Insight
Centre for Data Analytics

DEEP LEARNING WORKSHOP

Dublin City University
27-28 April 2017

DCU

#InsightDL2017

Day 2 Lecture 2

Deep Learning Architectures

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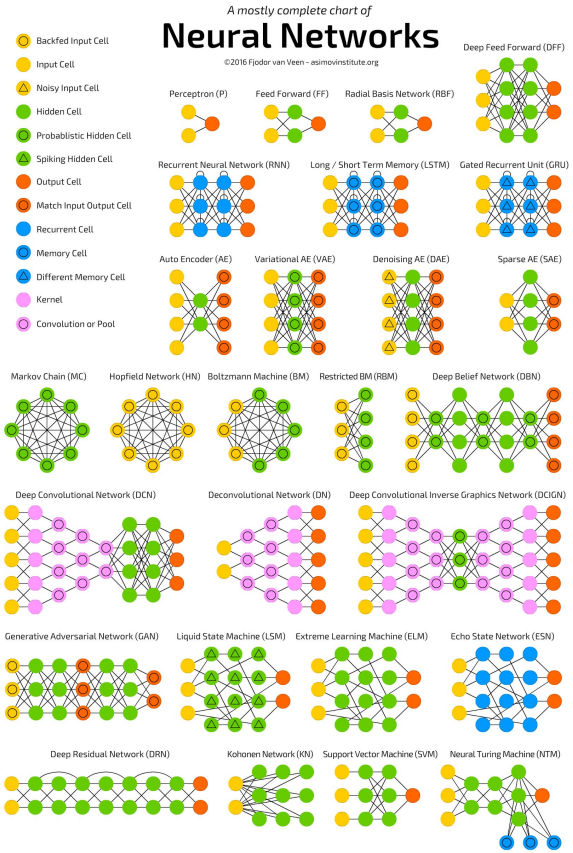
Associate Professor
Universitat Politecnica de Catalunya
Technical University of Catalonia

