Title: A ROBOT ARM SYSTEM AND A ROBOT ARM

Abstract: A robot arm system comprising a plurality of robot arms (102, 502, 504, 506; 102, 602, 604, 606), each robot arm comprising a plurality of modules (104, 108, 110, 112; 508, 510, 512, 514, 516, 510, 514, 518; 608, 610, 612, 614; 616, 618, 614) connectable to each other in series to form the robot arm (102, 502, 504, 506; 102, 602, 604, 606), wherein each module comprises a first set of two joint parts (302, 304; 304, 306) which are connected to each other to form a joint and are rotatable in relation to each other, wherein at least one of the modules of a first robot arm (102, 502, 504, 506; 102, 602, 604, 606) of said plurality of robot arms is adapted to be included as a module of the first robot arm to form the first robot arm and adapted to be included as a module of a second robot arm (102, 502, 504, 506; 102, 602, 604, 606) of said plurality of robot arms to form the second robot arm, and in that the longitudinal extension of the first robot arm when fully extended is different from the longitudinal extension of the second robot arm when fully extended. A robot arm (102, 502, 504, 506; 102, 602, 604, 606) to be used in said robot arm system.
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A ROBOT ARM SYSTEM AND A ROBOT ARM

Technical Field
The present invention relates to a robot arm system comprising a plurality of robot arms, each robot arm comprising a plurality of modules connectable to each other in series to form the robot arm, wherein each module comprises a first set of two joint parts which are connected to each other to form a joint and are rotatable in relation to each other. Further, the present invention relates to a robot arm of an industrial robot to be used in a robot arm system as mentioned above, where the robot arm comprises a plurality of modules connectable to each other in series to form the robot arm, wherein each module comprises a first set of two joint parts which are connected to each other to form a joint and are rotatable in relation to each other.

Background of the Invention
Industrial robots are conventionally designed according to a specific design scheme for how joint actuators, such as electric motor units, and structural elements, such as joint modules, are connected to form a robot arm, or a manipulator. There are various kinds of known robot arm designs in prior art. There are also various kinds of known modular robot designs and various designs of joints and arm modules in prior art.

EP-A1-930 129 describes an articulated manipulator comprising a plurality of arm bodies in series, and joint parts rotatably connecting two adjacent arm bodies of the plurality of arm bodies, where the joint parts are provided such that rotation axes of the adjacent joint parts intersect each other at right angles.

US 4,527,945 discloses a swivelling handle for a robot arm including three reduction gear assemblies, each assuring the control of movement about three axes of rotation, where one of the axes intersects both of the other two.

WO-A2-2007/09951 discloses a programmable robot system comprising a robot provided with a number of individual arm sections, where adjacent sections are interconnected by a joint.

US 5,155,423 discloses an industrial robot having integrated joint drive modules assembled in series to form an arm. The joint modules are of two basic types, roll joints and pitch joints, and the typical robot arm configuration includes a series of alternating pitch joints and roll joints terminating in a tool at the distal end of the arm. Each joint, or joint module, is independently powered by its own motor which is attached to the joint.

However, there is need for improvements in the production of robot arms, which facilitate the production and assembly process and make it more efficient, and reduce the production costs.

The Object of the Invention

The object of the present invention is thus to improve the production of robot arms. It is a further object of the present invention to facilitate the production and assembly of robot arms.

Summary of the Invention

The above-mentioned objects of the present invention are attained by providing a robot arm system comprising a plurality of robot arms, each robot arm comprising a plurality of modules connectable to each other in series to form the robot arm, wherein each module comprises a first set of two joint parts which are connected to each other to form a joint and are rotatable in relation to each other, at least one of the modules of a first robot arm of said plurality of robot arms is adapted to be included as a module of the first robot arm to form the first robot arm and adapted to be included as a module of a second robot arm of said plurality of robot arms to form the second robot arm, and the longitudinal extension of the first robot arm when fully extended is different from the longitudinal extension of the second robot arm when fully extended.

