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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 January 2007 (04.01.2007)

PCT

(10) International Publication Number
WO 2007/002790 A3

(51) International Patent Classification:
G06F 15/18 (2006.01) *G06N 3/00* (2006.01)
G06J 1/00 (2006.01)

(21) International Application Number: PCT/US2006/025264

(22) International Filing Date: 28 June 2006 (28.06.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/694,532 28 June 2005 (28.06.2005) US
11/426,881 27 June 2006 (27.06.2006) US

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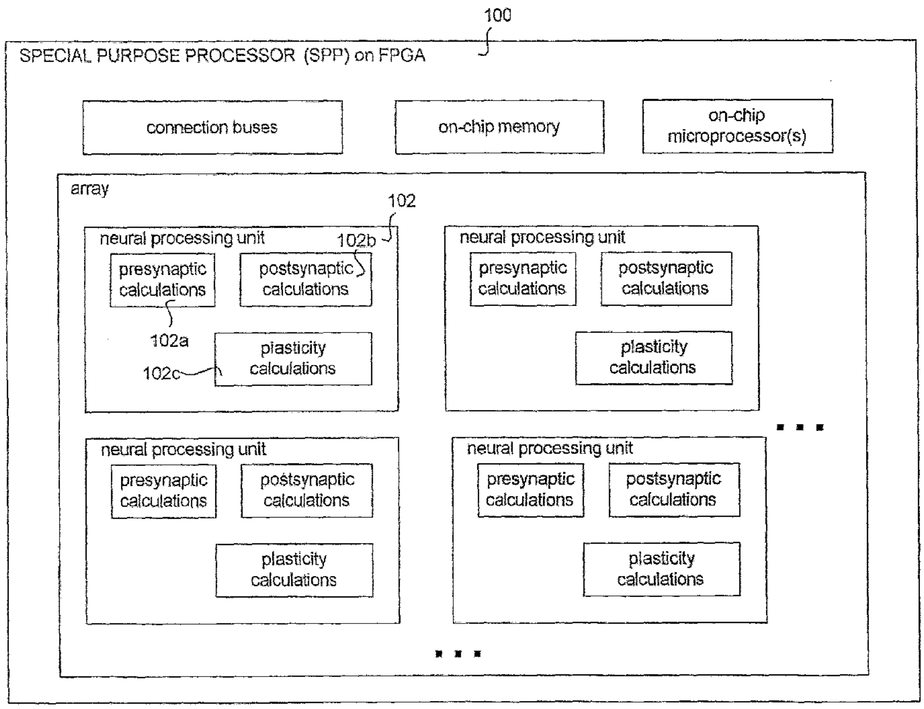
(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SY, 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, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(88) Date of publication of the international search report: 7 May 2009

(54) Title: NEURAL MODELING AND BRAIN-BASED DEVICES USING SPECIAL PURPOSE PROCESSOR



(57) Abstract: A special purpose processor (SPP) can use a Field Programmable Gate Array (FPGA) or similar programmable device to model a large number of neural elements. The FPGAs can have multiple cores doing presynaptic, postsynaptic, and plasticity calculations in parallel. Each core can implement multiple neural elements of the neural model.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US06/25264

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **G06F 15/18**(2006.01);**G06J 1/00**(2006.01);**G06N 3/00**(2006.01)

USPC: 706/33
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)
U.S. : 706/33

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)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	HALGAMUGE, et al. Fuzzy Interpretable Dynamically Developing Neural Networks with FPGA Based Implementation. IEEE Proceedings of the Fourth International Conference on Microelectronics for Neural Networks and Fuzzy Systems. 26-28 September 1994, pages 226-234.	1,4-5,8,25,27 ----------- 2-3,6-7,9-13,16,26,28-29
X --- Y	US 5,164,826 (DAILEY) 17 November 1992 (17.11.1992)	15 ----------- 16-17
Y	MILLER, W.T., III. Real-time Neural Network Control of a Biped Walking Robot. IEEE Control Systems Magazine. February 1994, Vol. 14. No. 1, pages 41-48.	2-3,6-7,9-13,26
Y	US 2003/0033032 A1 (LIND et al) 13 February 2003 (13.02.2003)	3,7,10,12-14
Y	US 4,095,367 (OGAWA) 20 June 1978 (20.06.1978)	17

☐ 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 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
31 January 2008 (31.01.2008)	01 APR 2008
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-3201	Authorized officer David Vincent Telephone No. 571-272-2100

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:
Please See Continuation 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 additional fees, this Authority did not invite payment of any 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.

BOX III. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

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, claim(s) 1-14 and 25-29, drawn to a neural model including multiple mores to implement multiple neural elements, the cores processing data in parallel, the processing including presynaptic calculations using input values and weights, postsynaptic calculations to produce postsynaptic outputs using the results of the presynaptic calculations and plasticity calculations to modify the weights.

