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(54) Title: A ROBOT CONTROLLER ARRANGEMENT, A ROBOT SYSTEM AND A METHOD THEREFOR

(57) Abstract: The present invention relates to a method of controlling a robot, comprising the steps of: sending an instruction to the robot; receiving a robot action status from the robot, wherein the robot action status is related to the instruction; and displaying a progress status for the robot action status to an operator of the robot; wherein the progress status is displayed for a programming step creating the instruction.

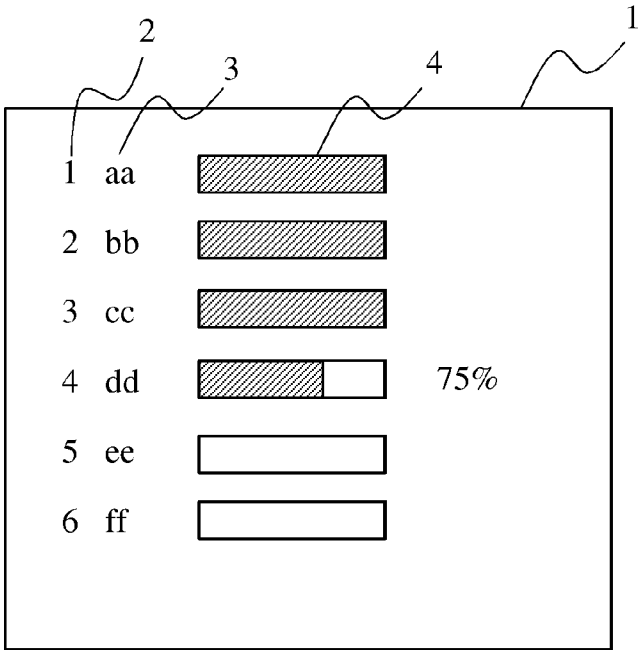


FIG. 1

WO 2014/071982 A1

A ROBOT CONTROLLER ARRANGEMENT, A ROBOT SYSTEM AND A METHOD THEREFOR

TECHNICAL FIELD

The present invention generally relates to robots and in particular to control of robots.

BACKGROUND

Industrial robots are generally controlled by a control program. When an operator of a robot is to configure or reconfigure operation of the robot this is performed by configuring/reconfiguring the control program.

SUMMARY

When an operator of a robot is checking the control of a configuration thereof, the operator has to verify that each step of the control program is performed by the robot as intended.

An object of the present invention is to improve control of a robot for an operator.

This object is according to the present invention attained by a robot controller arrangement, as well as method therefor, as defined by the appended claims.

By providing a method of controlling a robot, comprising the steps of: sending an instruction to drive the robot; receiving a robot action status, wherein the robot action status is related to the instruction; and displaying a progress status for the robot action status to an operator of the robot; wherein the progress status is displayed for a single programming step creating the instruction, control of the robot is improved for an operator thereof.

A problem with verification of robot control programs is that the display of the control program only displays the instruction currently being executed without providing information about where the robot is on the programmed path. When stopping the control program execution the displayed progress status helps the operator to know the position on the path. This is typically helpful for programmed movements that take a relatively long time to execute.

When programming slow movements or when the robot is obstructed from view, it can be difficult to see if the robot is actually moving. The progress status helps the operator to determine this.

The progress status is preferably displayed as a progress bar illustrating a relative time until completion of the programming step, to facilitate the operators control thereof. The progress status is alternatively, or additionally, displayed as a percentage of completion of the programming step.

The method preferably comprises the further step of: calculating a relative time of completion of the programming step, in a processing means in a control module of a robot controller arrangement, wherein the steps of sending, receiving and displaying is performed in the control module, whereby the progress status can be computed using information regarding where the current movement instruction started and where it is supposed to end, and the robot action status.

The method preferably comprises a further step of detection of the robot action status in a drive module of a robot controller arrangement, separate from a control module of the robot controller arrangement performing the steps of sending, receiving and displaying, allowing the processing means to use the robot action status to compute the progress status.

By providing a robot controller arrangement, comprising a graphical interface and a control module including processing means, wherein the processing means is configured to send an instruction to a drive module connected to a robot, to receive a robot action status from the drive module, to compute a progress status for the robot action, and to display the progress status for the robot action on the graphical interface, wherein the robot action status is related to the instruction and the progress status is configured to be displayed on the graphical interface for a single programming step controlling the robot action through the instruction, control of the robot is improved for an operator thereof.

A robot system comprising a robot controller arrangement is also provided.

Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, step, etc." are to be

interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated. Particularly, by a robot is here meant a mechanical structure controlled by one or more motors.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is now described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 schematically illustrates a graphical interface of a robot controller arrangement.

