

***CM3: CSU's Machine Learning,
Machine Vision group
... Ranjan's workshop***

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www.csu.edu.au/faculty/business/cm3/cm3-projects



Introduction to VICPU Workshop, 3 Nov. 2015

Outline: building on CRiCS



**Centre for Research in
Complex Systems**

How are bush fires important in evolution? Why is lightning like a river?
What has the World Wide Web in common with DNA and the genetic code?
How do we understand social change in the midst of rapid technological change?

The answer to these and many other exciting questions lie in the domain of complex adaptive systems. We live in an inc

- **Machine Learning now coming of age,**
 - getting useful in everyday services
- **Exciting research, Applications**



Terry Bossomaier,
Founding Director,
CRiCS, CSU.

CM3: a new centre for Machine Learning:

Core Techniques:

Pattern analysis and data mining

Data compression

Image processing, computer vision

Agent-based modeling, simulation

Application focus

Agriculture & Environment

Industry & Mining

e-Health

ICT Security

noticed by premier science journals:

Silicon smarts (editorial)

Ethics of artificial intelligence

S Russell, Sabine Hauert, Russ Altman, Manuela Veloso

.....

Machine intelligence

Tanguy Chouard & Liesbeth Venema

Deep learning

Yann LeCun, Y Bengio & Geoffrey Hinton (**Facebook; Google & U Toronto**)

Reinforcement learning improves behaviour from evaluative feedback

Michael L. Littman (**Brown U**)

Probabilistic machine learning and artificial intelligence

Zoubin Ghahramani (**Cambridge**)

Science, technology and the future of small autonomous drones

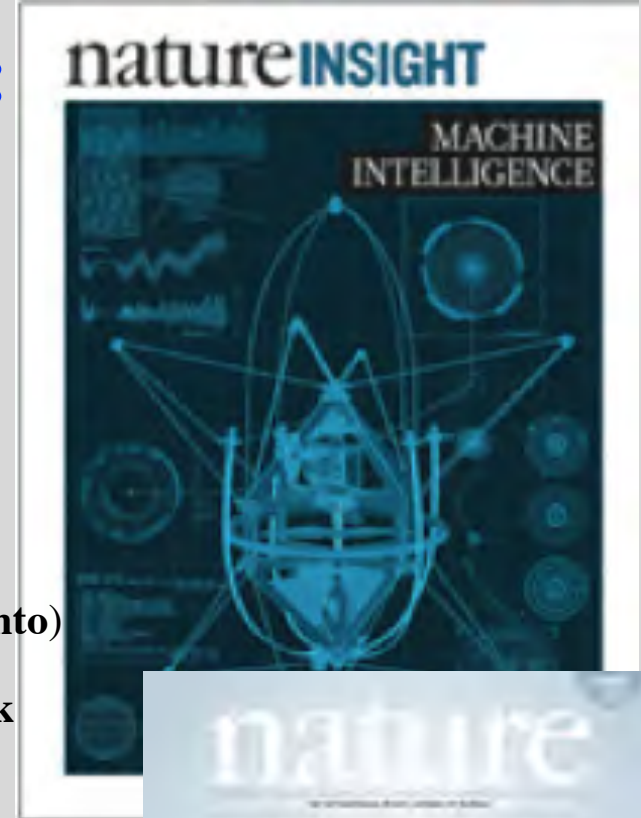
Dario Floreano & Robert J. Wood (**EPF Lausanne, Harvard**)

Design, fabrication and control of soft robots

Daniela Rus & Michael T. Tolley (**MIT, UCSD**)

From evolutionary computation to the evolution of thing

Agoston E. Eiben & Jim Smith (**U Amsterdam, Bristol**)



noticed by premier science journals:

Rise of the Machines

Jelena Stajic, R Stone, G Chin, B Wible

.....

