purpose. The general-purpose operating systems available on the market are often designed for handling wireless communication devices and are provided with a HMI for setting up the wireless communication. A suitable operating system is Windows 10. This operating system is ideal for handling Wi-Fi clients, mainly since it is the 1st choice of driver implementation for any wireless network adapter but also the HMI for setting up Wi-Fi connections is excellent. Windows 10 also comes fully equipped with the latest software for cyber protection and more can be added if that is deemed necessary.

According to an embodiment of the invention, the system comprises a plurality of robots, and each of the robots has a portable control unit comprising a wireless communication device for wireless communication with the local access point. If there are several robots at a plant, it can be advantageous to use a common access point for the robots. The common access point can be connected, for example, to an internal network and the internal network is connected to an external network, such as, the Internet. For example, the wireless communication device is a Wi-Fi client. The invention makes it possible to create a Wi-Fi client for the robot controller with reduced costs both directly and indirectly through the maintenance costs for a Wi-Fi solution.

For example, the wireless communication device is configured to use radio waves to communicate with the local access point.

The wireless communication device can be, for example, integrated in the portable control unit. However, the wireless communication device can also be a separate device, which is connected to the portable control unit. For example, the wireless communication device can

be a USB network device connected to a USB contact of the portable control unit. This is a simple and cheap way to provide the portable control unit with access to the Internet.

According to an embodiment of the invention, the wireless communication device is adapted for a wireless local area network. According to another embodiment of the invention, the wireless communication device is adapted for a mobile data network, such as Wi-Fi, GPRS, 3G, 4G, or 5G.

According to an embodiment of the invention, the wireless communication device is arranged inside of the portable control unit. Suitably, the antenna of the wireless communication device is embedded in the encapsulation of the portable control device.

The object of the invention is also achieved by a method for communication between at least one industrial robot and an external network as defined in claim 12.

The method comprises:
- enabling the portable control unit to be used as a wireless gateway for the robot controller,
- sending data from the robot controller to the portable control unit via the wire, and
- using the portable control unit as a gateway for wirelessly sending the received data to the external network.

According to an embodiment of the invention, the received data is sent to the external network via a local access point, which has the ability to communicate with the external network.

According to an embodiment of the invention, the received data is sent to the local access point using radio waves.

According to an embodiment of the invention, the method further comprises:
- sending service data for monitoring and diagnostic purpose from the robot controller to the portable control unit via the wire,
- forwarding the service data from the portable control unit to a remote service center connected to the external network using the portable control unit as a gateway for wireless transmission the service data to the external network, and
- receiving the service data at the remote service center and performing remote monitoring and service of the robot based on the received service data.

Brief description of the drawings

The invention will now be explained more closely by the description of different embodiments of the invention and with reference to the appended figures.

Fig. 1 shows an industrial robot system according to an embodiment of the invention comprising one robot.

Fig. 2 shows an industrial robot system comprising one robot and a remote server unit carrying out remote monitoring of the robot according to another embodiment of the invention.

Fig. 3 shows an industrial robot system comprising a plurality of robots communicating via a local access point with a remote server unit carrying out remote monitoring of the robots according to another embodiment of the invention.

Fig. 4 shows schematically a robot controller and a portable control unit.

Detailed description of preferred embodiments of the invention

Figure 1 shows an industrial robot system according to an embodiment of the invention. The robot system comprises a robot 1 including a manipulator 2 movable about a plurality of axes, a robot controller 3 configured to control the motions of the manipulator 2, and a portable control unit 4 connected to the robot controller 3 through a wire 5. The portable control unit 4 has a user interface 6a - b adapted to communicate with the robot controller 3 and to enable programming of the motions of the manipulator. The portable control unit 4 comprises a wireless communication device 8 for wireless connection to an external network. The portable control unit 4 is configured to receive data from the robot controller 3 and to transmit the received data to the external network by means of the wireless communication device 8. The external network is suitably the Internet. The portable control unit 4 is used as a gateway for the robot controller 3 so that the robot controller is provided with access to the external network via the portable control unit 4.

The portable control unit 4 is defined as a device for jogging and programming the robot. The portable control unit 4 is, for example, a traditional teach pendant unit (TPU). A TPU includes operator control means, for example, a joystick, a ball, or a set of buttons, which the operator uses to instruct the robot movement. The TPU further comprises an enabling device, for example, a dead man's switch or a push button, which has to be pressed by the operator to enable manual control of the robot by the TPU.