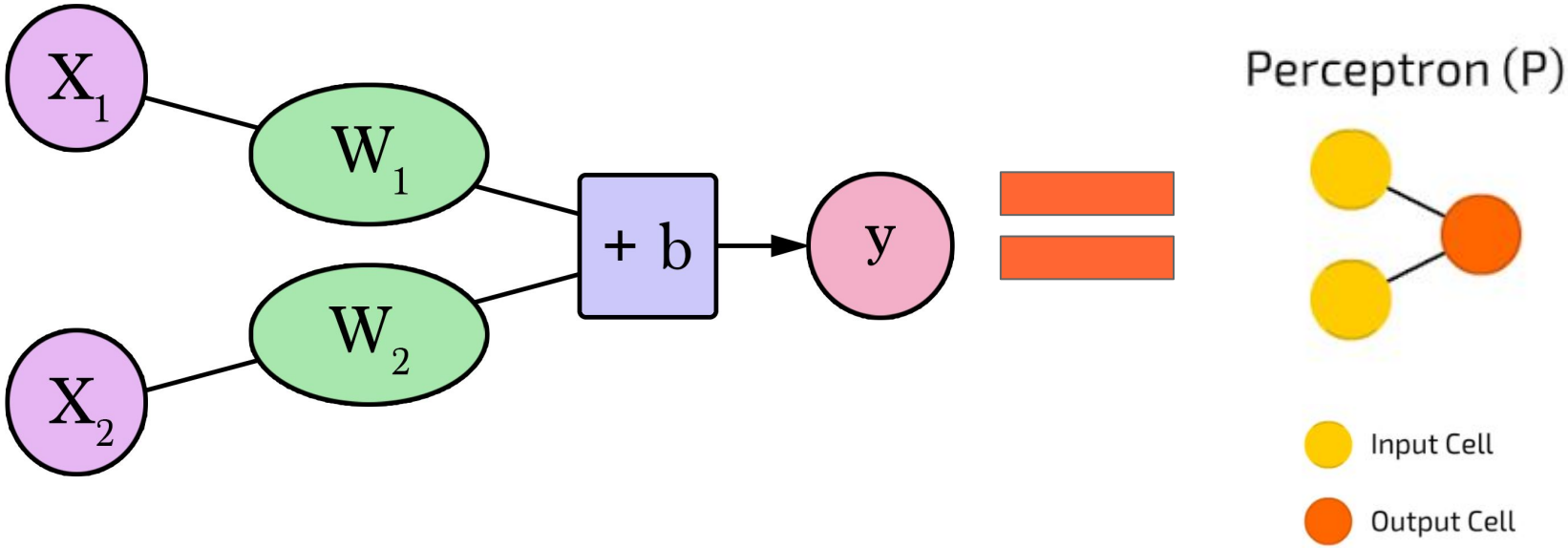
UPC

The Full Story



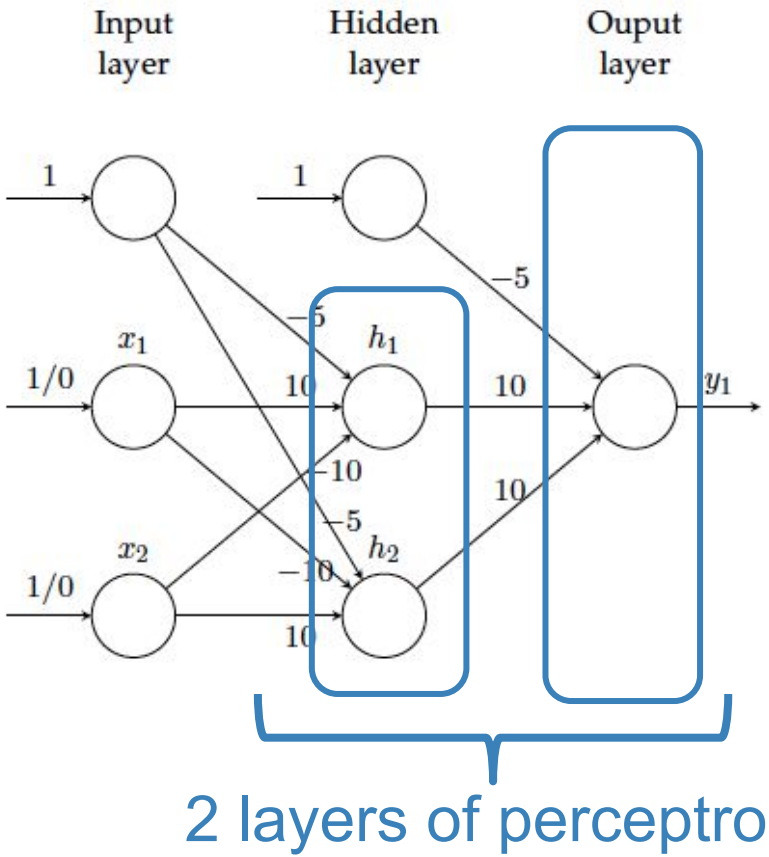
F. Van Veen, [“The Neural Network Zoo”](#) (2016)

A Perceptron



J. Alammar, [“A visual and interactive guide to the Basics of Neural Networks”](#) (2016)
F. Van Veen, [“The Neural Network Zoo”](#) (2016)

