



(51) International Patent Classification:

G06F 17/10 (2006.01) G06F 7/52 (2006.01)
G06F 17/16 (2006.01) G06F 7/523 (2006.01)
G06F 5/01 (2006.01) G06N 3/02 (2006.01)
G06F 7/32 (2006.01) G06N 20/00 (2019.01)
G06F 7/44 (2006.01)

(21) International Application Number:

PCT/US2020/019747

(22) International Filing Date:

25 February 2020 (25.02.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/810,851 26 February 2019 (26.02.2019) US

(71) Applicant: **LIGHTMATTER, INC.** [US/US]; 60 State Street, 10th Floor, Boston, MA 02109 (US).

(72) Inventors: **KENNEY, Tyler, J.**; 25 Morrissey Boulevard, Unit 1537, Boston, MA 02125 (US). **FORSYTHE, Mar-**

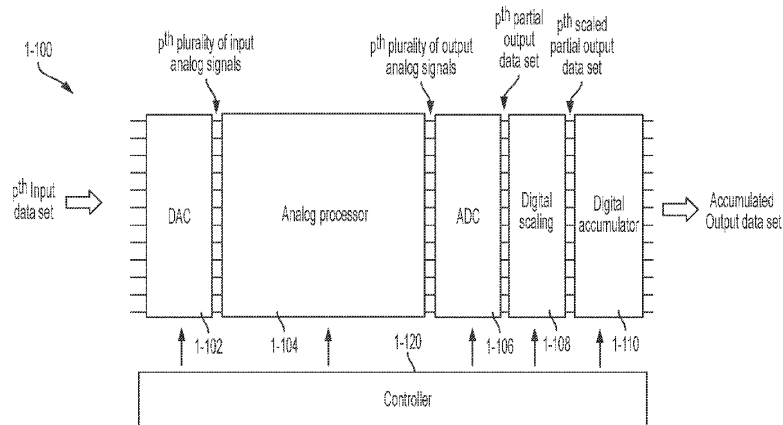
tin, B.z.; 14 Dunster Road, Apt. 2, Jamaica Plain, MA 02130 (US). **LAZOVICH, Tomo**; 130 Cambridgepark Drive, Unit 254, Cambridge, MA 02140 (US). **BUNANDAR, Darius**; 130 Bowdoin St., Apt. 706, Boston, MA 02108 (US).

(74) Agent: **MORESCO, Michele** et al.; WOLF, GREENFIELD & SACKS, P.C., 600 Atlantic Avenue, Boston, MA 02210-2206 (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, 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.

(54) Title: HYBRID ANALOG-DIGITAL MATRIX PROCESSORS

FIG. 1-2A



(57) Abstract: Techniques for computing matrix operations for arbitrarily large matrices on a finite-sized hybrid analog-digital matrix processor are described. Techniques for gain adjustment in a finite-sized hybrid analog-digital matrix processor are described which enable the system to obtain higher energy efficiencies, greater physical density and improved numerical accuracy. In some embodiments, these techniques enable maximization of the predictive accuracy of a GEMM-based convolutional neural network using low-precision data representations.

[Continued on next page]

(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))*
- *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))*