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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 January 2016 (07.01.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/004152 A3

(51) International Patent Classification:
A61B 5/053 (2006.01)

(21) International Application Number:
PCT/US2015/038735

(22) International Filing Date:
1 July 2015 (01.07.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/020,479 3 July 2014 (03.07.2014) US

(71) Applicant: **DUKE UNIVERSITY** [US/US]; 2812 Erwin Road, Suite 306, Durham, NC 27705 (US).

(72) Inventors; and
(71) Applicants : **GRILL, Warren, M.** [US/US]; c/o Duke University, 2812 Erwin Road, Suite 306, Durham, NC 27705 (US). **HOWELL, Bryan** [US/US]; c/o Duke University, 2812 Erwin Road, Suite 306, Durham, NC 27705 (US).

(74) Agent: **OLIVE, Bentley, J.**; Olive Law Group, LLC, 125 Edinburgh South Drive, Suite 220, Cary, NC 27511 (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, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, 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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, 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).

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

(88) Date of publication of the international search report:
24 March 2016

(54) Title: SYSTEMS AND METHODS FOR MODEL-BASED OPTIMIZATION OF SPINAL CORD STIMULATION ELECTRODES AND DEVICES

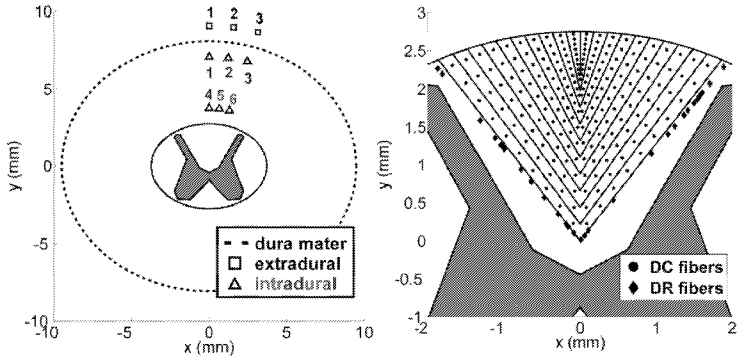

FIG. 3

(57) Abstract: Systems and methods for model-based optimization of spinal cord stimulation electrodes and devices are disclosed. According to an aspect a method includes providing a patient-specific electro anatomical model including the spine, spinal cord, and a map of target neural elements and non-target neural elements. The method also includes using model electrodes to stimulate the target neural elements. Further, the method includes determining differences in activation thresholds between the target neural elements and the non-target neural elements in a plurality of different configurations of the model electrodes. The method also includes generating an optimal spinal cord stimulation electrode configuration based on the determined differences in activation thresholds.

WO 2016/004152 A3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/038735

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61B 5/053 (2015.01)
CPC - A61N 1/0551 (2015.09)
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)
IPC(8) - A61B 5/053; A61N 1/05, 1/36, 1/372; G06F 19/00 (2015.01) (keyword delimited)
CPC - A61B 19/5225; A61N 1/0551, 1/36146; G06F 19/3437, 19/345, 19/3481 (2015.09) (keyword delimited)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 382/128; 607/59, 117; 702/19; 703/11
(keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents, Google Scholar, ProQuest
Search terms used: spinal, stimulation, electroanatomical, model, map, optimal, electrode, placement, configuration

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013/0150922 A1 (BUTSON et al) 13 June 2013 (13.06.2013) entire document	1-30
A	US 2009/0287271 A1 (BLUM et al) 19 November 2009 (19.11.2009) entire document	1-30
A	US 2014/0163640 A1 (EDGERTON et al) 12 June 2014 (12.06.2014) entire document	1-30
A	US 2004/0116978 A1 (BRADLEY) 17 June 2004 (17.06.2004) entire document	1-30
A	US 5,501,703 A (HOLSHEIMER et al) 26 March 1996 (26.03.1996) entire document	1-30

☐ 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	Date of mailing of the international search report
18 September 2015	07 OCT 2015
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)