WORKSHOP
L'Intelligence Naturelle au coeur
des enjeux de l'Intelligence Artificielle

NeuroCoG
Univ. Grenoble Alpes

Pôle GRENOBLE Cognition

Session Traitements
Architectures neuronales

Are Deep Neural Networks Bio-Inspired and Why Neuromorphism is Important for the Future of AI

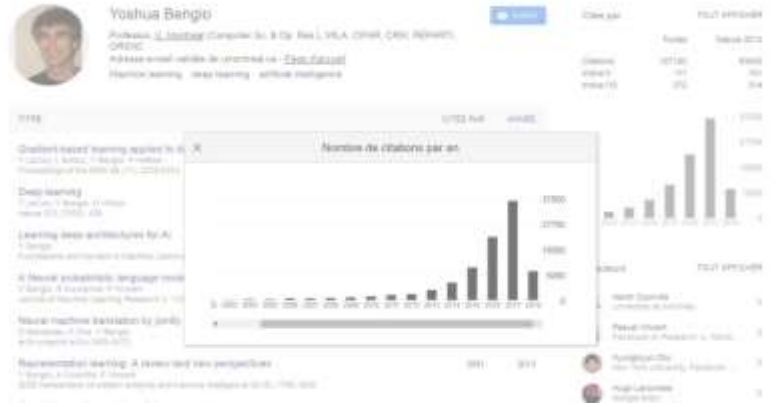
Martial Mermillod

LPNC

Deep Learning: The New Revolution of AI

Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). Imagenet classification with deep convolutional neural networks. In Advances in neural information processing systems (pp. 1097-1105).

Why on December 2012 ?



3 factors:

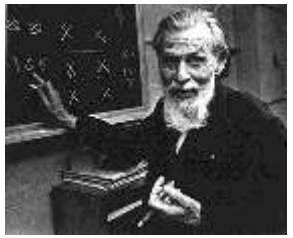
1. Deep Neural Networks ready for a while
2. GAFA -> BIG DATA
3. GPU -> convolution/pooling

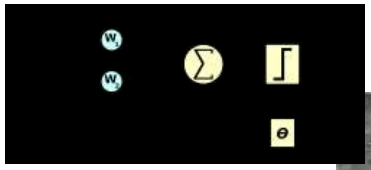
NeuroCoG
Univ. Grenoble Alpes
GRENOBLE Cognition

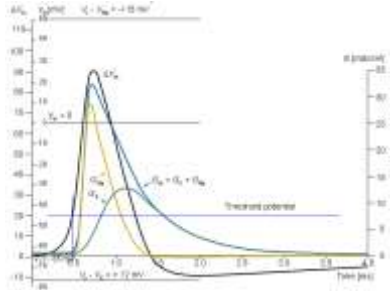
Question: To what extend Deep Learning is brain-inspired?

The fundamental component of human mind:
From neurons to the psyché.

McCulloch, W. S., & Pitts, W. (1943). A logical calculus of the ideas immanent in nervous activity. *The bulletin of mathematical biophysics*, *5*(4), 115-133.







$$i_m = i_{mI} + c_m \frac{\partial V_m}{\partial t} = \frac{1}{r_i + r_o} \frac{\partial^2 V_m}{\partial x^2}$$

Hodgkin, A. L., & Huxley, A. F. (1952). A quantitative description of membrane current and its application to conduction and excitation in nerve. *The Journal of physiology*, *117*(4), 500-544

$$w_{ij} = \frac{1}{p} \sum_{k=1}^{p} x_i^k x_j^k,$$

Hebb, D. O. (1949). *The organization of behavior: A neuropsychological theory*. Wiley, New York

