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Neuromorphic Technology for Computing and Machine Learning/AI

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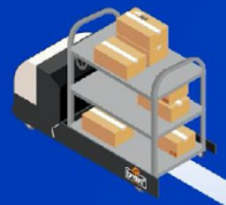

Opportunity to Acquire IP package on neuromorphic technology for computing and machine learning/AI

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Executive Summary

- Brain Corp is still recognized as a leader in neuromorphic technology even though it has been out of the business for years
  - https://www.marketwatch.com/press-release/strategic-analysis-of-neuromorphic-computing-systems-market-with-top-companies-brainchip-ibm-corporation-qualcomm-numenta-2021-04-26

- Brain Corporation is seeking an acquirer for its IP related to neuromorphic computers and algorithms:
  - Developed while working with Qualcomm on the architecture of its Zeroth processor
  - 38 issued patents

- Highlights
  - Patent portfolio on spiking neurons, spiking networks, spike-timing dynamics, neuromorphic learning/AI
  - Visual recognition and visual tracking optimized for specialized (neuromorphic) hardware

About Brain Corp

Brain Corp is an AI software leader that powers the world's largest fleet of autonomous mobile robots operating in commercial indoor public spaces. The BrainOS platform and its cloud-connected autonomy service are used by global manufacturing partners to successfully build, deploy, and support commercial robots at scale across industries and applications. Through intuitive software and controls, BrainOS also enables end customers to easily leverage the power of robotics to offload repetitive, labor-intensive tasks related to floor care, in-store inventory delivery, and shelf-scanning, freeing employees' time to focus on higher-value responsibilities. Working with its partners, Brain Corp has deployed over 10,000 robots within retail, grocery, malls, airports, hospitals, warehouses, and other industries. For more information, please visit www.braincorp.com.

Neuromorphic Zeroth Processor

- Qualcomm Inc. press release: https://www.qualcomm.com/news/onq/2013/10/10/introducing-qualcomm-zeroth-processors-brain-inspired-computing
- Business Insider: http://www.businessinsider.com/chips-inspired-by-the-brain-could-be-computings-next-big-thing-2013-10
- PR Newswire: http://www.prnewswire.com/news-releases/neuromorphic-chip-market-by-function---signal-processing-data-processing-image-recognition-by-application---defense-and-aerospace-automotive-medical-industrial-and-others---global-industry-analysis-size-trends-and-forec-570917021.html

Overview of Technology

- Neuromorphic algorithms based on spiking networks and spike-timing dynamics
  - Representation of information suitable for neuromorphic systems
  - Learning rules for visual perception, attention, object tracking, navigation, and obstacle avoidance

- Demo Movie 1: https://youtu.be/NQHI2VPeTp4
  - Pop-out (bottom-up) attention to salient objects based on motion, color, object features
  - Tracking of objects on natural backgrounds with occlusions and distractors

- Demo Movie 2 : https://www.youtube.com/watch?v=evDaaaEw6_I
  - Training a robot to understand human gestures and navigate

Patent List Overview

- US Patents – 38

US Patents (1/2)