Fig. 2 schematically illustrates a robot controller arrangement.

DETAILED DESCRIPTION

The invention will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout the description.

A robot controller arrangement for a robot according to the present invention will now, by way of example, be described in greater detail with reference to Figs. 1 and 2.

The robot controller arrangement comprises a graphical interface 1, a control module 5, and preferably a drive module 6, wherein the control module 5 includes processing means 8. The processing means 8 is configured to send an instruction to the drive module 6 connected to a robot, to receive a robot action status from the drive module 6, to compute a progress status for the robot action, and to display the progress status for the robot action on the graphical interface 1. The robot action status is related to the instruction and the progress status is configured to be displayed on the graphical interface 1 for a single programming step controlling the robot action through the

instruction. The graphical interface 1 is typically a display device attached to a controller cabinet housing the control module 5 and the drive module 6.

An exemplary display of the graphical interface 1 is shown in Fig. 1. In a first column 2 six programming lines are illustrated, enumerated from 1 to 6. In a second column 3, adjacent to the right of the first column 2, fictitious robot instructions are given, one for each of the programming lines 1 to 6. The robot instructions 3 are illustrated as aa to ff. For each programming line 2/instruction 3 a progress status 4 is provided, indicating the robot action status for each respective line. The first three lines have already been completed, and are illustrated as filled rectangles or progress bars. The fourth line is illustrating an instruction currently in progress, and a graphical illustration provides the relative progress status of an about three-quarter filled rectangle. Here a percentage number is also provided as a percentage of completion of the programming step. For programming lines 5 and 6, empty rectangles are provided. In this way a relative time until completion of an instruction is illustrated.

A progress status for a programming line may only be displayed when the instruction it is displaying progress for is active, but advantageously a completed instruction is displayed through a filled rectangle. Instead of a rectangle, other shapes/forms may be utilized. Further, a percentage number only may be provided, or in combination with a progress bar as illustrated. Before an instruction is active, i.e. being in progress of driving the robot, no progress status may be provided, since intrinsically a previous instruction must be completed before the next instruction is activated.

The robot controller arrangement preferably comprises the drive module 6, which drive module 6 is configured to drive the robot and to transmit a robot action status to the control module 5.

The control module 5 typically comprises a power and UPS (Uninterruptible Power Supply) unit 7, supporting the whole control module 5. The control module 5 typically also comprises I/O, sensors and process equipment 10 supporting the processing means 8 and a panel safety unit 9. The processing means 8 is typically provided with external access means 15, such as USB (Universal Serial Bus), LAN (Local Area Network) or service ports.

The drive module 6 typically comprises a power unit 12, supplying the whole drive module 6, a drive safety unit 11, a robot computer 13 and drives 14. The Drive safety unit 11 is in communication with the panel safety unit 9 of the control module 5, with the robot computer 13 and with the drives 14. The robot computer 13 is in communication with the drives 14, and through an external port 16 in communication with the robot. The drives 14 are through an external port 17 also in communication with the robot. The robot computer 13 and the drives 14 are typically in communication with a serial measurement board, break releases, and motors of the robot. The processing means 8 of the control module 5 and the robot computer 13 of the drive module 6 are further in communication with each other.

A robot action, typically a robot movement, is defined by a start point p_{start} and a desired programmed position, p_{end}. If the current robot position is named p_{curr} the relative progress of the programmed movement is computed as:

$$progress = \frac{\|p_{curr} - p_{start}\|}{\|p_{end} - p_{start}\|}$$

Here $\|.\|$ denotes a distance measurement. If two programmed points are described using Cartesian coordinates (x_1, y_1, z_1) and (x_2, y_2, z_2) the distance between them can be computed as

$$\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

If the position is given in joint angles, the distance between two points $(j_{11}, j_{12},\ldots,j_{1n})$ and $(j_{21}, j_{22},\ldots, j_{2n})$ of a robot consisting of n axes can be computed as

$$\sqrt{(j_{11} - j_{21})^2 + (j_{12} - j_{22})^2 + \cdots + (j_{1n} - j_{2n})^2}$$

Here $n \geq 1$.

An estimation of the remaining time for a movement instruction can then be computed as

$$\frac{\|p_{end} - p_{start}\|}{v_{prog}} \times (1 - progress)$$

wherein v_{prog} is a programmed speed. This estimation is made in the processing means 8, and the progress status of the current programming instruction can thus be updated in line therewith.

A robot is controlled by a method comprising the steps of:

sending an instruction to drive the robot;

receiving a robot action status, wherein the robot action status is related to the sent instruction; and

displaying a progress status for the robot action status to an operator of the robot;

wherein the progress status is displayed for a single programming step creating the instruction.