By the innovative module sharing presented by the present invention, a family, or system, of robot arms can be manufactured using a reduced number of differently sized modules, whereby the production and assembly of industrial robots is improved by the innovative modularity presented by the present invention, as the production and assembly process is facilitated and the production costs are
reduced. The development of industrial robots is also facilitated and the development costs are reduced by the innovative modularity of the present invention. Advantageously, most of the modules have the same design, which further improves the production of modular robots. The sharing of a module between two robot arms of different longitudinal extension, does not necessary include the actuator unit, or actuator, and the transmission, contained in the module. The actuator unit of the shared module can be exchanged when applied to robot arms of different sizes or of different longitudinal extension. Advantageously, the modules to be shared have the same design and structure.

Advantageously, the relative rotation of each set of joint parts is independently driven by its own actuator unit, which may include a transmission, advantageously housed within the module including the set of joint parts to be driven by the actuator unit. The actuator unit may comprise an electric motor, a speed reducer, a brake and a position sensor.

In most cases, the robot arms of the robot arm system are not connected to each other when used, but are physically independent form each other. However, two or several robot arms within the same robot arm system could be interconnected.

The plurality of robot arms includes two or more robot arms. According to an advantageous embodiment of the robot arm system according to the present invention, the system comprises two robot arms. According to a further advantageous embodiment of the robot arm system according to the present invention, the system comprises at least three robot arms, and advantageously, the longitudinal extension of each robot arm when fully extended is different from the longitudinal extension of each of the other robot arms when fully extended. The plurality of modules includes two or more modules.

According to an advantageous embodiment of the robot arm system according to the present invention, each robot arm comprises at least three modules of which a first module being indirectly, or directly, mountable to a base of an industrial robot including the robot arm, a second module being mountable to the first module, and a third module being mountable to the second module, where the third module of the first robot arm is adapted to be included as the second module of the second robot arm. This is an efficient way to provide sharing of modules between differently sized robot arms, which further improves the production of ro-
bots. The development process is also further facilitated and the development
costs are reduced.

According to a further advantageous embodiment of the robot arm system
according to the present invention, the dimensions of a robot arm's third module
are scaled down in relation to the dimensions of the same robot arm's second
module. By this embodiment, the production of robots of different size and different
longitudinal extension is further improved.

According to another advantageous embodiment of the robot arm system
according to the present invention, the second module of the first robot arm is
adapted to be included as the first module of the second robot arm. This is a fur-
ther efficient way to provide sharing of modules between differently sized robot
arms, which further improves the production of robots. The development process
is also further facilitated and the development costs are reduced.

According to yet another advantageous embodiment of the robot arm sys-
tern according to the present invention, the dimensions of a robot arm's second
module are scaled down in relation to the dimensions of the same robot arm's first
module. By this embodiment, the efficiency of the production of modular robots of
different size and different longitudinal extension is further increased.

According to still another advantageous embodiment of the robot arm sys-
tern according to the present invention, the robot arm system comprises at least
four robot arms. By this embodiment, the production and development are further
facilitated in an efficient way, and the costs associated therewith are decreased.
However, as mentioned above, the system may comprise two or three robot arms.

According to another advantageous embodiment of the robot arm system
according to the present invention, where the system comprises at least four robot
arms, the longitudinal extension of each robot arm when fully extended is different
from the longitudinal extension of each of the other robot arms when fully ex-
tended.

According to an advantageous embodiment of the robot arm system
according to the present invention, the at least one module, which is adapted to be
included as a module in both the first robot arm and the second robot arm, com-
prises, in addition to said first set of two joint parts, a second set of two joint parts
which are connected to each other to form a joint and are rotatable in relation to
each other. This is an efficient way to design the module, which reduces the num-
ber of modules to be handled when manufacturing robot arms of different sizes, which makes the production even more efficient, and consequently, reduces the production costs. The development process is also further facilitated and the development costs are reduced.

According to a further advantageous embodiment of the robot arm system according to the present invention, where the at least one module comprises two sets of joint parts, the first set's two joint parts of the module, which is adapted to be included as a module in both the first and the second robot arm, form a pitch joint, and the two joint parts of the same module's second set form a roll joint. This is a further efficient way to design the module, which provides flexibility in producing and developing robots by way of reduced number of modules to be handled.