8,315,305	SYSTEM AND METHODS FOR INVARIANT PULSE LATENCY CODING
8,467,623	INVARIANT PULSE LATENCY CODING SYSTEMS AND METHODS
8,793,205	ROBOTIC LEARNING AND EVOLUTION APPARATUS
8,942,466	SENSORY INPUT PROCESSING APPARATUS AND METHODS
8,943,008	APPARATUS AND METHODS FOR REINFORCEMENT LEARNING IN ARTIFICIAL NEURAL NETWORKS
8,972,315	APPARATUS AND METHODS FOR ACTIVITY-BASED PLASTICITY IN A SPIKING NEURON NETWORK
8,977,582	SPIKING NEURON NETWORK SENSORY PROCESSING APPARATUS AND METHODS
8,983,216	INVARIANT PULSE LATENCY CODING SYSTEMS AND METHODS
8,990,133	APPARATUS AND METHODS FOR STATE-DEPENDENT LEARNING IN SPIKING NEURON NETWORKS
8,996,177	ROBOTIC TRAINING APPARATUS AND METHODS
9,014,416	SENSORY PROCESSING APPARATUS AND METHODS
9,015,092	DYNAMICALLY RECONFIGURABLE STOCHASTIC LEARNING APPARATUS AND METHODS
9,047,568	APPARATUS AND METHODS FOR ENCODING OF SENSORY DATA USING ARTIFICIAL SPIKING NEURONS
9,070,039	TEMPORAL WINNER TAKES ALL SPIKING NEURON NETWORK SENSORY PROCESSING APPARATUS AND METHODS
9,082,079	SPIKING NEURON NETWORK PROPORTIONAL INTEGRATOR DIFFERENTIATOR CONTROLLER APPARATUS AND METHODS
9,098,811	SPIKING NEURON NETWORK APPARATUS AND METHODS
9,104,186	STOCHASTIC APPARATUS AND METHODS FOR IMPLEMENTING GENERALIZED LEARNING RULES
9,111,215	CONDITIONAL PLASTICITY SPIKING NEURON NETWORK APPARATUS AND METHODS
9,111,226	MODULATED PLASTICITY APPARATUS AND METHODS FOR SPIKING NEURON NETWORKS

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US Patents (2/2)

9,123,127	CONTRAST ENHANCEMENT SPIKING NEURON NETWORK SENSORY PROCESSING APPARATUS AND METHODS
9,152,915	APPARATUS AND METHODS FOR ENCODING VECTOR INTO PULSE-CODE OUTPUT
9,156,165	ADAPTIVE CRITIC APPARATUS AND METHODS
9,183,493	ADAPTIVE PLASTICITY APPARATUS AND METHODS FOR SPIKING NEURON NETWORK
9,189,730	MODULATED STOCHASTICITY SPIKING NEURON NETWORK CONTROLLER APPARATUS AND METHODS
9,193,075	APPARATUS AND METHODS FOR OBJECT DETECTION VIA OPTICAL FLOW CANCELLATION
9,195,934	SPIKING NEURON CLASSIFIER APPARATUS AND METHODS USING CONDITIONALLY INDEPENDENT SUBSETS
9,213,937	APPARATUS AND METHODS FOR GATING ANALOG AND SPIKING SIGNALS IN ARTIFICIAL NEURAL NETWORKS
9,218,563	SPIKING NEURON SENSORY PROCESSING APPARATUS AND METHODS FOR SALIENCY DETECTION
9,224,090	SENSORY INPUT PROCESSING APPARATUS IN A SPIKING NEURAL NETWORK
9,256,215	APPARATUS AND METHODS FOR GENERALIZED STATE-DEPENDENT LEARNING IN SPIKING NEURON NETWORKS
9,275,326	RATE STABILIZATION THROUGH PLASTICITY IN SPIKING NEURON NETWORK
9,311,593	APPARATUS AND METHODS FOR POLYCHRONOUS ENCODING AND MULTIPLEXING IN NEURONAL PROSTETHIC DEVICES
9,311,594	SPIKING NEURON NETWORK APPARATUS AND METHODS FOR ENCODING OF SENSORY DATA
9,367,798	SPIKING NEURON NETWORK ADAPTIVE CONTROL APPARATUS AND METHODS
9,405,975	APPARATUS AND METHODS FOR PULSE-CODE INVARIANT OBJECT RECOGNITION
9,384,443	ROBOTIC TRAINING APPARATUS AND METHODS
9,552,546	APPARATUS AND METHODS FOR EFFICACY BALANCING IN A SPIKING NEURON NETWORK
9,489,623	APPARATUS AND METHODS FOR BACKWARD PROPAGATION OF ERRORS IN A SPIKING NEURON NETWORK