Neural Network = Multi Layer Perceptron



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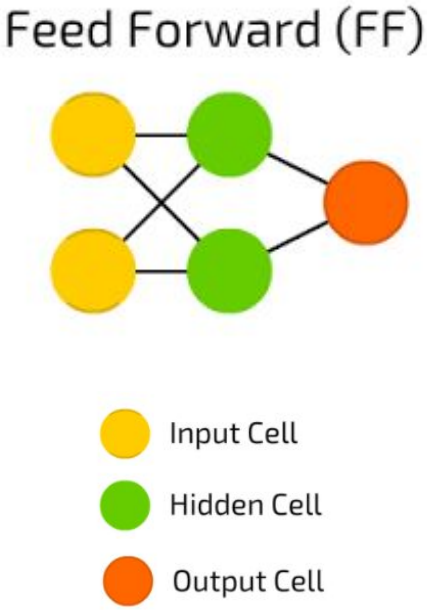
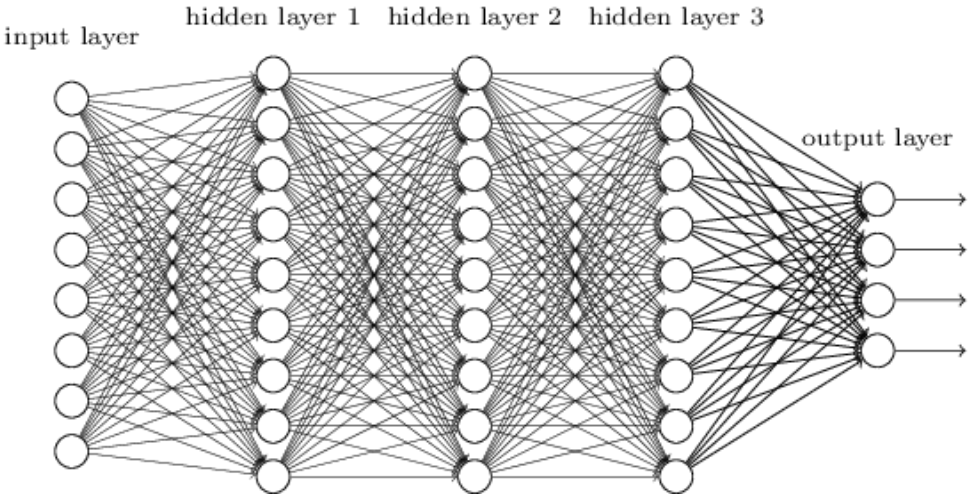
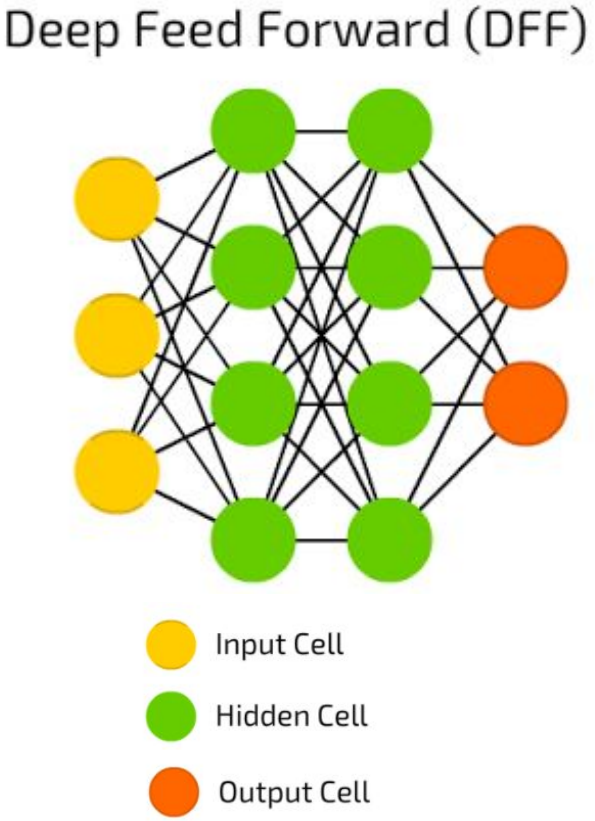


F. Van Veen, [“The Neural Network Zoo”](#) (2016)

Deep Neural Network (DNN)