According to another advantageous embodiment of the robot arm system according to the present invention, the at least one module, which is adapted to be included as a module in both the first robot arm and the second robot arm, comprises an actuator unit adapted to drive the relative rotation of the joint parts of a set, and the actuator unit is exchangeably mounted to the module. This embodiment provides further flexibility in producing and developing robot arms.

According to yet another advantageous embodiment of the robot arm system according to the present invention, the at least one module, which is adapted to be included as a module in both the first robot arm and the second robot arm, comprises an actuator unit adapted to drive the relative rotation of the joint parts of a set, wherein the actuator unit defines an axis of rotation and is provided with a through-hole substantially coaxial with the axis of rotation of the actuator unit, the through-hole being adapted to guide at least one line for power supply and/or signal transmission. The line for power supply can for example be a line for electric power supply, or a line for fluid supply, which fluid may be pressurized, for example a process line. The fluid can for example be a gas, air or a liquid. By combining the modular character of the robot arm with the pulling of lines through a through-hole coaxial with the axis of rotation of the actuator unit, it is facilitated to give the modules the same structural design, which further improves and facilitates the production of modular robots. The development process is also further facilitated and the development costs are reduced.

According to an advantageous embodiment of the robot arm system according to the present invention, at least one module of a robot arm is connected
to at least one adjacent module of the same robot arm via an extension element. The extension element can for example be in the form of an extension tube.

The above-mentioned objects of the present invention are also attained by providing a robot arm of an industrial robot to be used in a robot arm system according to any of the appended claims 1 to 11, or any of the above-mentioned embodiments of the robot arm system, the robot arm comprising a plurality of modules connectable to each other in series to form the robot arm, wherein each module comprises a first set of two joint parts which are connected to each other to form a joint and are rotatable in relation to each other, and wherein at least one of the modules of the robot arm comprises, in addition to said first set of two joint parts, a second set of two joint parts which are connected to each other to form a joint and are rotatable in relation to each other. This is an efficient way to design the module, which reduces the number of modules to be handled when manufacturing robot arms of different sizes, which makes the production more efficient, and consequently, reduces the production costs. The development process is also facilitated and the development costs are reduced by the innovative modularity of the present invention.

According to an advantageous embodiment of the robot arm according to the present invention, the first set's two joint parts of the at least one module, which comprises two sets of joint part, form a pitch joint, and in that the two joint parts of the same module's second set form a roll joint. This is a further efficient way to design the module, which provides flexibility in producing and developing robot arms by way of reduced number of modules.

According to a further advantageous embodiment of the robot arm according to the present invention, the module, which comprises two sets of joint parts, comprises an actuator unit adapted to drive the relative rotation of the joint parts of a set, and in that the actuator unit is exchangeably mounted to the module. This embodiment provides further flexibility in producing robots.

According to another advantageous embodiment of the robot arm according to the present invention, the module, which comprises two sets of joint parts, comprises an actuator unit adapted to drive the relative rotation of the joint parts of a set, wherein the actuator unit defines an axis of rotation and is provided with a through-hole substantially coaxial with the axis of rotation of the actuator unit, the through-hole being adapted to guide at least one line for power supply and/or sig-
nal transmission. By this embodiment, it is facilitated to give the modules of the robot arm the same structural design. The line for power supply can for example be a line for electric power supply, or a line for fluid supply, which fluid may be pressurized, for example a process line. The fluid can for example be a gas, air or a liquid.

According to an advantageous embodiment of the robot arm according to the present invention, at least one module of the robot arm is connected to at least one adjacent module via an extension element. The extension element can for example be in the form of an extension tube.

Advantageously, the actuator unit, which is included in the above-mentioned embodiments, comprises an electric motor, and the actuator unit may comprise a transmission. Advantageously, the transmission may include a speed reducer. Further, the actuator unit may be provided with a brake and at least one position sensor. The structure of each of the mentioned entities of the actuator unit can correspond to entities known to the person skilled in the art.