Machine learning: Trends, perspectives, and prospects

M. I. Jordan, T. M. Mitchell (Berkeley, CMU)

Advances in natural language processing

Julia Hirschberg, C D. Manning (Columbia, Stanford)

Economic reasoning and artificial intelligence

David C. Parkes, M P. Wellman (Harvard, U Michigan)

Computational rationality: A converging paradigm for intelligence in brains, minds, and machines

Samuel J. Gershman, Eric J. Horvitz,

J B. Tenenbaum (Harvard, Microsoft, MIT)



AI: from winning Games ... to Commonsense



"Jeopardy!" champions Ken Jennings, left, and Brad Rutter, right, look on as an IBM computer called them to the buzzer to answer a question during a practice round of the "Jeopardy!" quiz show. *Source: [unreadable]*



Eg Computer Vision combined with Machine Learning yields new services:

Jordan et al. *Science*,
349, 245, 2015.

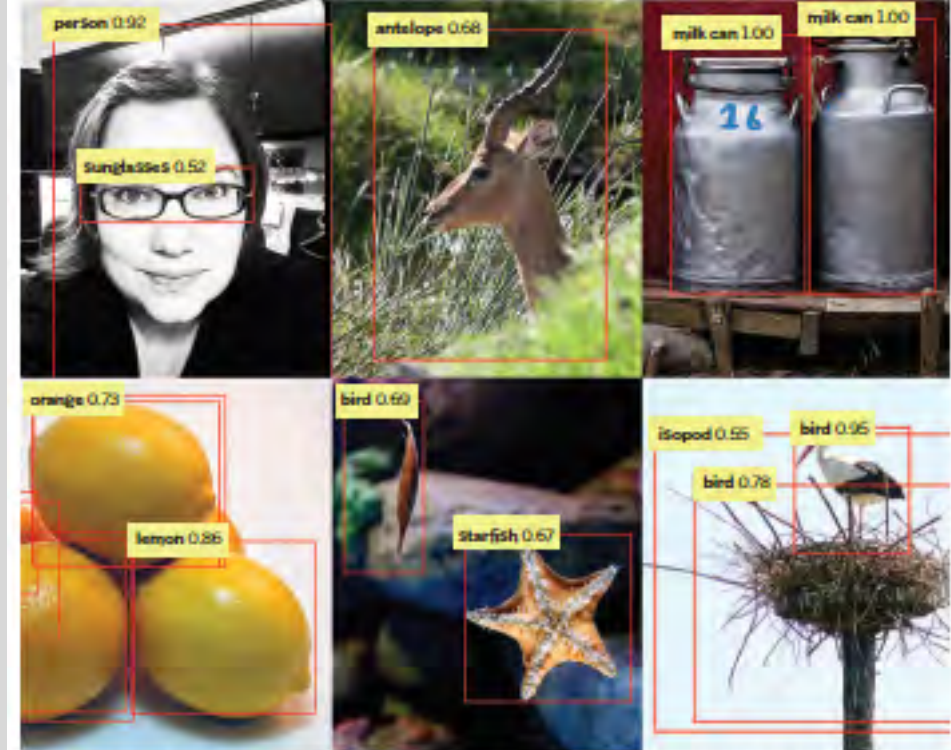
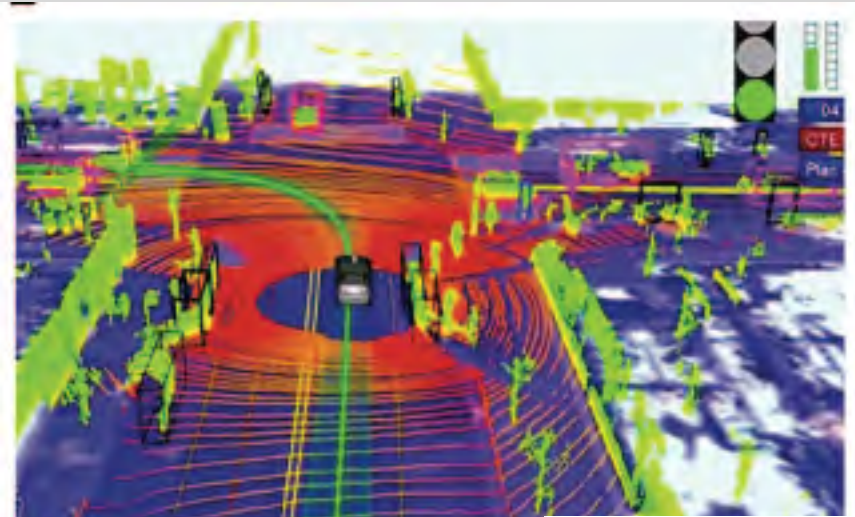