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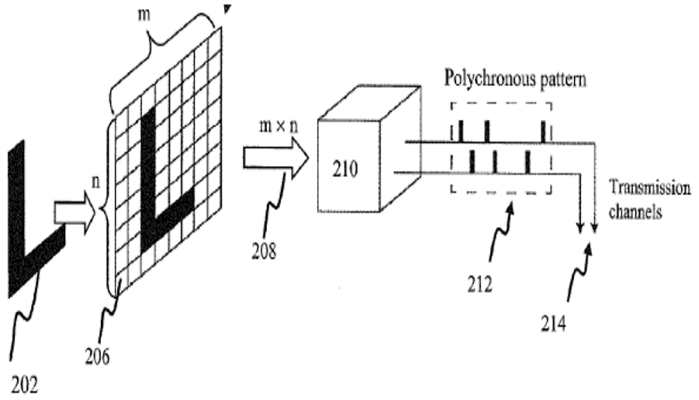
Technology Examples of Issued Patents

Invariant Pulse Latency Coding Systems and Methods
Example Patents - 8,467,623, 8,983,216

- Converts each frame of an input (206) into pulse-timing representation (212)
- May be infringed by any processor that uses pulses (spikes)

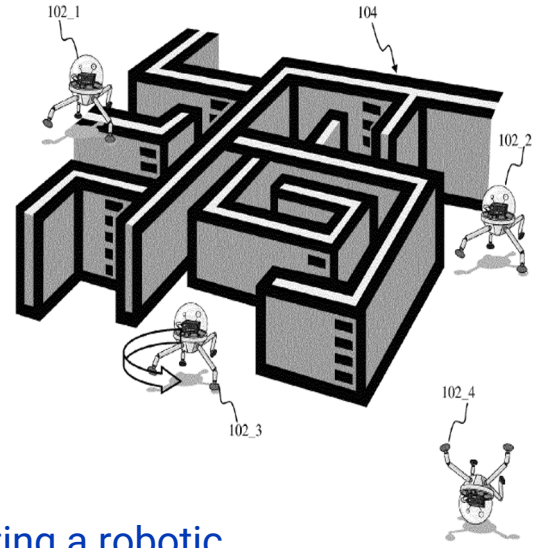


Claim 9 of U.S. Patent No. 8,983,216: An image processing apparatus, comprising: a filter logic module configured to determine a filtered signal based on a spatio-temporal filter of one or more images; an encoder logic module configured to encode the filtered signal into a temporal latency of one or more pulses based on a logarithmic function of the filtered signal; and an adapter logic module configured to provide a scaled signal based on scaling a given image based on a parameter configured based on one or more images occurring prior to the given image; wherein: the filter is applied to the scaled signal.

Technology Examples of Issued Patents

Robotic Learning and Evolution Apparatus
Example Patents - 8,793,205; 8,996,177; 9,156,165

- Copying of information from a robot that learned a task to other robots
- May be infringed by any robot with specialized HW that needs to share new memories with other robots



Claim 5 of U.S. Patent No. 8,793,205: A computer-implemented method of operating a robotic apparatus comprising network of a plurality of spiking neurons, the method being performed by one or more processors configured to execute computer program modules, the method comprising: operating the network in accordance with a learning process configured to cause the apparatus to perform a task, the operating being characterized by a network state information; and based on a completion of the task, transferring at least a portion of the network state information to another robotic apparatus; wherein the transferring is configured to enable the other robotic apparatus to perform the task.

Technology Examples of Issued Patents

Apparatus and Methods for Encoding of Sensory Data Using Artificial Spiking Neurons
Example Patent – 9,047,568

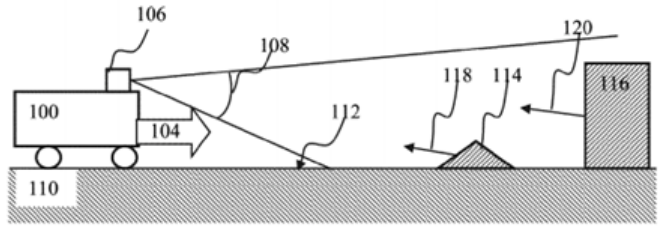
- Encodes multi-bit data, such as sensory data, into spiking responses

- May be infringed by spiking neuron networks that process multi-bit sensory data into impulses

Claim 22: A computerized data processing system, comprising: one or more processors configured to execute computer program modules, wherein execution of the computer program modules causes the one or more processors to implement a spiking neuron network that is configured to encode multi-bit data into binary output by: evaluating statistics of the multi-bit data; scaling a portion of the multi-bit data based on the statistics; adjusting network state based on the scaled portion of the multi-bit data; and generating the binary output based on a comparison of the adjusted state with a threshold; wherein the binary output is characterized by a lower bit-rate compared to the multi-bit input.