Group II, claim(s) 15-18, drawn to multiple pods including at least one sensor and a wheel controlled by a motor.

Group III, claim(s) 19-22, drawn to multiple pods with dedicated power management sensors and a neural model receiving inputs from the power management sensors of the multiple pods and providing outputs to at least one actuator of the brain based device.

Group IV, claim(s) 23-24, drawn to multiple pods including at least one sensor and a wheel controlled by a motor, the multiple removable pods including a bi-directional suspension and a central axis operably connected to the bi-directional suspensions.

The inventions listed as Groups I-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 common technical feature of Group I found in independent claims 1, 4, 8, 11, 13, and 25 is the neural model including multiple parallel processing cores determining postsynaptic outputs with postsynaptic calculations using the results of presynaptic calculations and plasticity calculations to modify weights -- this technical feature is not found in the independent claims of Groups II-IV, and furthermore, it cannot be a special technical feature under PCT Rule 13.2 because the element is shown in the prior art. *Halgamuge* (Fuzzy Interpretable Dynamically Developing Neural Networks with FPGA Based Implementation", 1994) teaches a special purpose processor (*see* p. 229, Fig. 2, *Examiner interprets "Prototype board" to be a special purpose processor.*) comprising: a FPGA implementing a neural model (*see* p. 227, col. 1, para. 2, "a neuron is described by its synaptic weight vector (the center of the hyper cuboid) and n extensions from the center to each of the n axes (n dimensional inputs)."), the neural model including multiple neural elements (*see* above), the FPGA including multiple cores to implement neural elements (*see* p. 229, Fig. 2 and §2.1 Distance Measure, "The distance between an input vector and all the reference vectors can be ideally calculated parallelly with FPGAs.", *Examiner interprets the "FPGAs" to be multiple cores.*), the cores processing data in parallel (*see* above), the processing in the cores including presynaptic calculations using input values and weights (*see* p. 230, col. 1, §3 FPGA Architecture for Parallel Processing, "If difference between x_i and w_i is less than r_i, PE sends '1' to the next element in the row and passes original input element x_i to the next PE in the column. If PE receives '1', it makes a comparison and if $| x_i - w_i | < r_i$, its output will be '1',if $| x_i - w_i | > r_i$ output will be '0'. If PE receives '0', its output is always '0', because the input vector does not fall into the attraction region of this hyper cuboid anyway.", *Examiner interprets the comparison of the input vectors to the weight vectors with respect to the reference vectors to be the presynaptic calculations.*), postsynaptic calculations to produce postsynaptic outputs using the results of the presynaptic calculations (*see* above, *Examiner interprets the generation of outputs and output passing to comprise the postsynaptic calculations.*) and plasticity calculations to modify the weights (*see* p. 228, col. 1, "Another modification (DVQ3) is described as follows:... Incorrect classification, Bayes approximation shows that at as desirable to have another decision. A new reference vector is assigned having the weight vector equivalent to the input vector and trained with LVQ.").

The common technical feature of Group II & IV found in independent claims 15 and 23 is the controlling of a wheel using multiple pods including at least one sensor -- this technical feature is not found in the independent claims of Groups II-IV, and furthermore, ~~it cannot be a special technical feature under PCT Rule 13.2 because the element is shown in the prior art. *Dailey* (USPN 5,164,826)~~

teaches a robot device (*see* Abstract) including: multiple pods (*see* Fig. 3 and col. 5, lines 1-40, Examiner interprets the "right hand driver" and the "left hand drive" to be pods.) including at least one sensor (*see* col. 4, lines 29-32, Examiner interprets "a miniature television camera 29" to be a sensor.) and at least one actuator (*see* col. 5, lines 1-40, Examiner interprets the "right hand driver" and the "left hand drive" to be actuators.), at least two of the multiple pods including a wheel controlled by a motor (*see* Fig. 3 and col. 5, lines 1-40, Examiner interprets); and a central portion including at least one motorized tread (*see* col. 6, lines 60-61, "the timing belts 61 and 81 serve as treads").

The special technical feature of Group III found in independent claim 19 is the neural model receiving inputs from the power management sensors of multiple pods and providing outputs to at least one actuator of a brain based device, which is not present in the independent claims of Groups I, II, or IV.

The special technical feature of Group IV found in independent claim 23 is the "multiple removable pods including at least one: sensor a wheel controlled by a motor, the multiple removable pods including a bi-directional suspension" and "a central axis operably connected to the bi-directional suspensions of the multiple removable pods", which is not found in the independent claims of Groups I-III.

Continuation of B. FIELDS SEARCHED Item 3:
Googlr; Google Scholar, search terms: neural, model, network, removable, pod, assembly, sub-asembly, subassembly, FPGA, chip, plasticity, weights