Further advantageous embodiments and further advantages of the robot arm system and the robot arm according to the present invention emerge from the detailed description of embodiments.

**Brief Description of the Drawings**

The present invention will now be described, for exemplary purposes, in more detail by way of embodiments and with reference to the enclosed drawings, in which:

- Fig. 1 is a schematic side view of an embodiment of the robot arm according to the present invention;
- Fig. 2 is a schematic cutaway view of the embodiment of Fig. 1;
- Fig. 3 is a schematic exploded view of details of a module of the embodiment of Fig. 2;
- Fig. 4 is a schematic cutaway partial view of the robot arm of Fig. 2;
- Fig. 5 is a schematic view illustrating aspects of the robot arm system according to the present invention; and
- Fig. 6 is a schematic view illustrating further aspects of the robot arm system according to the present invention.
Detailed Description of Preferred Embodiments

Fig. 1 schematically shows the exterior of an embodiment of an individual robot arm 102, or manipulator, according to the present invention, which is part of an embodiment of the robot arm system according to the present invention. The robot arm 102 includes a base module 104 adapted to be indirectly, or directly, mounted to a base 106 of an industrial robot. The robot arm 102 further includes a first module 108 pivotally mounted to the base module 104, a second module 110 pivotally mounted to the first module 108, and a third module 112 pivotally mounted to the second module 110. The third module 112 is provided with mounting means, or a mounting unit, or mounting element, for holding at least one tool, for example a gripping tool. The dimensions of the second module 110 are scaled down in relation to the dimensions of the first module 108, and the dimensions of the third module 112 are scaled down in relation to the dimensions of the second module 110.

With reference to Fig. 2, which is a schematic cutaway view of the robot arm 102, the base module 104 includes a first axis of rotation 114 about which the base module 104 and the first module 108 are rotatable in relation to each other. The base module 104 is provided with a set of two joint parts (which will be described in more detail below in connection with Figs. 3-4) which are indirectly attached to each other to form a so called roll joint and are rotatable in relation to each other. These two joint parts provide the relative rotation of the base module 104 and the first module 108. One of the joint parts of the base module's 104 set is rigidly attached, secured, or affixed, to the base 106, and the other joint part of the base module's 104 set is rigidly attached to the first module 108. The base module 104 is further provided with an actuator unit 116, including an electric motor and a transmission in the form of a harmonic drive assembly. However, other kinds of transmission are also possible. The actuator unit 116 is adapted to drive the relative rotation of the joint parts of a base module's 104 set.

The first module 108 includes a second axis of rotation 118 about which two joint parts of a first set of the first module 108 (which will be described in more detail below in connection with Figs. 3-4) are rotatable in relation to each other to form a so called pitch joint. The first module 108 further includes a third axis of rotation 120 about which the first module 108 and the second module 110 are rotatable in relation to each other via a second set of two joint parts of the first mod-
ule 108, which are indirectly and pivotally attached to each other to form a roll joint. One of the joint parts of the first module's 108 second set is rigidly attached to the first module 108, and the other joint part of the first module's 108 second set is rigidly attached to the second module 110. The first module 108 is further provided with a first actuator unit 122, of the type disclosed above, adapted to drive the relative rotation of the joint parts of a the first module's 108 first set, and a second actuator unit 124, of the type disclosed above, adapted to drive the relative rotation of the joint parts of the first module's 108 second set.

The second module 110 includes a fourth axis of rotation 126 about which two joint parts of a first set of the second module 110 are rotatable in relation to each other to form a so called pitch joint. The second module 110 further includes a fifth axis of rotation 128 about which the second module 110 and the third module 112 are rotatable in relation to each other via a second set of two joint parts of the second module 110, which are indirectly and pivotally attached to each other to form a roll joint. One of the joint parts of the second module's 110 second set is rigidly attached to the second module 110, and the other joint part of the second module's 110 second set is rigidly attached to the third module 112. The second module 110 is further provided with a first actuator unit 130, of the type disclosed above, adapted to drive the relative rotation of the joint parts of a the second module's 110 first set, and a second actuator unit 132, of the type disclosed above, adapted to drive the relative rotation of the joint parts of the second module's 110 second set.