Fig. 1. Applications of machine learning. Machine learning is having a substantial effect on many



Internal state of Google car

Gershman et al. *Science*,
349, 273, 2015.

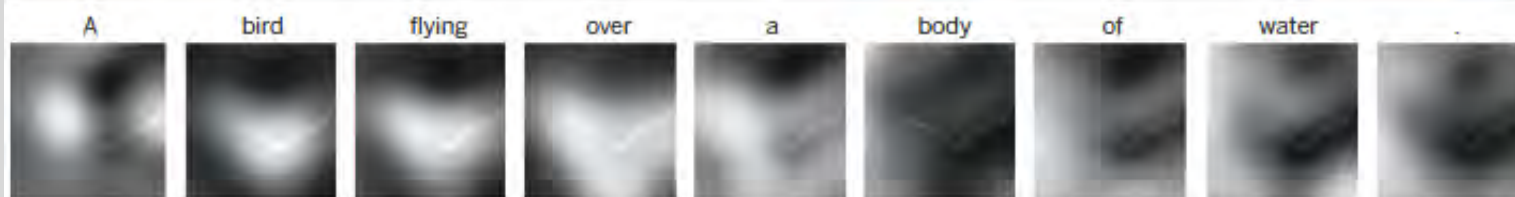
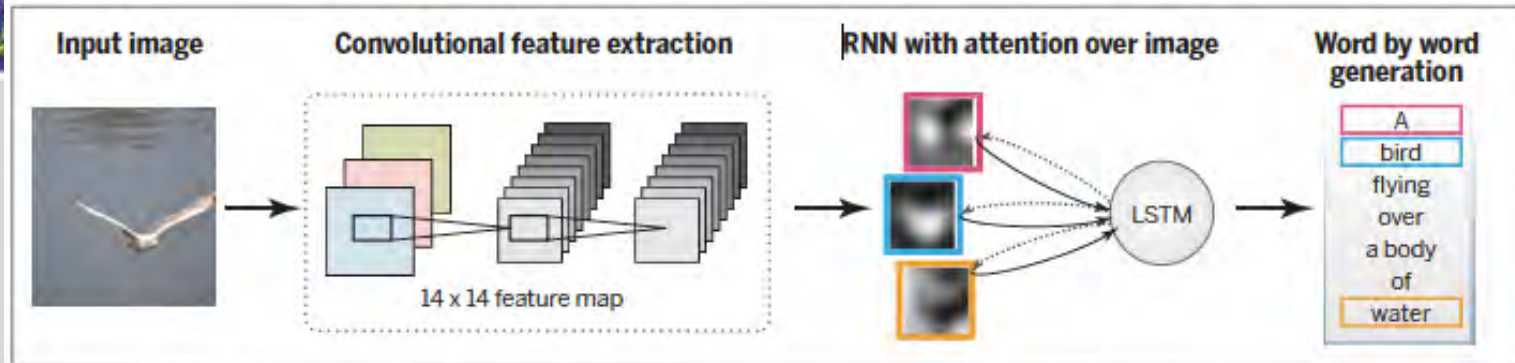


Fig. 2. Automatic generation of text captions for images with deep networks. A convolutional neural network is trained to interpret images, and its