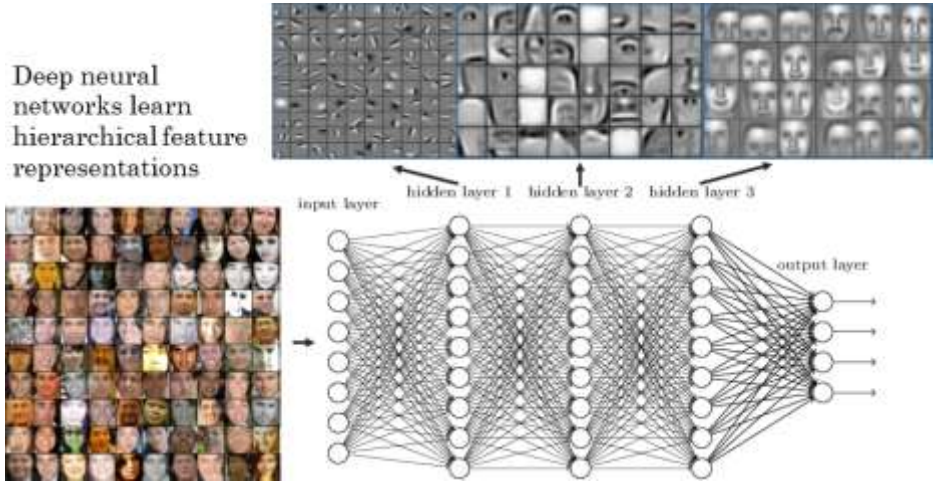
Rosenblatt, F. (1958). The perceptron: a probabilistic model for information storage and organization in the brain. *Psychological review*, *65*(6), 386.

From Multi-Layer Perceptron (MLP) to Deep Neural Networks (DNN)

Geoffrey Hinton
(1947-20XX) : Psychology & Computer Science, University of Toronto. Parallel Distributed Processing Group.

James McClelland
(1948-20XX) : Psychology & Cognitive Science, Stanford University. Parallel Distributed Processing Group.

David Everett Rumelhart
(1942-2011) : Psychology, UCSD and Stanford University. Parallel Distributed Processing Group.

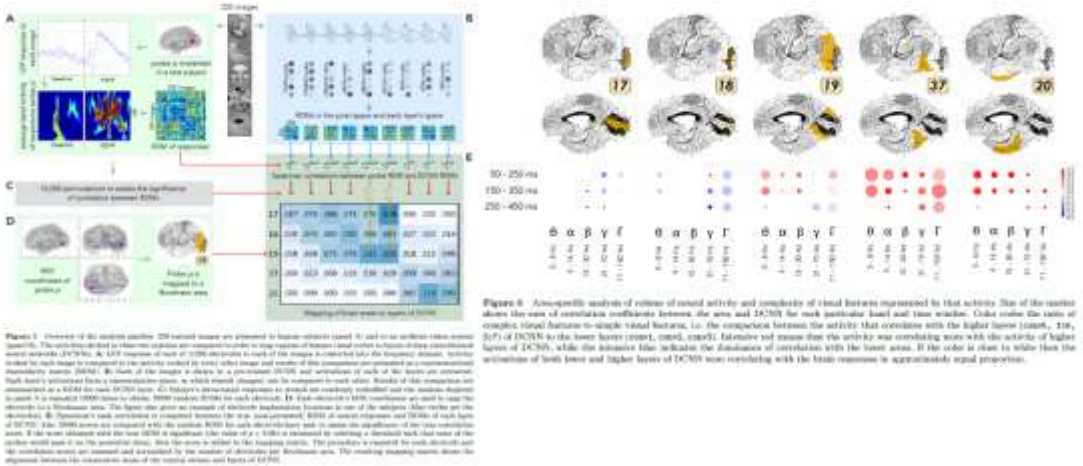


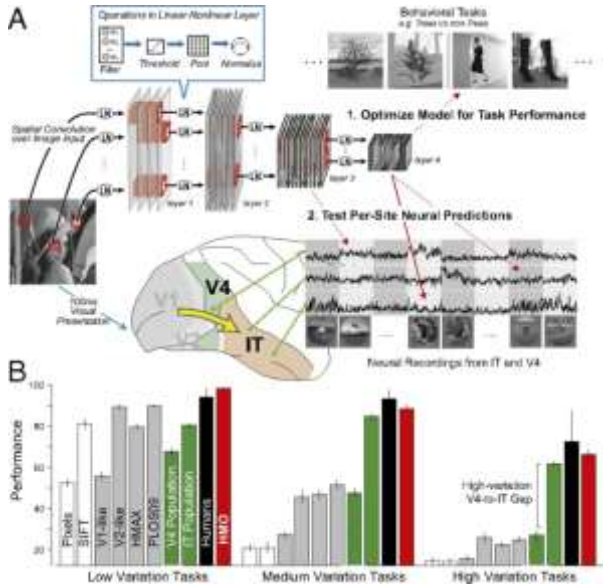
LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. N*ature*, *521*(7553), 436.