The method preferably also comprises the step of:

calculating a relative time of completion of the programming step, in the processing means 8 in the control module 5 of the robot controller arrangement,

wherein the steps of sending, receiving and displaying is performed in the control module 5.

Advantageously, the method further comprises a step of detection of the robot action status in the drive module 6 of the robot controller arrangement, separate from the control module 5 of the robot controller arrangement performing the steps of sending, receiving and displaying.

The drive module 6 preferably periodically reports the robot action status to the control module 5. The control module 5 utilizes the received information about the robot action status to calculate how the present position of the robot relates to the planned trajectory according to the instruction sent. The communication between the graphical interface 1 and the control module 5 is preferably by the control module 5 sending the progress status to the graphical interface 1. Alternatively the graphical interface 1 may e.g. poll the control module to update the progress status. The robot

controller arrangement, including the graphical interface 1, the control module 5 and the drive module 6, and a robot together makes up a robot system.

The invention has mainly been described above with reference to a few examples. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the present invention, as defined by the appended claims.

CLAIMS

1. A method of controlling a robot, **characterized by** the steps of:

sending an instruction to drive said robot;

receiving a robot action status, wherein said robot action status is related to said instruction; and

displaying a progress status for said robot action status to an operator of said robot;

wherein said progress status is displayed for a single programming step creating said instruction.

2. The method according to claim 1, wherein said progress status is displayed as a progress bar illustrating a relative time until completion of said programming step.

3. The method according to claim 1 or claim 2, wherein said progress status is displayed as a percentage of completion of said programming step.

4. The method according to one of claims 1 to 3, comprising the step of:

calculating a relative time of completion of said programming step, in a processing means (8) in a control module (5) of a robot controller arrangement,

wherein said steps of sending, receiving and displaying is performed in said control module.

5. The method according to one of claims 1 to 4, comprising a step of detection of said robot action status in a drive module (6) of a robot controller arrangement, separate from a control module of said robot controller arrangement performing said steps of sending, receiving and displaying.

6. The method according to one of claims 1 to 5, wherein said progress status is displayed on a graphical interface (1).

7. A robot controller arrangement, **characterized in** that it comprises a graphical interface (1), a control module (5) including processing means (8), wherein said

processing means is configured to send an instruction to a drive module (6) connected to a robot, to receive a robot action status from said drive module, to compute a progress status for said robot action, and to display said progress status for said robot action on said graphical interface, wherein said robot action status is related to said instruction and said progress status is configured to be displayed on said graphical interface for a single programming step controlling said robot action through said instruction.

8. The robot controller arrangement according to claim 7, comprising said drive module, which drive module is configured to drive said robot and to transmit a robot action status to said control module.

9. The robot controller arrangement according to claim 7 or 8, wherein said progress status is configured to be displayed on said graphical interface as a progress bar illustrating a relative time until completion of said programming step.

10. The robot controller arrangement according to one of claims 7 to 9, wherein said progress status configured to be displayed on said graphical interface as a percentage of completion of said programming step.

11. A robot system, **characterized in** that it comprises a robot controller arrangement according to one of claims 7 to 10 and a robot connected to said robot controller arrangement.