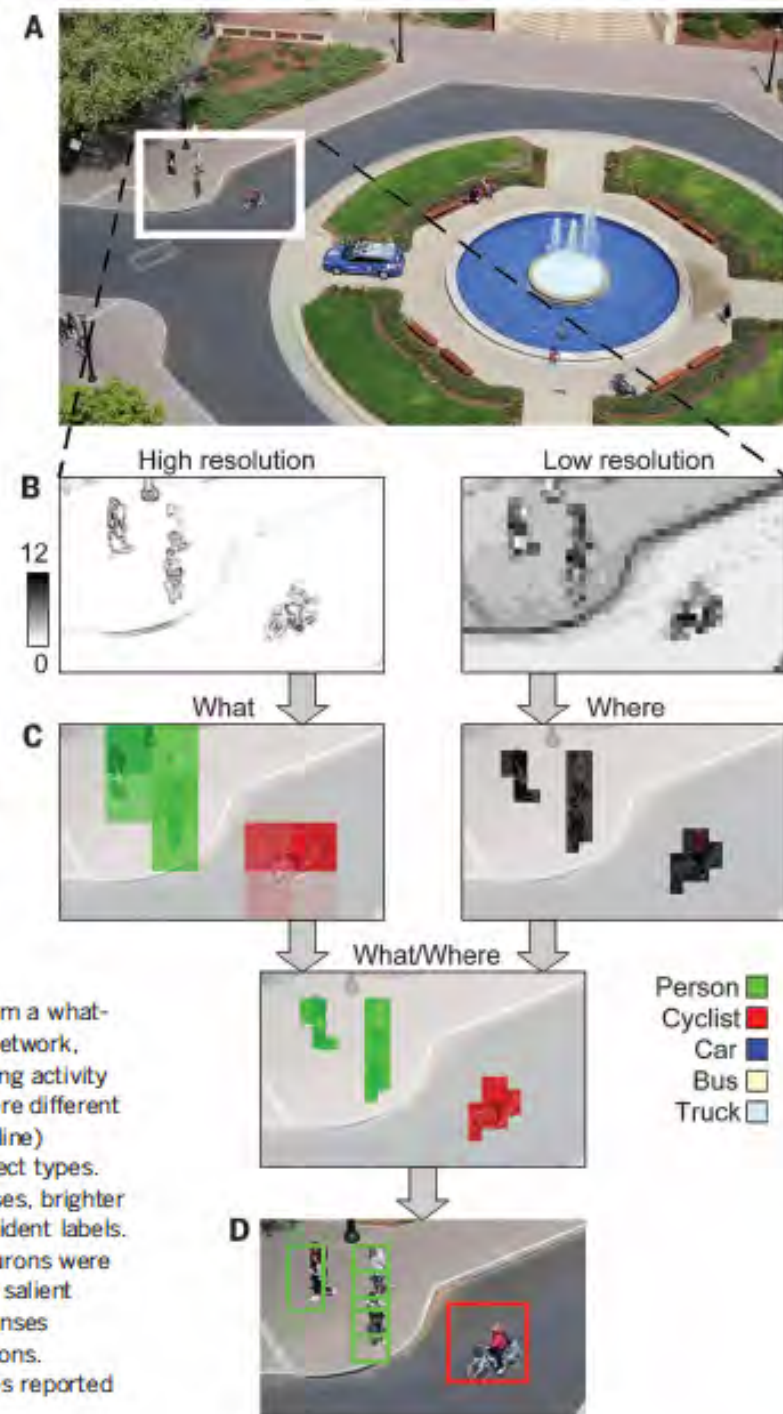
and do it in real time:
new computer architectures

- IBM *TrueNorth* chip
- Qualcomm *neuromorphic* chip
- Intel
- neuroscience inspired computing;
“compute more like we do”
- + Corelet Language
for Composing Networks of
Neurosynaptic Cores
(cf. DARPA SyNAPSE roadmap)

from: Merolla et al. *Science*,
345, p668, 2014.