Ok, Neural Networks are coming from Cognitive Sciences, but Is Deep Neural Network Still bio-inspired?

iEEG Data with humans

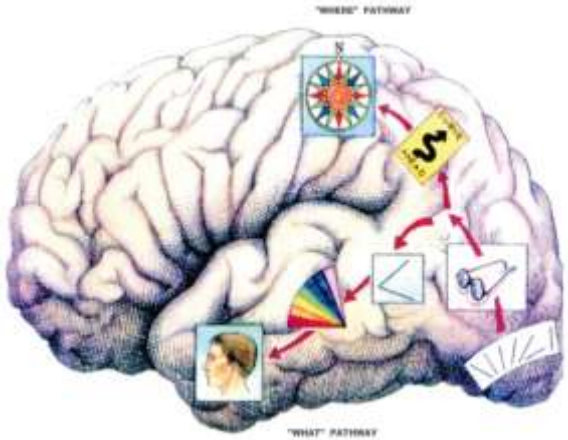
Kuzovkin, I., Vicente, R., Petton, M., Lachaux, J. P., Baciu, M., Kahane, P., ... & Aru, J. (*in press*). Activations of Deep Convolutional Neural Network are Aligned with Gamma Band Activity of Human Visual Cortex. *Nature Communication Biology*.





Yamins, D. L., Hong, H., Cadieu, C. F., Solomon, E. A., Seibert, D., & DiCarlo, J. J. (2014). Performance-optimized hierarchical models predict neural responses in higher visual cortex. *Proceedings of the National Academy of Sciences*, *111*(23), 8619-8624.

Ok, but is Brain-Inspired Technology still required for future AI?

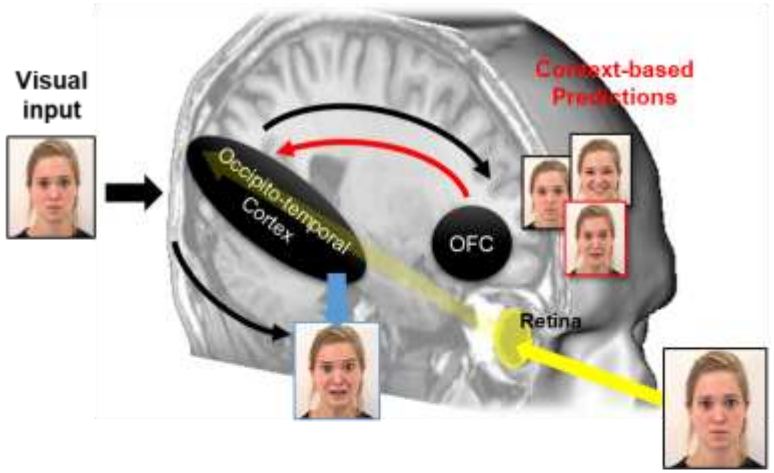


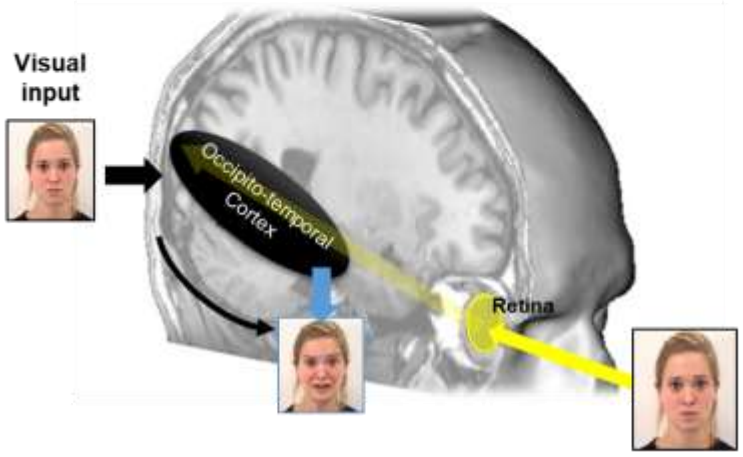
Gestalt processes and top-down expectations urgently required!