The portable control unit 4 can also be a general-purpose device, such as a smart phone or a tablet computer, adapted to communicate with the robot controller. In the embodiment disclosed in figure 1, the portable control unit 4 is a tablet computer and the user interface comprises a touch screen 6a and one or more physical buttons 6b. In this case, the robot comprises a separate enabling unit (not shown) including an enabling device that has to be activated to enable jogging of the robot. The portable control unit 4 is configured to communicate with the robot controller via the wire 5. The portable control unit 4 is provided with one or more software modules adapted to configure the existing user interface of the device to enable a user to input jog instructions to the device, and to generate and send jog commands to the robot controller in response to user interactions with the user interface. The robot controller controls the movements of the manipulator based on jog information

received from the portable control unit 4 and in dependence on the state of the enabling device.

The wireless communication device 8 comprises an antenna, a transmitter, and software for handling transmission of wireless data. Optionally, the wireless communication device also comprises a receiver, and software for handling received wireless data, to enable two-way communication with the external network. The wireless communication device 8 can be integrated, for example, in the portable control unit 4, or be a separate device, which is connected to the portable control unit. For example, the wireless communication device 8 can be a USB network device connected to a USB contact of the portable control unit, as shown in figure 1. The wireless communication device 8 can, for example, be adapted to communicate directly with the external network via a mobile data network, such as GPRS, 3G, 4G, or 5G. The wireless communication device can also be adapted for a wireless local area network, and for communication with a local access point, as shown in figure 3.

Figure 2 shows an industrial robot system comprising one robot 1 and a remote server unit 10 carrying out remote monitoring of the robot. The robot 1 is located at a local site and the remote server unit 10 is located at a remote site. The robot 1 and the remote server unit 10 are communicating over an external network 12, which suitably is the Internet. The robot controller 3 comprises an embedded service module 14 configured to collect service data from the robot controller for monitoring and diagnostic purpose. The remote server unit 10 is connected to the external network 12, and is adapted to receive service data collected by the service module 14, and to perform remote monitoring and service of the robot based on the received service data. The robot controller 3 is configured to send the service data to the portable control unit 4, and the portable control unit is configured to transmit the service data to the remote server unit 10 via the wireless communication device 8. In this embodiment, the wireless communication device 8 communicates directly with the external network 12. The service data is sent from the robot controller 3 to the portable control unit 4 via the wire 5, and the portable control unit 4 wirelessly transmits the received service data to the external network by means of the wireless communication device 8.

In another embodiment according to figure 3, the system comprises a local access point 16, which has the ability to communicate with the external network, and the wireless communication device 8 is configured to wirelessly communicate with the local access point. In this case, the service data is sent from the robot controller 3 to the portable control unit 4 via the wire 5, and the portable control unit 4 wirelessly transmits the received service data to the local access point by means of the wireless communication device 8, and the service data is transmitted to the external network 12 from the local access point either through a wire or wirelessly. The remote server 10 can also be configured to send commands to the robot controller and more particularly to the embedded service module 14. The commands are sent to the local access point 16 via the external network 12, and then wirelessly to the portable control unit 4 via the wireless communication device 8. The portable control unit 4

forwards the commands further to the robot controller 3 through the wire 5. The wireless communication device 8 is, for example, configured to use radio waves to communicate with the local access point 16. The local access point is defined, for example, by a router, or a modem.

Figure 3 shows an industrial robot system comprising a plurality of robots 1a-d communicating via a local access point 16 with a remote server unit 10 carrying out remote monitoring of the robots. The local access point 16 has the ability to communicate with an external network, such as the Internet. Each of the robots 1a-d comprises a manipulator 2 movable about a plurality of axes, a robot controller 3 configured to control the motions of the manipulator 2, and a portable control unit 4 connected to the robot controller 3 through a wire 5. Each of the robot controllers 3 comprises an embedded service module 14 configured to collect service data from the robot controller for monitoring and diagnostic purpose. Each of the portable control units 4 is provided with a user interface 6a-b adapted to communicate with the robot controller 3 and to enable programming of the motions of the manipulator.