Fig. 3. Real-time multi-object recognition on TrueNorth. (A) The

Neovision2 Tower data set is a video from a fixed camera, where the objective is to identify the labels and locations of objects among five classes. We show an example frame along with the selected region that is input to the chip. (B) The region is transduced from pixels into spike events to create two parallel channels: a high-resolution channel (left) that represents the what pathway for labeling objects and a low-resolution channel (right) that represents the where pathway for locating salient objects. These pathways are inspired by dorsal and ventral streams in visual cortex (4). (C) What and where pathways are combined to form a what-where map. In the what network, colors represent the spiking activity for a grid of neurons, where different neurons were trained (offline) to recognize different object types. By overlaying the responses, brighter colors indicate more-confident labels. In the where network, neurons were trained (offline) to detect salient regions, and darker responses indicate more-salient regions. (D) Object bounding boxes reported by the chip.



new Intel chips:

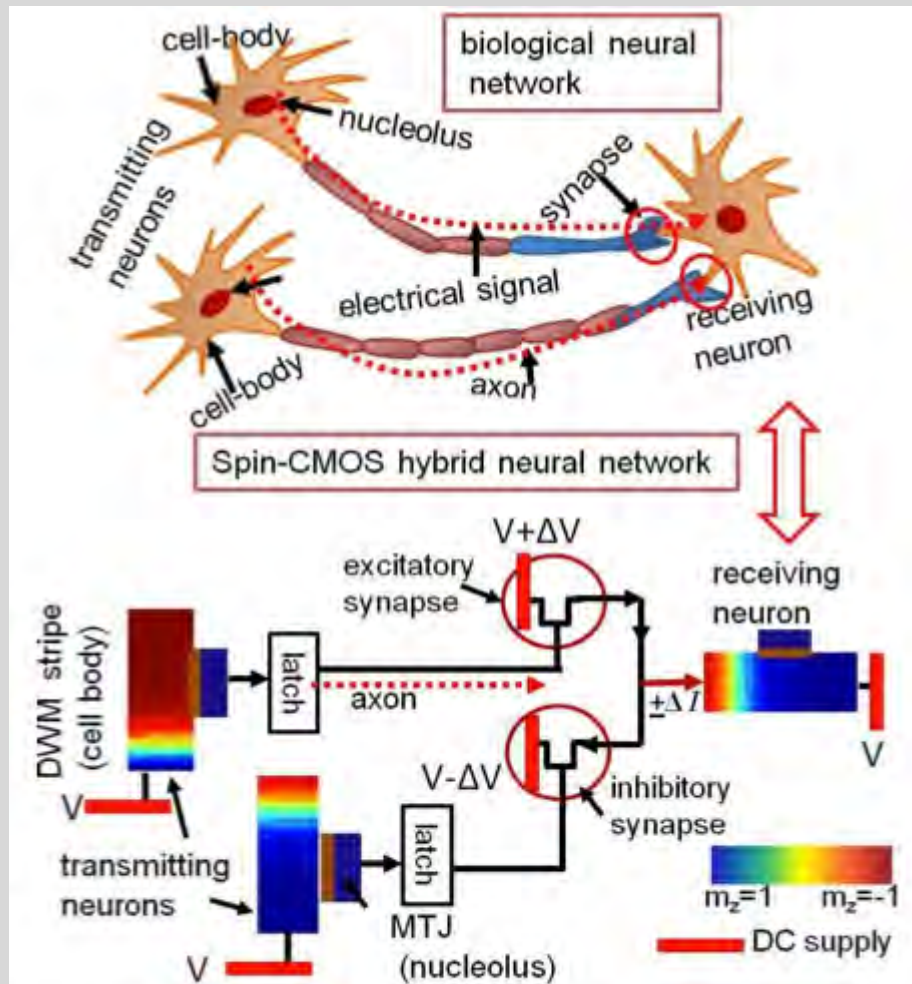


Fig. 11 Emulation of neural network using spin-CMOS hybrid circuit: In each neuron, the MTJ acts as the firing