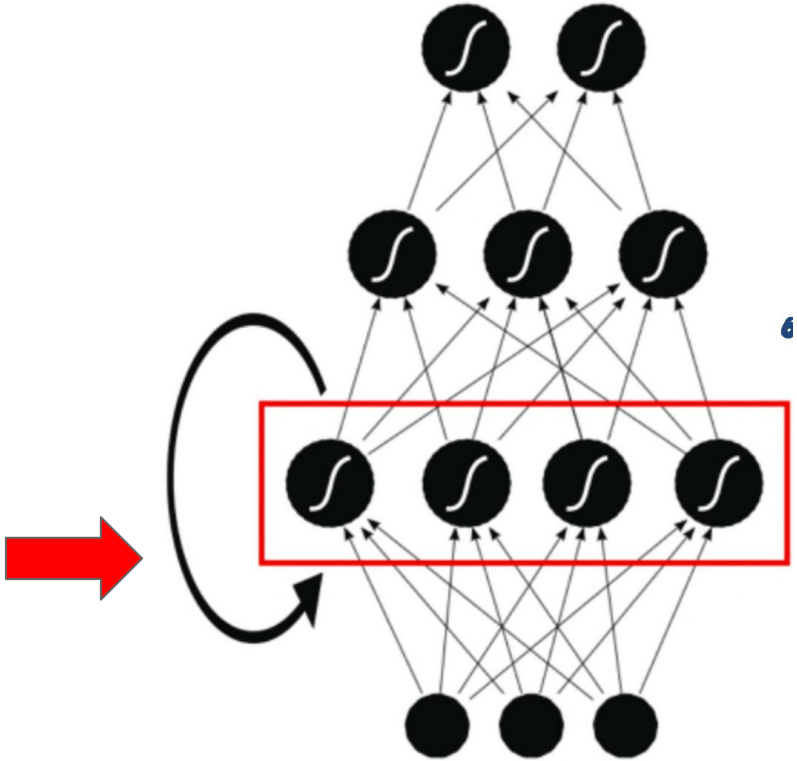




F. Van Veen, [“The Neural Network Zoo”](#) (2016)

Recurrent Neural Network (RNN)

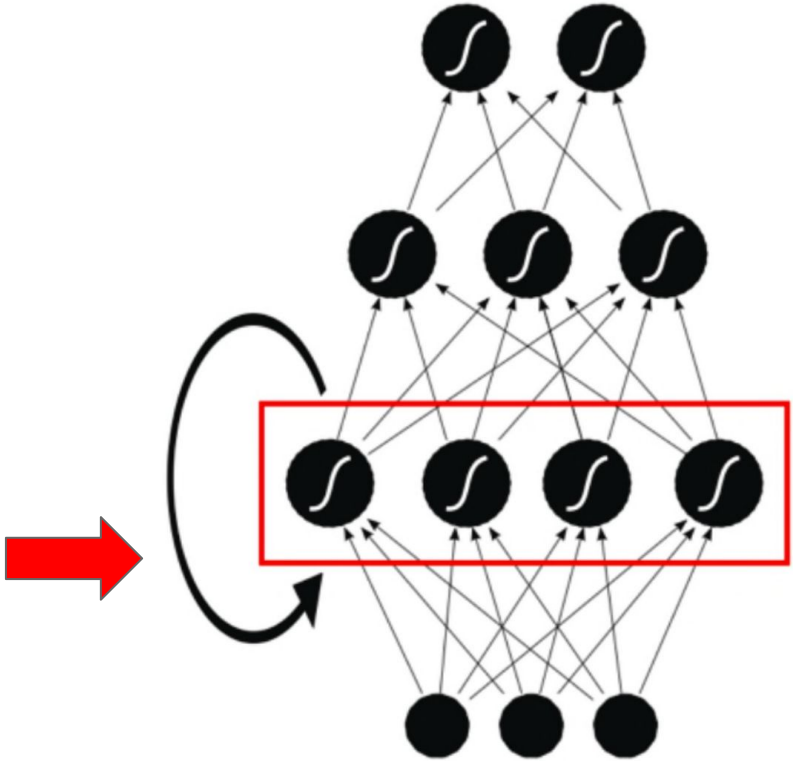
The hidden layers and the output depend from previous states of the hidden layers