Technology Examples of Issued Patents

Apparatus and Methods for Object Detection Via Optical Flow Cancellation
Example Patent – 9,193,075



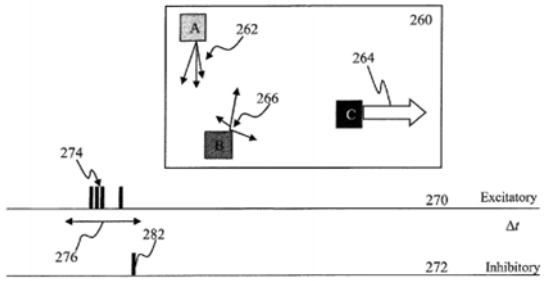
- Encodes motion in video stream into pulse-timing representations
- May be infringed by any processor that uses pulses (spikes) to process video streams

Claim 12: A computer implemented method of encoding optical flow, the method being performed by one or more processors configured to execute computer program modules, the method comprising: encoding motion information into one or more motion pulses; and based on the one or more motion pulses, encoding optical flow into one or more pulse latencies; wherein the optical flow is configured to characterize velocity of at least a portion of a visual data frame.

Technology Examples of Issued Patents

Contrast Enhancement Spiking Neuron Network Sensory Processing Apparatus and Methods
Example Patent – 9,123,127

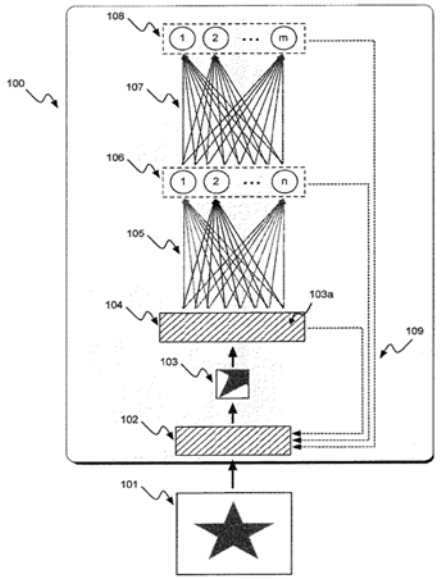
- Implements deep network where perception of an object depends on the context in proximity to the object
- May be infringed by any computer vision system that uses backgrounds in object recognition



Claim 1: A computerized apparatus comprising a storage medium, the storage medium comprising a plurality of computer-readable instructions configured to, when executed, detect an object in a sensory input by at least: based on at least one feed-forward signal, generate an inhibitory signal configured to suppress generation of a secondary feed-forward signal, thereby enabling the object detection; wherein: the at least one feed-forward signal comprises one or more pulses generated based on a portion of the sensory input comprising a representation of the object; the secondary feed-forward signal corresponds to a portion of the sensory input proximate the representation of the object; and the representation of the object being characterized by a parameter having a value that is different from a parameter value associated with the portion of the sensory input.

Technology Examples of Issued Patents

Sensory Input Processing Apparatus and Methods
Example Patent – 8,942,466



- Implements a spatio-temporal filter via pulses
- May be infringed by a processor that uses pulses to process video streams

Claim 18: A processing apparatus, comprising: a sampler configured to receive an input data frame and to generate a sequence of sub-frames comprising a first sub-frame and a second sub-frame, at least one of the first sub-frame and the second sub-frame comprising at least a portion of a feature; an encoder operably coupled to the sampler and configured to receive and to encode the first sub-frame and the second sub-frame into a group of pulses; and a first decoder configured to generate a detection signal responsive at least in part to reception of said group of pulses; and where at least a portion of the input data frame comprises the feature; the first decoder is configured to detect the feature via a displacement of the second sub-frame relative to the first sub-frame; and where information related to at least the portion of the feature is encoded into a pattern of latencies of the group of pulses relative to one another.