The third module 112 includes a sixth axis of rotation 134 about which two joint parts of a first set of the third module 112 are rotatable in relation to each other to form a so called pitch joint. The third module 112 further includes a seventh axis of rotation 136 about which the third module 112 and any wrist unit, or tool, connected to the third module, are rotatable in relation to each other to form a roll joint of which one joint part is rigidly attached to the third module 112 and the other joint part is part of said tool. The third module 112 is further provided with a first actuator unit 138, of the type disclosed above, adapted to drive the relative rotation of the joint parts of the third module's first set, and a second actuator unit 140, of the type disclosed above, adapted to drive the relative rotation of the joint parts of the third module's 112 second set.
Fig. 3 illustrates in a schematic exploded view of the first module 108 of the robot arm of Fig. 2, and in this embodiment the second and third modules 110, 112 have the same structural design as the first module 108, which here is described in detail. However, the geometric dimensions of the second and third modules 110, 112 are reduced in relation to the first module 108. The first module 108 includes a first joint part 302 included in the first module’s 108 first set, which first joint part 302 is associated with the second axis of rotation 118 and also constitutes a joint part associated with the first axis of rotation 114 of the base module 104. The first joint part 302 of the first module 108 rigidly houses the first actuator unit 122 of the first module 108. The first module 108 includes a second joint part 304 included in the first module’s 108 first set, which second joint part 304 is associated with the second axis of rotation 118. The second joint part 304 is also a joint part 304 of the first module’s 108 second set and also is associated with the third axis of rotation 120. The second joint part 304 of the first module 108 is attached to the first actuator unit 122 of the first module 108 and rigidly houses the second actuator unit 124 of the first module 108. The second actuator unit 124 of the first module 108 is attached to and drives the rotation of a third joint part 306 which is included in the first module’s 108 second set. As mentioned above, the second and third modules 110, 112 have a corresponding structure as the first module 108.

Each of the actuator units of the embodied robot arm 102 of Figs. 1 and 2, defines an axis of rotation and is provided with a through-hole substantially coaxial with the axis of rotation of the actuator unit, the through-hole being adapted to guide at least one line for power supply and/or signal transmission, for example a process line. Fig. 4, which is a schematic cutaway partial view of the first module 108, shows how the first actuator unit 122 of the first module 108 defines an axis of rotation 118, which is coaxial with the second axis of rotation 118 of the robot arm 102, and is provided with a through-hole 308 substantially coaxial with the axis of rotation 118 of the actuator unit 122. Fig. 4 also shows how the actuator unit 116 of the base module 104 is provided with a corresponding through-hole 310. Through the through-holes 308, 310 of all actuator units of the robot arm, a cable 312 is pulled, which cable 312 can include lines for power supply and signal transmission to control the actuator units of the robot arm 102 and the terminal wrist tool. By combining the modular robot arm 102 with the pulling of lines through
through-holes coaxial with the axis of rotation of each actuator unit, it is facilitated to give the modules the same structural design.