Alex Graves, [“Supervised Sequence Labelling with Recurrent Neural Networks”]

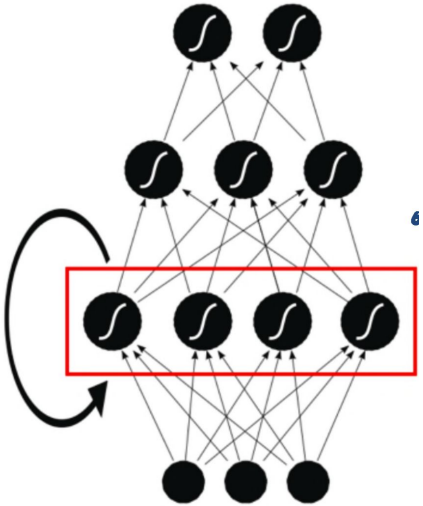
Recurrent Neural Network (RNN)

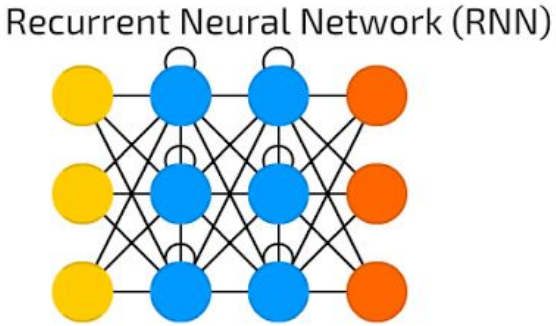
The hidden layers and the output depend from previous states of the hidden layers



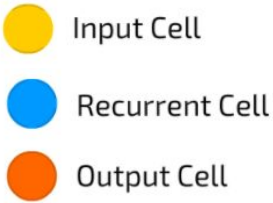
Alex Graves, [“Supervised Sequence Labelling with Recurrent Neural Networks”]

Recurrent Neural Network (RNN)