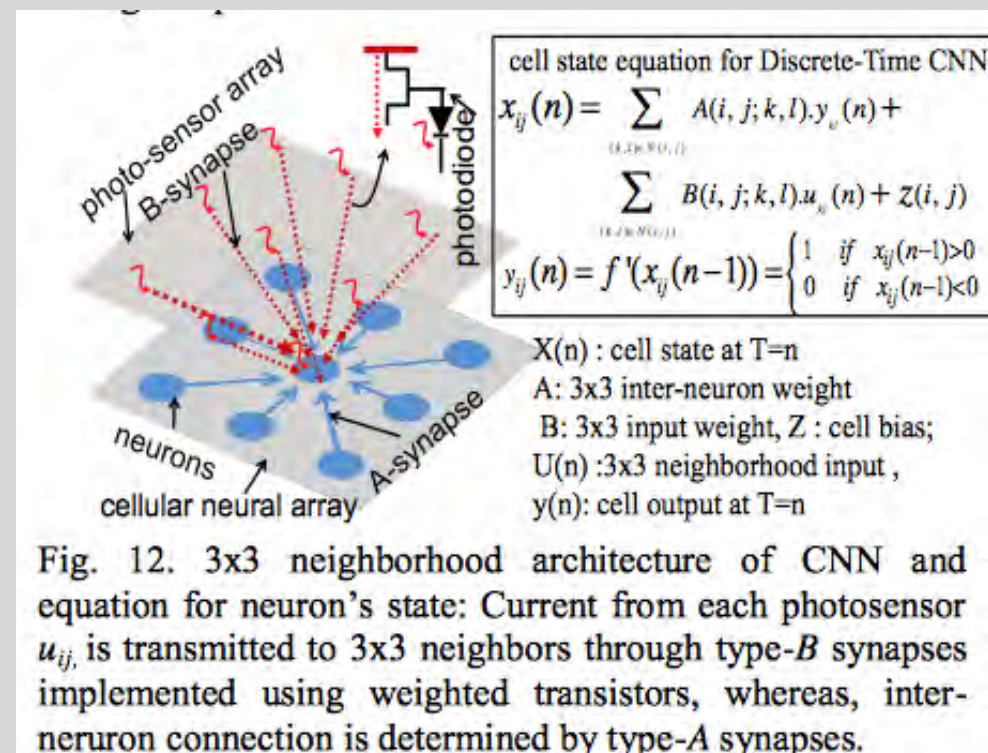
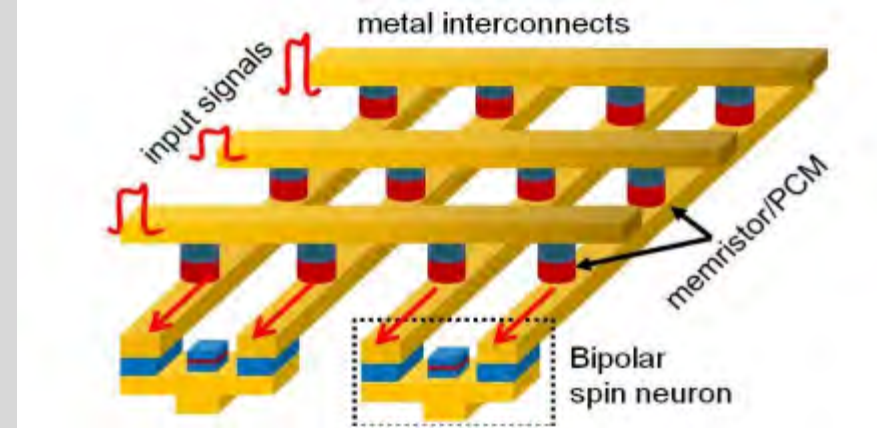


