

# Deep Learning Concepts from Theory to Practice

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- ▶ Joined Snt in September 2015 as a PhD student
- ▶ Collaboration with Choice Technologies Holding on detection of non-technical losses (NTLs)
- ▶ MSc in Machine Learning from Imperial College London
- ▶ Previously worked at CERN and SAP



## Definition (Artificial Intelligence)

"AI is the science of knowing what to do when you don't know what to do." (Peter Norvig)<sup>a</sup>

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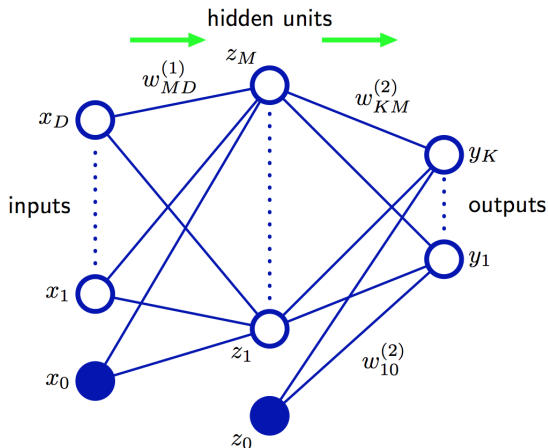
<sup>a</sup><http://www.youtube.com/watch?v=rtmQ3x1t-4A4m45>

## Definition (Machine Learning)

Machine Learning is the field of study that gives computers the ability to learn without being explicitly programmed.

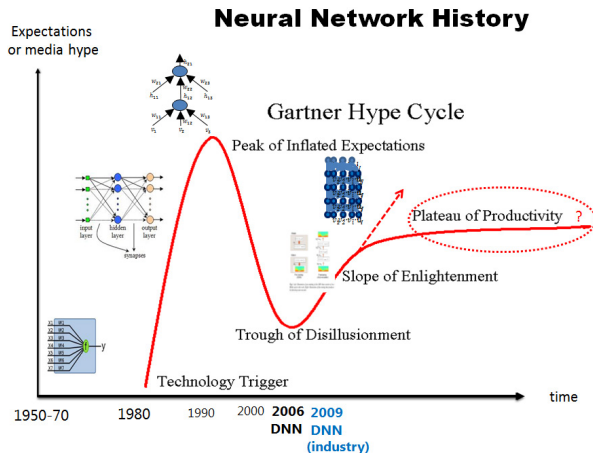
- ▶ Deep Learning attracted major IT companies including Google, Facebook, Microsoft and Baidu to make significant investments
- ▶ Learning features from data rather than modeling them
- ▶ Specialized artificial intelligences have started to outperform humans on certain tasks
- ▶ Advances have been raising many hopes about the future of machine learning

1. Neural networks
2. Deep Learning
3. Event-driven stock prediction
4. Conclusions and outreach



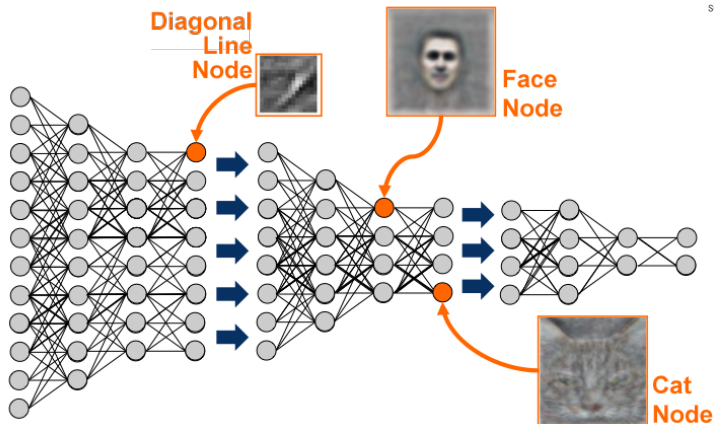
Neural network with two input and output units <sup>1</sup>.

<sup>1</sup>Bishop, Christopher M.: Pattern Recognition and Machine Learning. Springer. 2007.



## History of neural networks <sup>2</sup>.

<sup>2</sup>Deng, Li and Yu, Dong: Deep Learning Methods and Applications. Foundations and Trends in Signal Processing, 7 (3-4), 197-387. 2014.



Deep neural network layers learning complex feature hierarchies <sup>3</sup>.

<sup>3</sup>The Analytics Store: Deep Learning.

<http://theanalyticsstore.com/deep-learning/>. Retrieved: March 1, 2015.



- ▶ Specialized artificial intelligences based on Deep Learning have started to outperform humans on certain tasks
- ▶ Training time can be accelerated using GPUs<sup>4 5</sup> or a distributed environment, such as Apache Spark<sup>6</sup>

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<sup>4</sup>Bergstra, J.; Breuleux, O.; Bastien, F.; Lamblin, P.; Pascanu, R.; Desjardins, G.; Turian, J.; Warde-Farley, D. and Bengio, Y.: Theano: A CPU and GPU Math Expression Compiler. Proceedings of the Python for Scientific Computing Conference (SciPy) 2010. June 30 - July 3, Austin, TX. 2010.