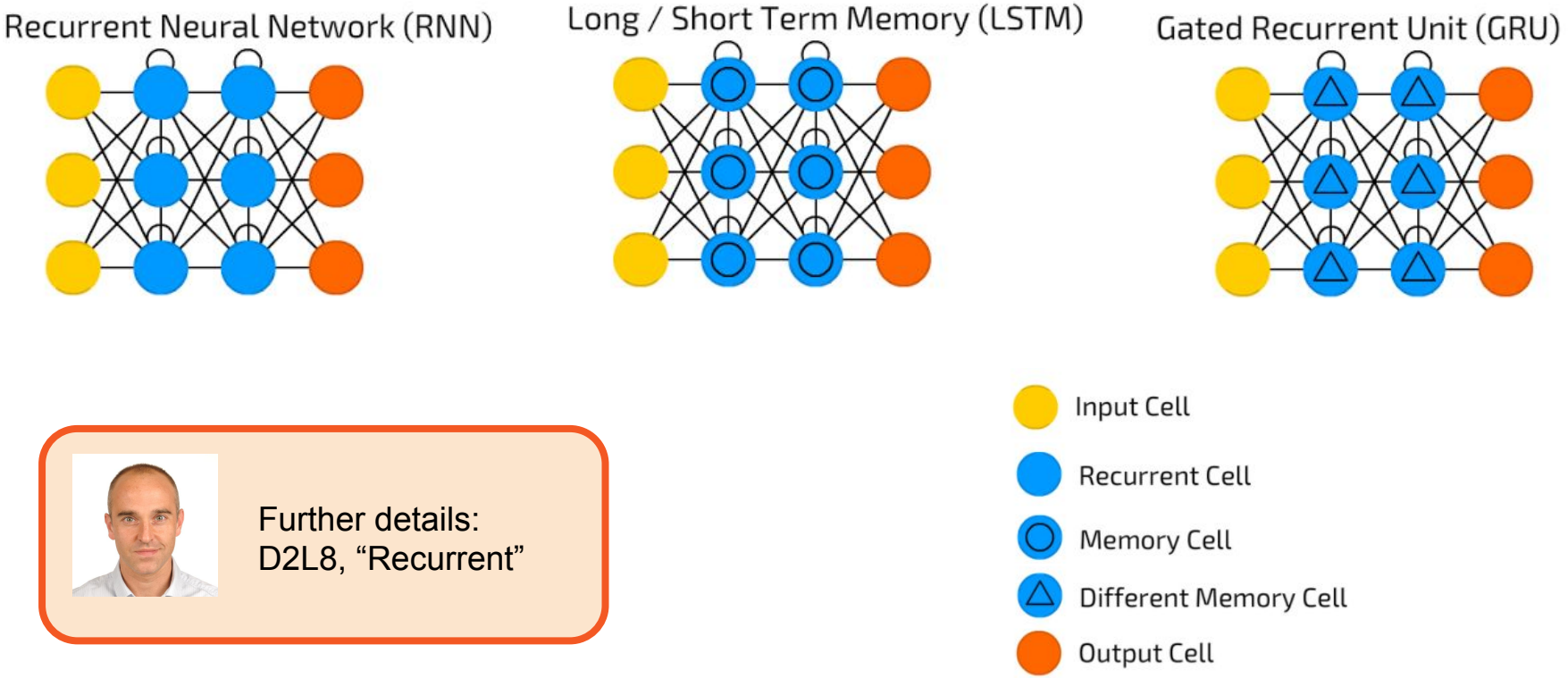


Further details:
D2L8, “Recurrent”



F. Van Veen, “The Neural Network Zoo” (2016)

Recurrent Neural Network (RNN)



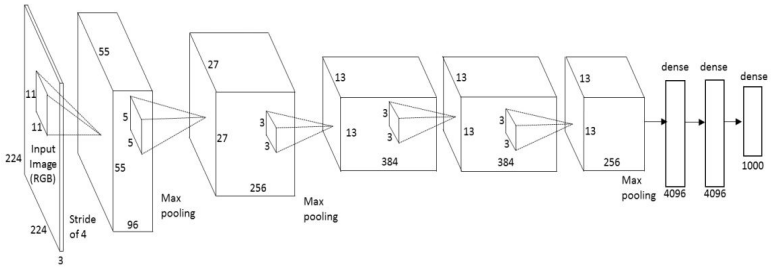
Further details:
D2L8, “Recurrent”

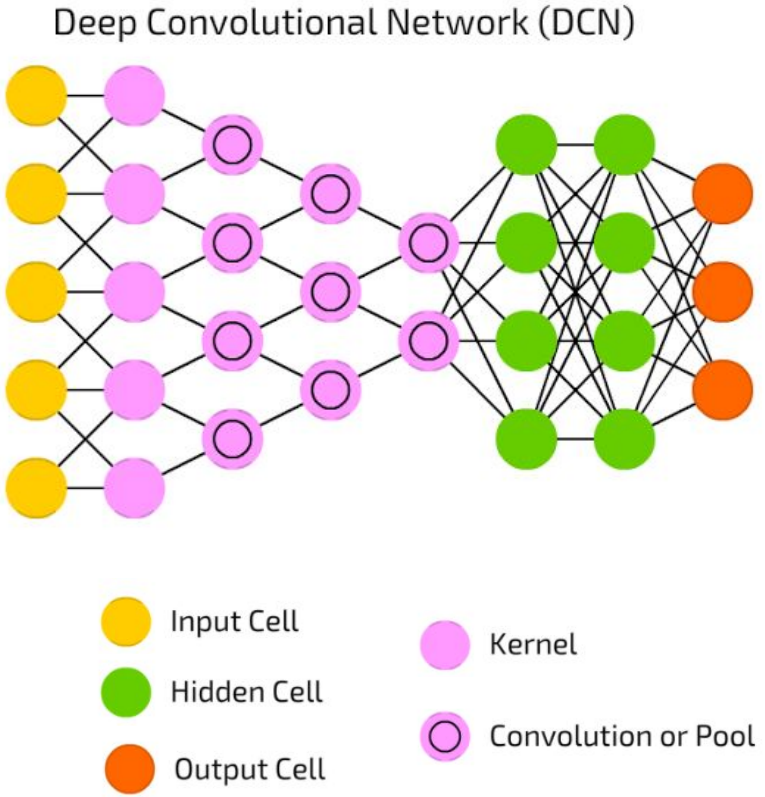
F. Van Veen, [“The Neural Network Zoo”](#) (2016)