Fig. 5 is a schematic view illustrating exemplary aspects of the robot arm system according to the present invention including four robot arms 102, 502, 504, 506, in which robot arm system robot arms having the structure previously described are employed. Here, the previously described robot arm 102 forms the first robot arm. The second and third modules 110, 112 of the first robot arm 102 are adapted to be included as the first and second modules 110, 112 of a second robot arm 502 of said four robot arms to form the second robot arm 502. The second robot arm 502 further includes a base module 508 to which the second module 110 of the first robot 102 is mounted and a third module 510 which is mounted to the third module 112 of the first robot arm 102. The second and third modules 112, 510 of the second robot arm 502 are adapted to be included as the first and second modules 112, 510 of a third robot arm 504 of said four robot arms to form the third robot arm 504. The third robot arm 504 further includes a base module 512 to which the second module 112 of the second robot 502 is mounted and a third module 514 which is mounted to the third module 510 of the second robot arm 502. The second and third modules 510, 514 of the third robot arm 504 are adapted to be included as the first and second modules 510, 514 of a fourth robot arm 506 of said four robot arms to form the fourth robot arm 506. The fourth robot arm 506 further includes a base module 516 to which the second module 510 of the third robot 504 is mounted and a third module 518 which is mounted to the third module 514 of the third robot arm 504. For each robot arm 102, 502, 504, 506, the dimensions of the second module 110, 112, 510, 514 are scaled down in relation to the dimensions of the first module 108, 110, 112, 510, and the dimensions of the third module 112, 510, 514, 518 are scaled down in relation to the dimensions of the second module 110, 112, 510, 514. By the illustrated innovative reuse of modules, or sharing of modules between the four robot arms, four different robot arms of different longitudinal extensions, when fully extended, can be constructed using only ten different modules, instead of sixteen which otherwise would have been the case.

According to further aspects of the robot arm system according to the present invention, an embodiment of the robot arm system includes only two of the robot arms of Fig. 5, for example the first robot arm 102 and the second robot arm
502, or the second robot arm 502 and the third robot arm 504, or the third robot arm 504 and the fourth robot arm 506. According to still further aspects of the robot arm system according to the present invention, an embodiment of the robot arm system includes only three of the robot arms of Fig. 5, for example the first robot arm 102, the second robot arm 502 and the third robot arm 504, or the second robot arm 502, the third robot arm 504 and the fourth robot arm 506.

Fig. 6 is a schematic view illustrating further exemplary aspects of the robot arm system according to the present invention including four robot arms 102, 602, 604, 606, in which robot arm system robot arms having the structure previously described are employed. The second and third modules 110, 112 of the first robot arm 102 are adapted to be included as the second and third modules 110, 112 of a second robot arm 602 of said four robot arms to form the second robot arm 602. The second robot arm 602 further includes a base module 608 and a first module 610 to which the second module 110 of the first robot arm 102 is mounted. The base module 608 and the first module 610 of the second robot arm are adapted to be included as the base module 608 and the first module 610 of a third robot arm 604 of said four robot arms to form the third robot arm 604. The third robot arm 604 further includes a second module 612 and a third module 614, where the second module 612 is mounted to the first module 610 of the third robot arm 604. The second and third modules 612, 614 of the third robot arm 604 are adapted to be included as the second and third modules 612, 614 of a fourth robot arm 606 of said four robot arms to form the fourth robot arm 606. The fourth robot arm 606 further includes a base module 616 and a first module 618 to which the second module 612 of the fourth robot arm 606 is mounted. For each robot arm 102, 602, 604, 606, the dimensions of the second module 110, 612 are scaled down in relation to the dimensions of the first module 108, 610, 618, and the dimensions of the third module 112, 614 are scaled down in relation to the dimensions of the second module 110, 612. Herein, the previously described robot arm 102 forms the first robot arm, but could form any of the second, third of fourth robot arms 602, 604, 606. Also by this illustrated innovative reuse of modules, or sharing of modules between the four robot arms, four different robot arms of different longitudinal extensions, when fully extended, can be constructed using only ten different modules, instead of sixteen which otherwise would have been the case.
According to further aspects of the robot arm system according to the present invention, an embodiment of the robot arm system includes only two of the robot arms of Fig. 6, for example the first robot arm 102 and the second robot arm 602, or the second robot arm 602 and the third robot arm 604, or the third robot arm 604 and the fourth robot arm 606. According to still further aspects of the robot arm system according to the present invention, an embodiment of the robot arm system includes only three of the robot arms of Fig. 6, for example the first robot arm 102, the second robot arm 602 and the third robot arm 604, or the second robot arm 602, the third robot arm 604 and the fourth robot arm 606.