Technology Examples of Issued Patents

Apparatus and Methods for Activity-Based Plasticity in a Spiking Neuron Network
Example Patent – 8,972,315

- Implements a general framework for lateral competition in spiking networks
- May be infringed by many applications running on neuromorphic chips

Claim 1: A signal processing apparatus comprising a storage medium, the storage medium comprising a plurality of executable instructions configured to, when executed, determine plasticity rule in a spiking neuron network by at least: determination of an intra-similarity measure between outputs of neurons of a first portion of the network; determination of an inter-similarity measure between outputs of neurons of the first portion and neurons of a second portion of the network; configure the plasticity rule based on a combination of the intra-similarity and inter-similarity measure; and adjust an efficacy of one or more inhibitory connections between neurons of the network in accordance with the plasticity rule.
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Companies in the space

Machine Learning/AI
(will require HW acceleration)

Robots with AI
(will require machine learning on efficient HW)

Neuromorphic chips
(specialized HW to accelerate machine learning)

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Software Applications

- Neuromorphic computing is expected to expand rapidly in the coming years: https://finance.yahoo.com/news/neuromorphic-computing-market-worth-550-133000670.html
- Once neuromorphic processors are commercially available, many software companies will rewrite their algorithms to be optimized for the neuromorphic hardware. They will likely recast their proprietary algorithms into forms covered by this IP portfolio.
- Major tech companies, including Google, Facebook, Baidu, and Microsoft, have ongoing AI and machine learning projects.

Hardware Applications

- Neuromorphic hardware offers the ability to dramatically reduce power consumption for machine learning algorithms and to accelerate processing speeds.
- Neuromorphic hardware could become essential for machine learning (see, e.g., https://www.zdnet.com/article/neuromorphic-computing-could-solve-the-tech-industrys-looming-crisis/).
- Major semiconductor companies continue to have projects in neuromophic chip technology, for example:
  - IBM: https://news.yale.edu/2017/11/28/new-research-creates-computer-chip-emulates-human-cognition
  - Intel: https://newsroom.intel.com/news/intel-scales-neuromorphic-research-system-100-million-neurons/#gs.28g46b
  - More: https://www.accenture.com/_acnmedia/PDF-145/Accenture-Neuromorphic-Computing-POV.pdf

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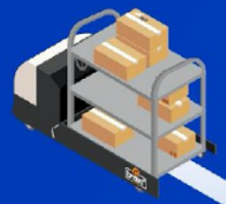
Deal Specifics

- Current Licensees to the IP Portfolio– Qualcomm

Thank You

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- Price Spread 价差
- Ask 要价
- Sold 成交
- In Market (Lot Will Sell) 待拍品
- Transaction Pending

DOCUMENT PROCESSING SYSTEM
用户界面
SOLD
LOTS: 64 专利拍品数量 SOURCE CODE 源代码
9 ASSETS 专利数量

DIGITAL DISPLAY SYSTEM
数字内容访问
LOT: 65 专利拍品数量
4 ASSETS 专利数量

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市场一览

INDUSTRIAL INTERNET SECURITY & INSPECTION
一种工业互联网安全和检查的装置
LOT: 66 专利拍品数量 SALE 出售 LEASE
21 ASSETS 专利数量

OZONIX
种名为OXONIX的装置
LOT: 67 专利拍品数量 PATENTS 专利 TRADEMARKS 商标
18 ASSETS 专利数量

LOT NUMBER 拍品编号	DATA ROOM 数据服务室	PTO 知识产权局	NICKNAME 拍品名称	REPRESENTATIVE PATENT 专利	PRIORITY DATE 优先权日期	EVENT DATE* 活动日	BID USD/RMB* 竞价	BID EXP. DATE 竞价截止日	ASK USD/RMB* 要价	ASK EXP. DATE 要价截止日	PRICE SPREAD 价差	ASSETS 资产	TYPE 类型	NEXT MAINT. DUE DATE 下一个截止日	FORWARD CITATIONS 前引
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