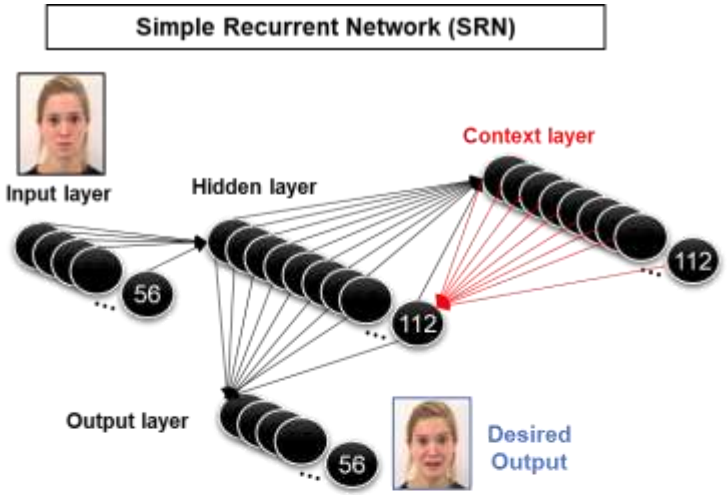
Koffka, K. (1922). Perception: an introduction to the Gestalt-Theorie. *Psychological Bulletin, 19*(10), 531.

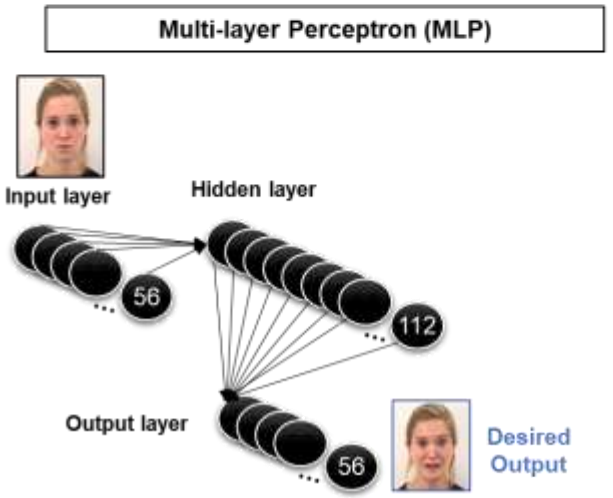
Example: Bio-inspired Predictive Brain

Mermillod et al. (in revision). The Importance of Recurrent Top-Down Synaptic Connections for the Anticipation of Dynamic Emotional Expressions. *Neural Networks.*







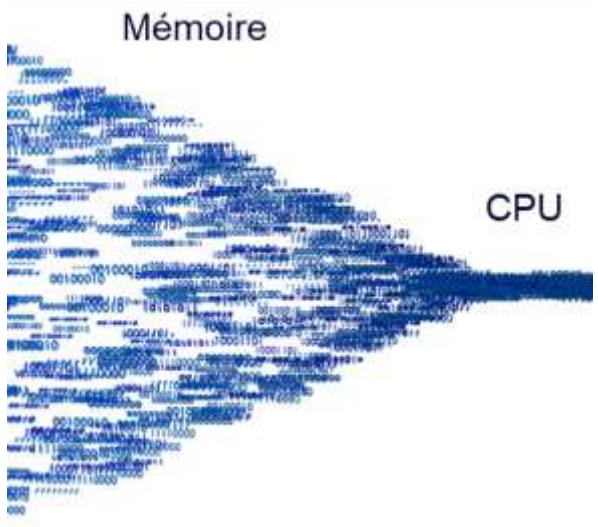


Perspective: Beyond Turing-Von Neumann machine

Torrejon, J., Riou, M., Araujo, F. A., Tsunegi, S., Khalsa, G., Querlioz, D., ... & Kubota, H. (2017). Neuromorphic computing with nanoscale spintronic oscillators. *Nature*, *547*(7664), 428.