<sup>5</sup>NVIDIA: TESLA. <http://www.nvidia.com/object/tesla-servers.html>. Retrieved: August 20, 2015.

<sup>6</sup>Apache Spark. <http://spark.apache.org/>. Retrieved: November 3, 2015.

# Deep Learning: DeepMind

- ▶ Founded in 2010 in London
- ▶ Created a neural network that learns how to play video games in a similar fashion to humans
- ▶ Acquired by Google in 2014, estimates range from USD 400 million to over GBP 500 million
- ▶ Now being used in Google's search engine

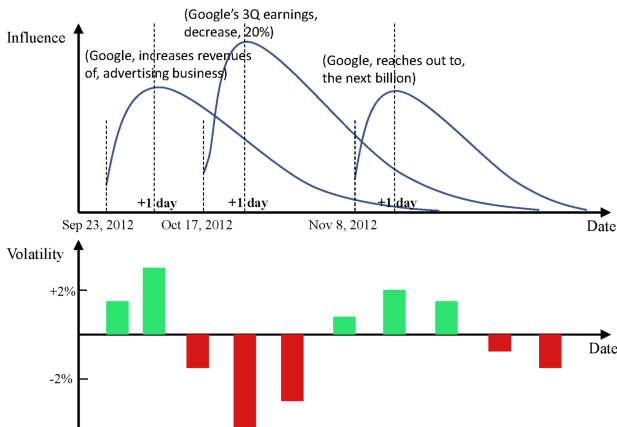


Google DeepMind <sup>7</sup>.

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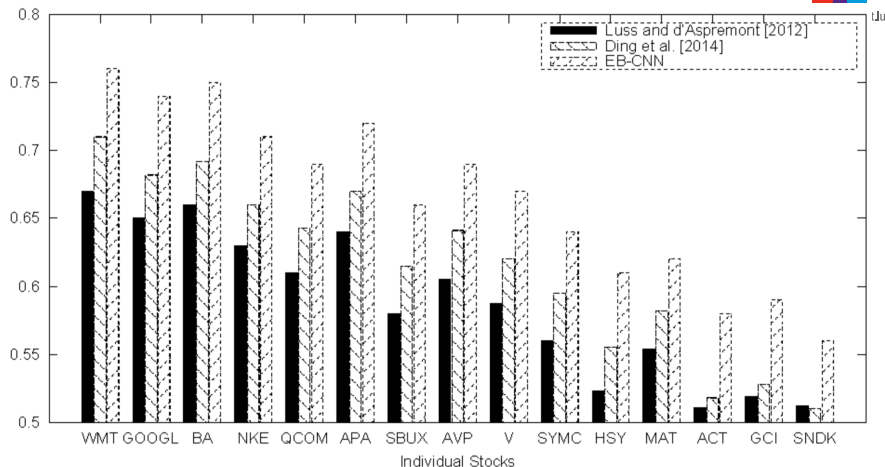
<sup>7</sup><http://deepmind.com/>. Retrieved: January 15, 2016.

# Event-driven stock prediction



Example news influence of Google Inc. <sup>8</sup>.

<sup>8</sup>Ding, Xiao; Zhang, Yue; Liu, Ting and Duan, Junwen: Deep Learning for Event-Driven Stock Prediction. Proceedings of the Twenty-Fourth International Joint Conference on Artificial Intelligence (IJCAI 2015), Buenos Aires, Argentina. 2015.



Accuracies of prediction for selected stocks from S&P 500<sup>9</sup>.

<sup>9</sup>Ding et al. (2015)

# Event-driven stock prediction

- ▶ This model combines influence of long-term, mid-term and short-term events on stock price movements
- ▶ It significantly outperforms state-of-the-art models by an extra 6% of accuracy, in particular for stocks with low amount of news

Stock	Profit of Lavrenko et al. [2000]	Profit of EBCNN
IBM	\$47,000	\$42,000
Lucent	\$20,000	\$27,000
Yahoo	\$19,000	\$32,000
Amazon	\$14,000	\$35,000
Disney	-\$53,000	\$7,000
AOL	-\$18,000	\$14,000
Intel	-\$14,000	\$8,000
Oracle	-\$13,000	\$17,000

Compared to baseline from Feb. to Nov. 2013 using 35,603 news <sup>10</sup>.

<sup>10</sup>Ding et al. (2015)

- ▶ Deep neural networks can learn complex feature hierarchies
- ▶ Significant speedup of training due to GPU acceleration
- ▶ About to be applied to the detection of NTLs
- ▶ Has been successfully applied to stock prediction
- ▶ Promising methods, lots of potential to be applied to FinTech
- ▶ SEDAN Lab is happy to provide more details on Deep Learning and to discuss potential joint projects!