The actuator units are powered and controlled by a control system for controlling the robot arm. The control system is designed in a conventional way known to the skilled person, and may include a digital computer, a data memory and an input unit for input of control parameters, for example in the form of control schemes. The actuator units are powered and controlled by the control system via suitable conventional means known to the skilled person, such as cables suitably arranged along the extension of the robot arm, and it is to be understood that the robot arm and its apparatuses can be equipped with sensors and additional equipment known to the person skilled in the art, in order to effect a suitable performance of the industrial robot arm, or manipulator, for example as described in US 5,155,423. Each actuator unit can be provided with a brake and at least one position sensor.

The invention shall not be considered limited to the embodiments illustrated, but can be modified and altered in many ways by one skilled in the art, without departing from the scope of the appended claims. For example, the different modules can be designed in various ways, and can be provided with various kinds of protective skins or housings, and additional equipment. Additional modules can also be connected to each robot arm providing the robot arm with further DOF, i.e. further axes of rotation. Each robot arm can also be formed using fewer, or modified, modules and thus providing the robot arm with fewer DOF, i.e. fewer axes of rotation.
CLAIMS

1. A robot arm system comprising a plurality of robot arms (102, 502, 504, 506; 102, 602, 604, 606), each robot arm comprising a plurality of modules (104, 108, 110, 112; 508, 110, 112, 510; 512, 112, 510, 514; 516, 510, 514, 518; 608, 610, 110, 112; 608, 610, 612, 614; 616, 618, 612, 614) connectable to each other in series to form the robot arm (102, 502, 504, 506; 102, 602, 604, 606), wherein each module comprises a first set of two joint parts (302, 304; 304, 306) which are connected to each other to form a joint and are rotatable in relation to each other, characterized in that at least one of the modules of a first robot arm (102, 502, 504, 506; 102, 602, 604, 606) of said plurality of robot arms is adapted to be included as a module of the first robot arm to form the first robot arm and adapted to be included as a module of a second robot arm (102, 502, 504, 506; 102, 602, 604, 606) of said plurality of robot arms to form the second robot arm, and in that the longitudinal extension of the first robot arm when fully extended is different from the longitudinal extension of the second robot arm when fully extended.

2. A robot arm system according to claim 1, characterized in that each robot arm (102, 502, 504, 506; 102, 602, 604, 606) comprises at least three modules (104, 108, 110, 112; 508, 110, 112, 510; 512, 112, 510, 514; 516, 510, 514, 518; 608, 610, 110, 112; 608, 610, 612, 614; 616, 618, 612, 614) of which a first module being indirectly, or directly, mountable to a base of an industrial robot including the robot arm, a second module being mountable to the first module, and a third module being mountable to the second module, and in that the third module of the first robot arm is adapted to be included as the second module of the second robot arm.

3. A robot arm system according to claim 2, characterized in that the dimensions of a robot arm's (102, 502, 504, 506; 102, 602, 604, 606) third module are scaled down in relation to the dimensions of the same robot arm's second module.
4. A robot arm system according to claim 2 to 3, characterized in that the second module of the first robot arm is adapted to be included as the first module of the second robot arm.

5. A robot arm system according to any of the claims 2 to 4, characterized in that the dimensions of a robot arm’s (102, 502, 504, 506; 102, 602, 604, 606) second module are scaled down in relation to the dimensions of the same robot arm’s first module.

6. A robot arm system according to any of the claims 1 to 5, characterized in that the robot arm system comprises at least four robot arms (102, 502, 504, 506; 102, 602, 604, 606).

7. A robot arm system according to claim 6, characterized in that the longitudinal extension of each robot arm (102, 502, 504, 506; 102, 602, 604, 606) when fully extended is different from the longitudinal extension of each of the other robot arms (102, 502, 504, 506; 102, 602, 604, 606) when fully extended.

8. A robot arm system according to any of the claims 1 to 7, characterized in that the at least one module, which is adapted to be included as a module in both the first robot arm and the second robot arm, comprises, in addition to said first set of two joint parts (302, 304), a second set of two joint parts (304, 306) which are connected to each other to form a joint and are rotatable in relation to each other.