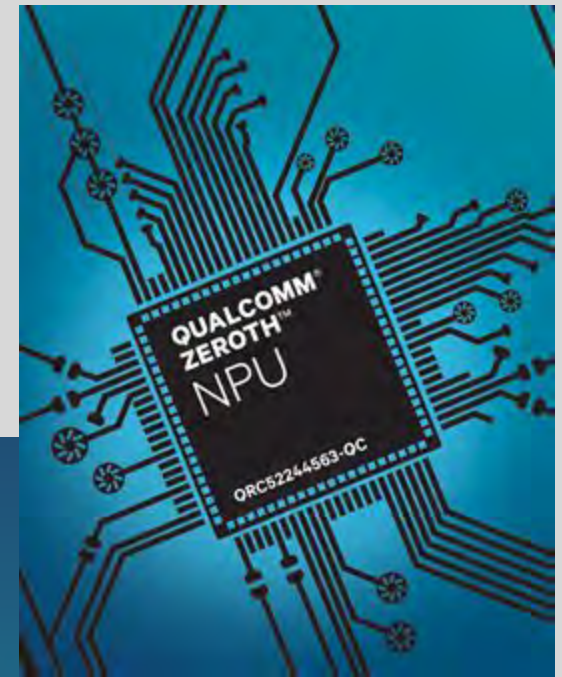
Fig. 12. 3x3 neighborhood architecture of CNN and equation for neuron's state: Current from each photosensor u_{ij} is transmitted to 3x3 neighbors through type-B synapses implemented using weighted transistors, whereas, inter-neuron connection is determined by type-A synapses.

C. Augustine, Intel (Hillsborough, Or.) June 2012;
M Sharad et al <http://arxiv.org/pdf/1206.3227v4.pdf>

new computer chips .. coming to cell phones

Introducing Qualcomm Zeroth Processors: Brain-Inspired Computing:

1. Biologically Inspired Learning
2. Enable Devices To See and Perceive the World as Humans Do
3. Creation and definition of an Neural Processing Unit—NPU



Neural Processing Units (NPUs)

A new class of processors mimicking human perception and cognition



CPU _s	MULTIMEDIA Audio, Video and Gestures
GPU	
DSP	SENSORS
NPUs	ISPs
CONNECTIVITY 4G LTE, Wi-Fi USB, BT and FM	DISPLAY / LCD
	NAVIGATION

Massively parallel,
reprogrammable

Comprehensive tools

Human-like functions

new computer chips .. and new programming tools

Zeroth Neural Network Tools Platform

Zeroth Development Studio (ZDS): end to end package

- Programming Language: High Level Network Description language (HLND)
- Development Environment: Integrated Development Environment (IDE)
- Libraries- Neuromorphic Development Kit (NDK)
- Robotics Simulator- Virtualization World (VW)

Support multiple execution targets:

- Software simulation: Linux workstation or equivalent (*today*)
- Hardware emulation: Custom Xilinx-K7 based FPGA board (*today*)
- ASIC Chip: Zeroth Neural Processing Unit (NPU) (*future*)



HLND example

IDE/NDK

NST
Compiler

automated
engine specific
format support



CPU (*today*)
GPU (*future*)



1-N Compute
Cluster

Automatic distribution
onto multiple cores
→ scalable



FPGA



NPU ASIC (*future*)

Supports multiple
neuron types

... and new spinoff companies



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Building Brains for Tomorrow's Robots

Brain Corporation applies expertise in machine learning and computer vision to create intelligent systems capable of functioning autonomously in complex human environments.

We're building brains for robots, and turning today's manually-operated machines into tomorrow's autonomous solutions.



Brain Corporation is a Qualcomm Ventures portfolio company. [Qualcomm Ventures](#) invests in companies in the digital, mobile, and technology space. Qualcomm Ventures portfolio companies include PayPal, Waze, Xiaomi, and FitBit.



... and new research: eg. new journals



Neuromorphic Engineering 

3.7

IMPACT FACTOR

... meanwhile, back in oz: we have an **Innovation Agenda**

- **more collaboration: Univ – Industry**
- **applicable research**
 - for CSU: **Regional impact.**
- **CSIRO (Larry Marshall) ~ catalyst: Univ – Indr.**
- **Data61 (NICTA – CSIRO: Adrian Turner) ~ data analytics**

This is what CM3 is trying to do: *Venture catalyst*