(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 November 2021 (18.11.2021)

WIPO | PCT

(10) International Publication Number
WO 2021/231663 A3

(51) International Patent Classification:
B25J 9/00 (2006.01) *G10H 3/06* (2006.01)
G06F 19/00 (2018.01)

(21) International Application Number:
PCT/US2021/032111

(22) International Filing Date:
12 May 2021 (12.05.2021)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

63/023,839	12 May 2020 (12.05.2020)	US
63/023,844	12 May 2020 (12.05.2020)	US
63/023,833	12 May 2020 (12.05.2020)	US

(71) Applicant: **AESCAPE, INC.** [US/US]; c/o Eric A. Litman, 170 North 5th Street, #1 D, Brooklyn, NY 11211 (US).

(72) Inventors: **LITMAN, Eric A.**; c/o Aescape, Inc., 170 North 5th Street, #1 D, Brooklyn, NY 11211 (US). **WALSH, David N.**; c/o Aescape, Inc., 170 North 5th Street, #1 D, Brooklyn, NY 11211 (US). **PACE, Charles Paul**; c/o Aescape, Inc., 170 North 5th Street, #1 D, Brooklyn, NY 11211 (US). **DICICCO, Matthew**; c/o Aescape, Inc., 170 North 5th Street, #1 D, Brooklyn, NY 11211 (US).

(74) Agent: **LECOMTE, Linda**; c/o Wuersch & Gering LLP, 100 Wall Street, 10th Floor, New York, NY 10005 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(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).

(54) Title: METHOD AND SYSTEM FOR AUTONOMOUS OBJECT INTERACTION

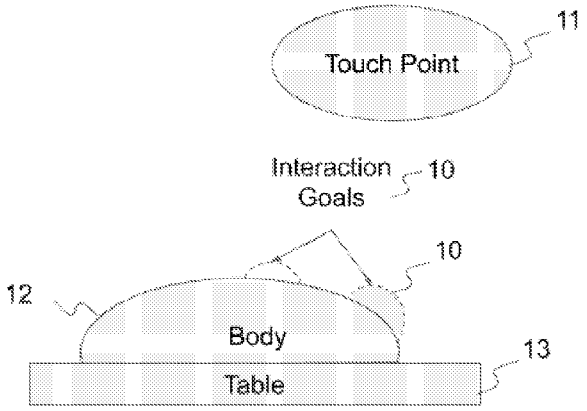

FIG. 1

(57) Abstract: A system, method, and apparatus for a robot system that manipulates the surface of an object effect programmed manipulation goals such as reaching specific locations on the surface of the object, displacing the surface of the object, applying a predetermined force and torque to the surface of the object, dynamically changing the contact point between the robot and the object, and applying force to structures below the surface of the object. The system and method determine the state of the object through a sensing method that includes, without limitation: torque and force measurement, visible light sensors, range and depth sensors, ultrasound sensors, thermographic sensors, and worktable force measurement.

WO 2021/231663 A3

[Continued on next page]

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:
24 February 2022 (24.02.2022)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2021/032111

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B25J 9/00; G06F 19/00; G10H 3/06 (2021.01)
CPC - G05D 1/0242; B25J 5/007; G05D 1/0246; G06N 3/008; B25J 9/0003 (2021.08)

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)
see Search History document

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
see Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017/0266077 A1 (MACKIN) 21 September 2017 (21.09.2017) entire document	1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A
A	US 2007/0000374 A1 (CLARK et al) 04 January 2007 (04.01.2007) entire document	1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A
A	US 20020/013641 A1 (NOURBAKHSH et al) 31 January 2002 (31.01.2002) entire document	1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A
A	US 2017/0281254 A1 (P TECH, LLC) 05 October 2017 (05.10.2017) entire document	1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A
A	US 2007/0192910 A1 (VU et al) 16 August 2007 (16.08.2007) entire document	1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A

☐ 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
"D" document cited by the applicant in the international application
"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	Date of mailing of the international search report
18 December 2021	JAN 24 2022
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Harry Kim Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2021/032111

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 extra sheet(s).

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 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.:
1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A

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.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2021/032111

Continued from Box No. III Observations where unity of invention is lacking

There are three groups of claims as follows: first group (claims 1-11), second group (claims 1-4) and third group (claims 1, 2, 3). Therefore, in order to distinguish these groups of claims, the first group: claims 1-11A are considered as claims 1A-11A; the second group: claims 1-4 as claims 1B-4B, and the third group: claims 1, 2, 3 as claims 1C, 2C, 3C.

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1A-8A, is drawn to a body interaction system, comprising: a robotic arm, the robotic arm having a touch point.

Group II, claims 9A-11A, is drawn to a body interaction method, comprising: receiving, by a computer processor, sensor data from a sensor monitoring a body interaction.

Group III, claims 1B-4B, is drawn to a robotic control system that utilizes a fused sensing stream to predict the deformation of a robotic end effector and the tissue that it is in contact with using a Finite Element Analysis model.

Group IV, claims 1C-3C, is drawn to a robotic control system changing the control system's contact point of the robot continuously based on sensed force.

The inventions listed as Groups I, II, III or IV do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: a robotic arm, the robotic arm having a touch point; a support structure, the support structure configured to have a body disposed thereon; a controller, using a computer processor, the controller providing electronic instructions to the robotic arm to make contact with the touch point to a destination, wherein the destination is configured to be the body as claimed therein is not present in the invention of Groups II, III or IV. The special technical feature of the Group II invention: receiving, by a computer processor, sensor data from a sensor monitoring a body interaction; locating body data from the received sensor data; determining body position and body orientation from the located body data; generating at least one body shape parameter from the located body data; transforming the body data, the body position, the body orientation, and the at least one body shape parameter into a body model; and using the body model, generating a body mapping, wherein the body mapping is configured to be used to generate an interaction protocol as claimed therein is not present in the invention of Groups I, III or IV. The special technical feature of the Group III invention: a robotic control system that utilizes a fused sensing stream to predict the deformation of a robotic end effector and the tissue that it is in contact with using a Finite Element Analysis model, the model updates provide adjustment parameters for the control system to compensate for changes in the mechanical nature of the robotic end effector and the tissue it is manipulating as claimed therein is not present in the invention of Groups I, II or IV. The special technical feature of the Group IV invention: a robotic control system changing the control system's contact point of the robot continuously based on sensed force, the robotic control system changing the controller gain selectively relative to the sensed orientation of the surface that the robot is in contact with as claimed therein is not present in the invention of Groups I, II or III.

Groups I, II, III, and IV lack unity of invention because even though the inventions of these groups require the technical feature of a body interaction system, comprising a robotic control system, this technical feature is not a special technical feature as it does not make a contribution over the prior art.

Specifically, US 2007/0000374 to Clark et al. teaches a body interaction system, comprising a robotic control system (Paras. [0071], [0075], [0226]).

Since none of the special technical features of the Group I, II, III, or IV inventions are found in more than one of the inventions, unity of invention is lacking.