9. A robot arm system according to claim 8, characterized in that the first set’s two joint parts (302, 304) of the module, which is adapted to be included as a module in both the first and the second robot arm, form a pitch joint, and in that the two joint parts (304, 306) of the same module’s second set form a roll joint.

10. A robot arm system according to any of the claims 1 to 9, characterized in that the at least one module, which is adapted to be included as a module in both the first robot arm and the second robot arm, comprises an actuator unit (116, 122, 124, 130, 132, 138, 140) adapted to drive the relative rotation of the joint.
parts (302, 304; 304, 306) of a set, and in that the actuator unit (116, 122, 124, 130, 132, 138, 140) is exchangeably mounted to the module.

11. A robot arm system according to any of the claims 1 to 10, characterized in that the at least one module, which is adapted to be included as a module in both the first robot arm and the second robot arm, comprises an actuator unit (116, 122, 124, 130, 132, 138, 140) adapted to drive the relative rotation of the joint parts (302, 304; 304, 306) of a set, and in that the actuator unit (116, 122, 124, 130, 132, 138, 140) defines an axis of rotation (114, 118, 120, 126, 128, 134, 136) and is provided with a through-hole (310, 308) substantially coaxial with the axis of rotation of the actuator unit, the through-hole (310, 308) being adapted to guide at least one line for power supply and/or signal transmission.

12. A robot arm (102, 502, 504, 506; 102, 602, 604, 606) of an industrial robot to be used in a robot arm system according to any of the claims 1 to 11, the robot arm comprising a plurality of modules (104, 108, 110, 112; 508, 110, 112, 510; 512, 112, 510, 514; 516, 510, 514, 518; 608, 610, 110, 112; 608, 610, 612, 614; 616, 618, 612, 614) connectable to each other in series to form the robot arm, wherein each module comprises a first set of two joint parts (302, 304; 304, 306) which are connected to each other to form a joint and are rotatable in relation to each other, characterized in that at least one of the modules of the robot arm comprises, in addition to said first set of two joint parts (302, 304; 304, 306), a second set of two joint parts (302, 304; 304, 306) which are connected to each other to form a joint and are rotatable in relation to each other.

13. A robot arm according to claim 12, characterized in that the first set's two joint parts (302, 304) of the at least one module, which comprises two sets of joint parts, form a pitch joint, and in that the two joint parts (304, 306) of the same module's second set form a roll joint.

14. A robot arm according to claim 12 or 13, characterized in that the module, which comprises two sets of joint parts (302, 304; 304, 306), comprises an actuator unit (116, 122, 124, 130, 132, 138, 140) adapted to drive the relative rota-
15. A robot arm according to any of the claims 12 to 14, characterized in that the module, which comprises two sets of joint parts (302, 304; 304, 306), comprises an actuator unit (116, 122, 124, 130, 132, 138, 140) adapted to drive the relative rotation of the joint parts (302, 304; 304, 306) of a set, and in that the actuator unit defines an axis of rotation (114, 118, 120, 126, 128, 134, 136) and is provided with a through-hole (308, 310) substantially coaxial with the axis of rotation of the actuator unit, the through-hole (308, 310) being adapted to guide at least one line for power supply and/or signal transmission.
A. CLASSIFICATION^ SUBJECT MATTER

INV. B25J9/08 B25J17/02

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B25J

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>DE 42 44 379 A1 (NIKO LUFTFAHRT ROBOTIC GMBH [DE] NIKO AUTOMATISIERUNGSSYSTEME G [DE]) 30 June 1994 (1994-06-30) column 3, lines 50-65 column 4, line 12 - column 6, line 8 figures 1,2</td>
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X Further documents are listed in the continuation of Box C
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Date of the actual completion of the international search
10 March 2010

Date of mailing of the international search report
17/03/2010

Authorized officer
Grenier, Alain
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<td>WO 01/51259 A2 (ZHU HAI HONG [SG]; XIE MING [SG]; LIM MONG KING [SG]) 19 July 2001 (2001-07-19) page 3, last paragraph - page 4, paragraph first figure 1</td>
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# INTERNATIONAL SEARCH REPORT

**Information on patent family members**

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