Each of the portable control units 4 comprises a wireless communication device 8 for wireless connection to the access point 16. Each of the portable control units 4 is configured to receive service data from the robot controller 3 though the wire 5, and to wirelessly transmit the received service data to the local access point 16 by means of the wireless communication device 8. The local access point 16 is connected to the external network 12, either directly or through an internal network. The remote server unit 10 is communicating with each of the robots on the local site via the external network 12. In this embodiment, the wireless communication device 8 is adapted for a wireless local area network. For example, the communication device 8 is a Wi-Fi client. This means that each of the portable control units must be provided with a Wi-Fi driver. A general-purpose device, such as a tablet computer or a smart phone is mostly provided with a Wi-Fi driver upon delivery from the supplier, or can easily be provided with a standard Wi-Fi driver. In one embodiment of the invention, the portable control unit 4 is used as a Wi-Fi gateway for the robot controllers 3.

Figure 4 shows schematically a robot controller 3 and a portable control unit 4. The robot controller comprises software as well as hardware, such as input and output means, a processor unit including one or more central processing units (CPUs), for handling main functions of the robot controller 3 such as executing robot control programs, and providing orders to the drive unit of the robot regarding movements of the manipulator 2. In addition to the standard software, the robot controller comprises an embedded service module 14 for remote service, which collects service data from the robot controller 3 for monitoring and diagnostic purposes. The embedded service module 14 is a software module executed on the robot controller. The robot controller also comprises a port 18 for connection to the portable control unit 4. The collected service data is sent to the portable control unit 4 through the wire 5.

The portable control unit 4 is, for example, an external computer of tablet type, provided with a user interface 6a-b that makes it possible for a user to communicate with the robot controller. The control unit 4 is provided with one or more software modules 20 adapted to configure the existing user interface 6a-b of the device to enable a user to input jog instructions to the device, and to generate and send jog commands to the robot controller in response to user interactions with the user interface. The portable control unit 4 is further provided with a wireless communication device 8, for wireless communication. The wireless communication device 8 comprises an antenna 22. The wireless communication device 8 is, for example, a Wi-Fi/3G client. The portable control unit 4 comprises a general-purpose operative system 24, for example Windows 10.

Setting up the connectivity for the embedded remote service functionality would benefit greatly if the robot could connect to a Wi-Fi Access Point (AP) that supplies Internet connectivity instead of relying on wired networking. This would allow the embedded remote service agent cheap Internet connectivity with greater ease and one or many robots could connect to the same AP.

The present invention is not limited to the embodiments disclosed but may be varied and modified within the scope of the following claims. For example, the wireless communication device 8 can be based on other wireless technologies and other configurations than mentioned above.

Claims

1. An industrial robot system comprising at least one robot (1) including a manipulator (2) movable about a plurality of axes, a robot controller (3) configured to control the motions of the manipulator, and a portable control unit (4) connected to the robot controller (3) through a wire (5) and having a user interface (6a-b) adapted to communicate with the robot controller (3) and to enable programming of the motions of the manipulator (2), characterized in that the portable control unit (4) comprises a wireless communication device (8) for wireless connection to an external network (12), and the portable control unit (4) is configured to receive data from the robot controller (3) and to transmit the received data to the external network (12) by means of the wireless communication device (8).

2. The robot system according to claim 1, wherein the robot (1) is located at a local site, the robot controller (3) comprises an embedded service module (14) configured to collect service data from the robot controller (3) for monitoring and diagnostic purpose, and the system comprises a remote server unit (10) located at a remote site, connected to the external network (12), and adapted to receive service data from the robot controller (3) and to perform remote monitoring and service of the robot (1) based on the received service data, the robot controller (3) is configured to send the service data to the portable control unit (4), and the portable control unit is configured to transmit the service data to the remote server unit (10) via said wireless communication device (8).

3. The robot system according to claim 1 or 2, wherein the portable control unit (4) is a portable general-purpose device configured to communicate with the robot controller (3) and includes a user interface (6a-b) adapted to allow jogging of the manipulator.

4. The robot system according to any of the previous claims, wherein the portable control unit (4) comprises a general-purpose operating system designed for handling wireless communication.

5. The robot system according to any of the previous claims, wherein the system comprises a local access point (16), which has the ability to communicate with the external network (12), said wireless communication device (8) is configured to wirelessly communicate with the local access point (16), and to transmit the received data to the local access point.