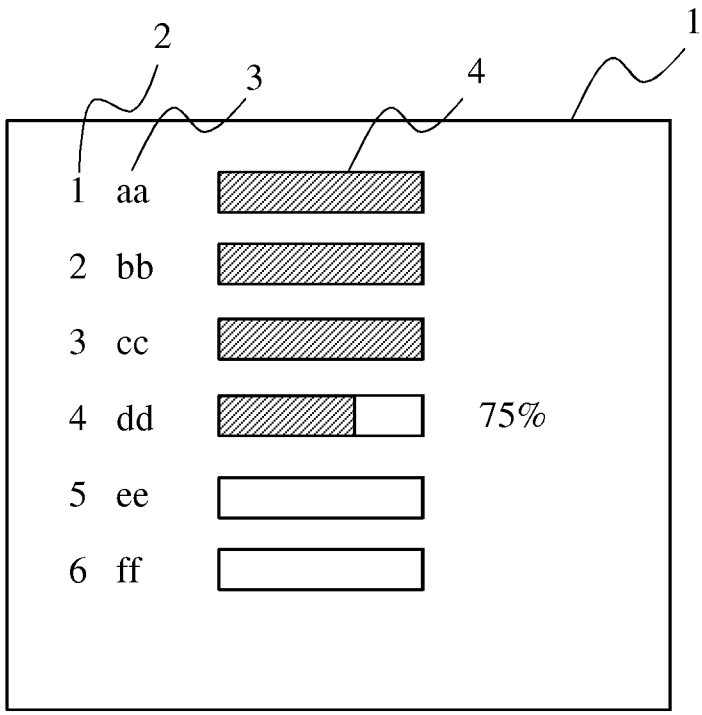


FIG. 1

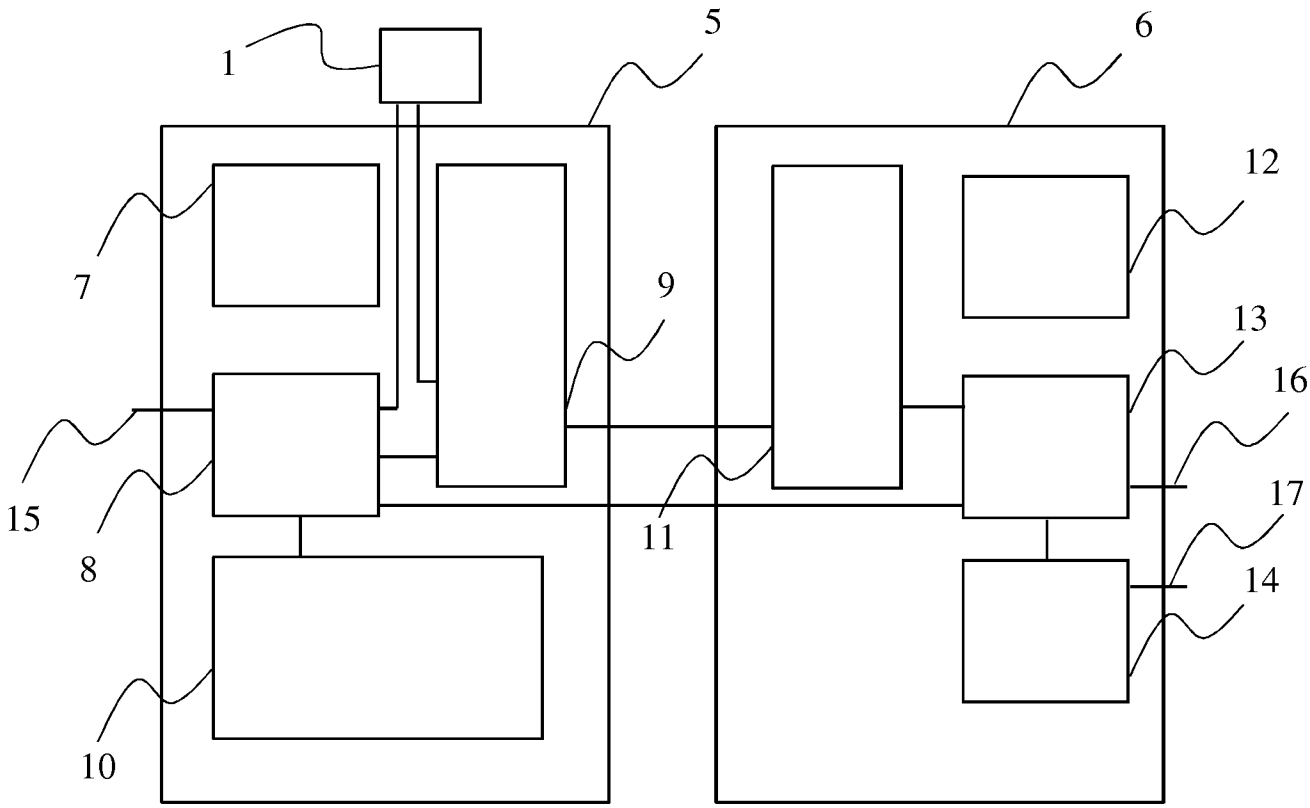


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/072205

A. CLASSIFICATION OF SUBJECT MATTER
INV. G05B19/409
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G05B 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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP H01 228759 A (FANUC LTD) 12 September 1989 (1989-09-12) the whole document	1-11
X	JP 2003 037032 A (TOKYO ELECTRON LTD) 7 February 2003 (2003-02-07)	1-4,6
A	the whole document	7,9-11
X	JP H03 166609 A (FANUC LTD) 18 July 1991 (1991-07-18) the whole document	1,5-8,11
A	JP S61 221905 A (OKUMA MACHINERY WORKS LTD) 2 October 1986 (1986-10-02) the whole document	1-11

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 June 2013	03/07/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Orobitg Oriola, R

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/072205

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 0 623 860 A1 (FANUC LTD [JP]) 9 November 1994 (1994-11-09) column 2, line 6 - column 4, line 39 column 5, line 44 - column 6, line 7 column 8, line 1 - column 12, line 24 figure 6 -----	1,4-8,11

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/072205

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