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(54) Title: METHOD, CONSTRAINING DEVICE AND SYSTEM FOR DETERMINING GEOMETRIC PROPERTIES OF A MANIPULATOR

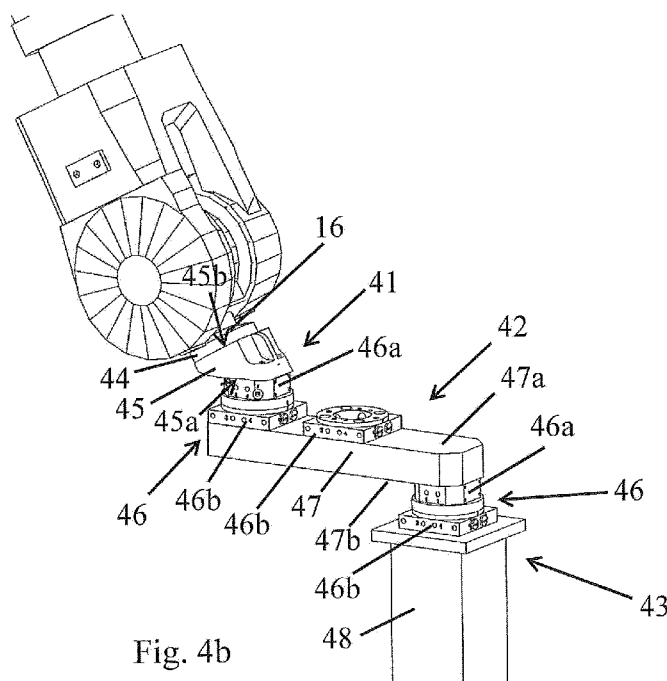


Fig. 4b

(57) Abstract: A method and system for determining geometric properties of a manipulator (2). The manipulator (2) is controlled to perform constrained motions exhibiting force interaction with the environment, or between different links of the manipulator (2), such that a kinematic chain is formed mechanically. The chain may include peripherals and external axes of motion. A constraining device, enables motions that facilitate the determination of geometric properties. A unified model of joint and link compliances facilitates determination of stiffness parameters. The force interaction is controlled with awareness of friction such that non-geometric properties are possible to identify, thereby enabling separation of non-geometric effects from the geometric ones, which improves accuracy.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/057187

A. CLASSIFICATION OF SUBJECT MATTER
INV. G05B19/401 B25J9/16
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	WO 2015/030650 A2 (COGNIBOTICS AB [SE]) 5 March 2015 (2015-03-05) cited in the application	1-13, 16-27, 29,30, 32-35,43
Y	abstract pages 1,6-8 pages 11,12,15 pages 17-29 pages 34,35 claim 1 figures 1,4,5 figures 6a-6c,9 figures 10,11a,11b figures 13a,13b ----- -/--	14,28, 36-40



Further documents are listed in the continuation of Box C.



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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

11 October 2017

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08/11/2017

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/057187

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LEHMANN, Christian et al: "Robot joint modeling and parameter identification using the clamping method", IFAC Proceedings, vol. 46(9) 19 June 2013 (2013-06-19), pages 813-818, XP002761378, Retrieved from the Internet: URL:http://ac.els-cdn.com/S1474667016343889/1-s2.0-S1474667016343889-main.pdf?_tid=a2d4fb0e-7044-11e6-882e-00000aacb360&acdnat=1472735257_d2102ef4ff58f7e8c002b6babbade3a7 [retrieved on 2016-09-02] page 813 - page 815	1-13, 16-27, 29,30, 33-35, 41-43
A	BENNETT D J ET AL: "AUTONOMOUS CALIBRATION OF SINGLE-LOOP CLOSED KINEMATIC CHAINS FORMED BY MANIPULATORS WITH PASSIVE ENDPOINT CONSTRAINTS", IEEE TRANSACTIONS ON ROBOTICS AND AUTOMATION, IEEE INC, NEW YORK, US, vol. 7, no. 5, 1 October 1991 (1991-10-01), pages 597-606, XP000234416, ISSN: 1042-296X, DOI: 10.1109/70.97871 abstract pages 598,603	1-43
A	Ruderman, Michael: "Modeling of Elastic Robot Joints with Nonlinear Damping and Hysteresis", Internet, 1 February 2012 (2012-02-01), XP055107616, ISBN: 978-9-53-307941-7 Retrieved from the Internet: URL:http://www.intechopen.com/source/pdfs/27414/InTech-Modeling_of_elastic_robot_joints_with_nonlinear_damping_and_hysteresis.pdf [retrieved on 2014-03-13] page 306	1-43
X,P	Bergström, G., Green, B.: "Evaluation of Calibration Method for Redundant Dual Arm Industrial Robots Using Internal Sensors", Lund University Department of Automatic Control, December 2016 (2016-12), XP002774062, Retrieved from the Internet: URL:http://lup.lub.lu.se/luur/download?func=downloadFile&recordId=8923541&fileId=8923542 [retrieved on 2017-10-09] pages 42-44 pages 69,70	1-4, 9-11,13, 14, 17-19, 22-30, 32, 34-36, 38,41-43
Y,P		14,28, 36,38
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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/057187

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	Brand, S., Nilsson, N.: "Calibration of robot kinematics using a double ball-bar with embedded sensing", Lund University Department of Automatic Control, December 2016 (2016-12), XP002774063, Retrieved from the Internet: URL: http://lup.lub.lu.se/luur/download?func=downloadFile&recordId=8898906&fileId=8898907 [retrieved on 2017-10-09]	1-4, 9-11, 17-27, 29,30, 33-35, 40-43
Y,P	pages 3,39-41 pages 52,62	40
X	----- DE 101 43 753 A1 (DEUTSCH ZENTR LUFT & RAUMFAHRT [DE]) 3 April 2003 (2003-04-03)	1-4,6,7, 9-19, 22-32, 34-39, 41-43
Y	abstract paragraphs [0001], [0009], [0086] paragraph [0102] figures 6,7,9 -----	37,39

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/057187

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-9, 11-13, 17-21, 26, 27, 33-35, 43(completely);
22-25(partially)

Identification of robots exhibiting non-linearities (e.g.
friction, backlash)

2. claims: 10, 15, 29-31, 41, 42(completely); 22-25(partially)

Robot identification involving specific use of a tool
exchanger

3. claims: 14, 16, 28, 32, 36-40(completely); 22-25(partially)

Robot identification involving a plurality of clamping
points

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/057187

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2015030650 A2	05-03-2015	AU 2014311922 A1	10-03-2016
		CA 2922631 A1	05-03-2015
		CN 105682865 A	15-06-2016
		EP 3038799 A2	06-07-2016
		SE 1350981 A1	28-02-2015
		US 2016221189 A1	04-08-2016
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		EP 1302285 A2	16-04-2003