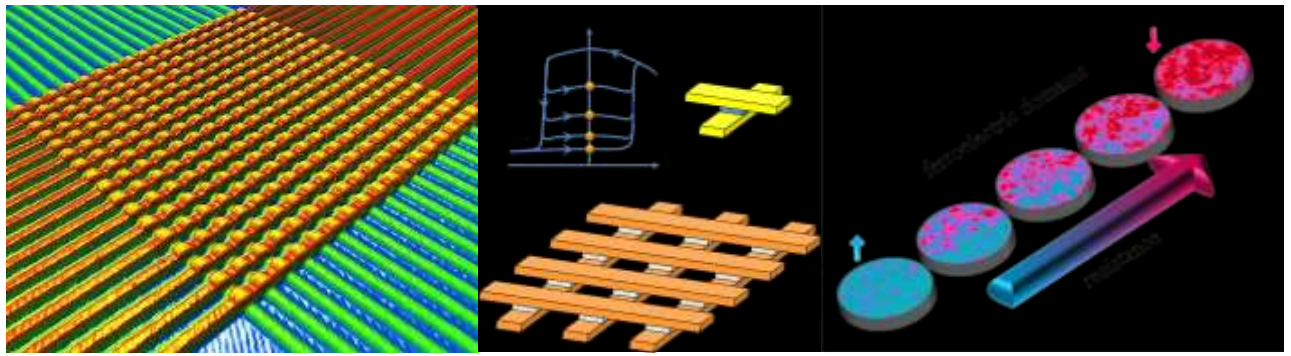
Turing-Von Neumann Machine

- CPU ≠ Memory
- CPU serial processes



Neural Networks

- CPU = Memory
- Parallel and distributed processes



The Importance of Training for a New Generation of Researcher in AI !

Fei-Fei Li
Professor of Computer Science, Stanford University; Chief Scientist of AI/ML, Google Cloud

Known for:
Computer vision
Machine learning
Artificial intelligence
Cognitive neuroscience

10 Professor positions in Cognitive Systems and Materials, to break new scientific ground

Yann LeCun
Postdoc at Hinton's lab.
Developed DJVu format.

Father of Convolutional Neural Networks and Optical Character Recognition (OCR).

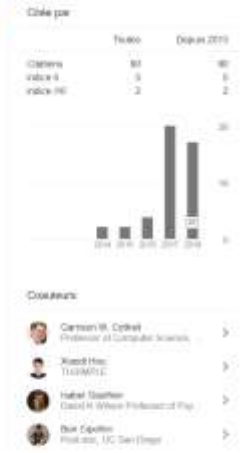
Proposed bio inspired ML methods like "Optimal Brain Damage" a regularization method.

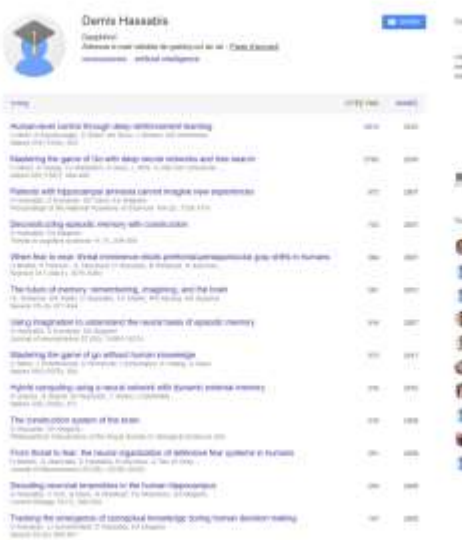
LeNet-5 is now state-of-the-art in artificial vision.

Issues Facing the Trucking Industry

Panqu Wang
TuSimple
Object Recognition Cognitive Modeling

Understanding convolution for semantic segmentation
Are face and object recognition independent? A neurocomputational modeling exploration
A computational model of the development of hemispheric asymmetry of face processing
Encoding visuals with deep learning
Modeling the contribution of central versus peripheral vision in scene, object, and face recognition
Basic Level Categorization Facilitates Visual Object Recognition
Experience matters: Modeling the relationship between face and object recognition
Central and peripheral vision for scene recognition: A neurocomputational modeling exploration
Modeling the Object Recognition Pathway: A Deep Hierarchical Model Using Gnostic Fields





NeuroCoG
Univ. Grenoble Alpes
GRENOBLE Cognition