6. The robot system according to claim 5, wherein the wireless communication device (8) is configured to use radio waves to communicate with the local access point (16).

7. The robot system according to claim 5 or 6, wherein the system comprises a plurality of said robots (1), and each of the robots has a portable control unit (4) comprising a wireless communication device (8) for wireless communication with the local access point (16).

8. The robot system according to any of the previous claims, wherein said wireless communication device (8) is adapted for a wireless local area network.

9. The robot system according to any of the claims 1 - 7, wherein said wireless communication device (8) is adapted for a mobile data network.

10. The robot system according to any of the previous claims, wherein said wireless communication device (8) is a USB network device connected to the portable control unit (4).

11. The robot system according to any of the claims 1 - 10, wherein said wireless communication device (8) is arranged inside the portable control unit (4).

12. A method for communication between at least one industrial robot (1) and an external network (12), wherein the robot (1) comprises a manipulator (2) movable about a plurality of axes, a robot controller (3) for controlling the motions of the manipulator (2), and a portable control unit (4) connected to the robot controller (3) through a wire (5) and having a user interface (6a-b) for communication with the robot controller (3) and enabling programming of the motions of the manipulator (2), characterized in that the method comprises:
- enabling the portable control unit (4) to be used as a wireless gateway for the robot controller (3),
- sending data from the robot controller (3) to the portable control unit (4) via the wire (5), and
- using the portable control unit (4) as a gateway for wirelessly sending the received data to the external network (12).

13. The method according to claim 12, wherein the method comprises:
- sending service data for monitoring and diagnostic purpose from the robot controller (3) to the portable control unit (4),
- forwarding the service data from the portable control unit (4) to a remote server unit (10) connected to the external network (12) using the portable control unit (4) as a gateway for wirelessly transmitting the service data to the external network (12), and
- receiving the service data at the remote server unit (10) and performing remote monitoring and service of the robot (1) based on the received service data.

14. The method according to claim 12 or 13, wherein the received data is sent to the external network (12) via a local access point (16) which has the ability to communicate with the external network (12).

15. The method according to claim 14, wherein the received data is sent to the local access point (16) using radio waves.

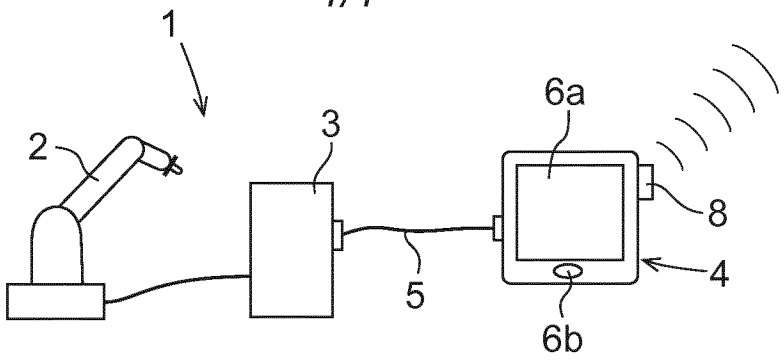

Fig. 1

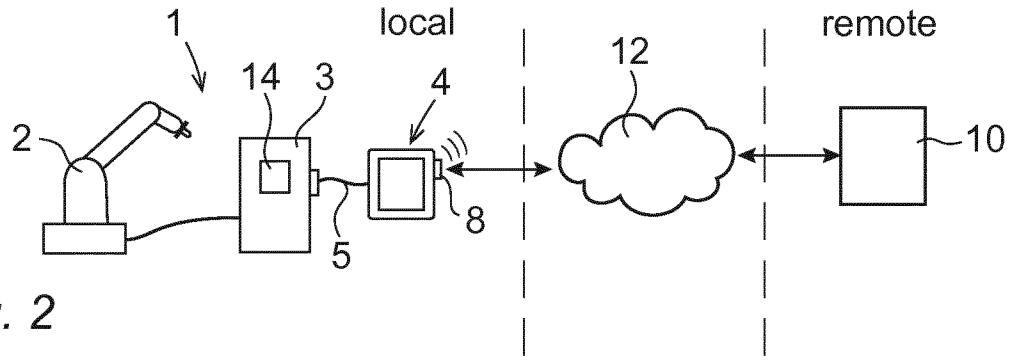

Fig. 2

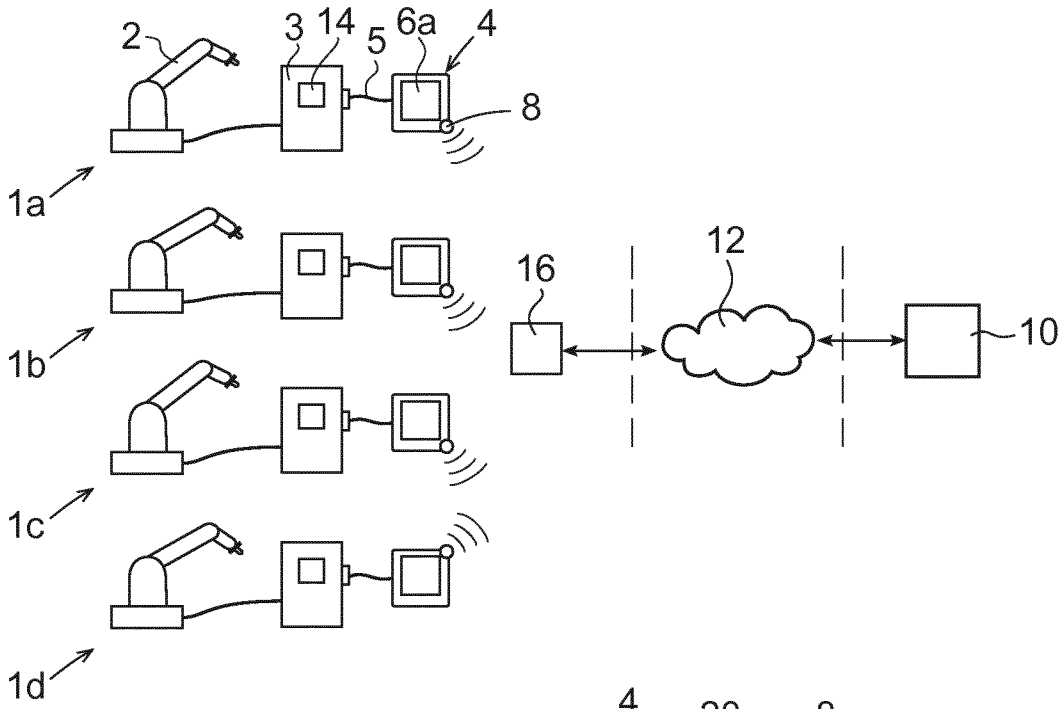

Fig. 3

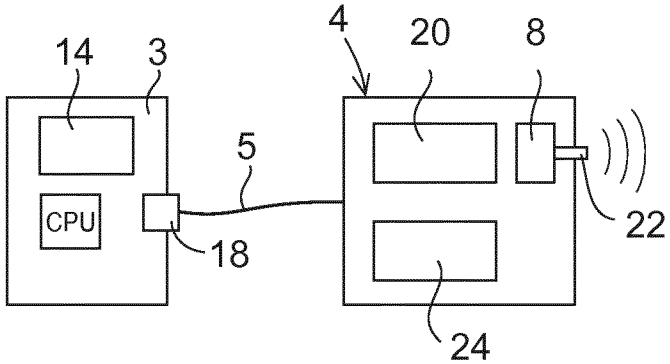

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/061230

A. CLASSIFICATION OF SUBJECT MATTER
INV. B25J9/16 B25J13/00 B25J13/06 G05B19/409
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 03/088011 A2 (KEBA AG [AT]; GRAIGER DIETER [AT]) 23 October 2003 (2003-10-23) paragraphs [0006], [0013], [0017], [0041], [0067] - [0075], [0085], [0096] - [0099], [0112], [0117] - [0128], [0135], [0148] - [0152] -----	1,3-12, 14,15 2,13
X Y	US 2014/074286 A1 (GEHEB GORDON [US] ET AL) 13 March 2014 (2014-03-13) paragraphs [0001] - [0005], [0024] - [0040], [0048], [0051], [0052] -----	1,4,9, 11,12 2,13
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
18 January 2017	30/01/2017

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/061230

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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