Recurrent Neural Network (RNN)

Deep Learning TV, [“Recurrent Neural Networks - Ep. 9”]

Convolutional Neural Network (CNN)



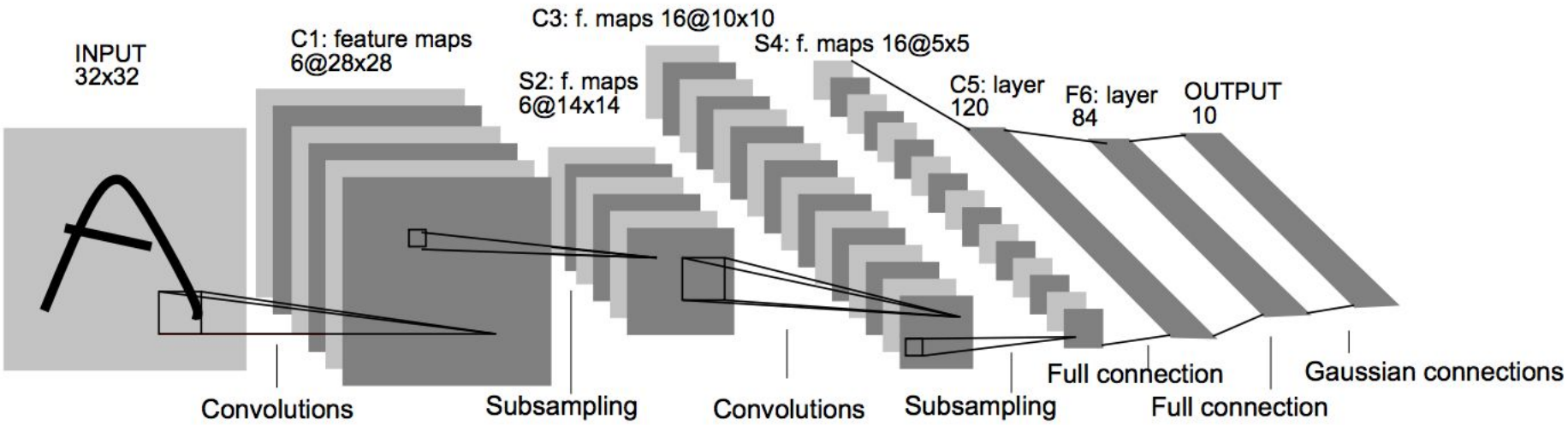


Further details:
D2L7, “Segmentation”

F. Van Veen, “The Neural Network Zoo” (2016)

Convolutional Neural Network (CNN)

LeNet-5



LeCun, Y., Bottou, L., Bengio, Y., & Haffner, P. (1998). Gradient-based learning applied to document recognition. *Proceedings of the IEEE*, *86*(11), 2278-2324.

Convolutional Neural Network (CNN)

Yann LeCun

NYU | COURANT INSTITUTE OF MATHEMATICAL SCIENCES

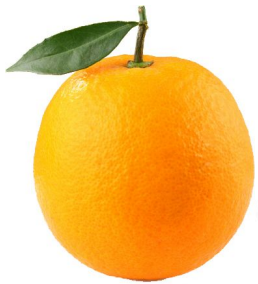
Facebook AI Research

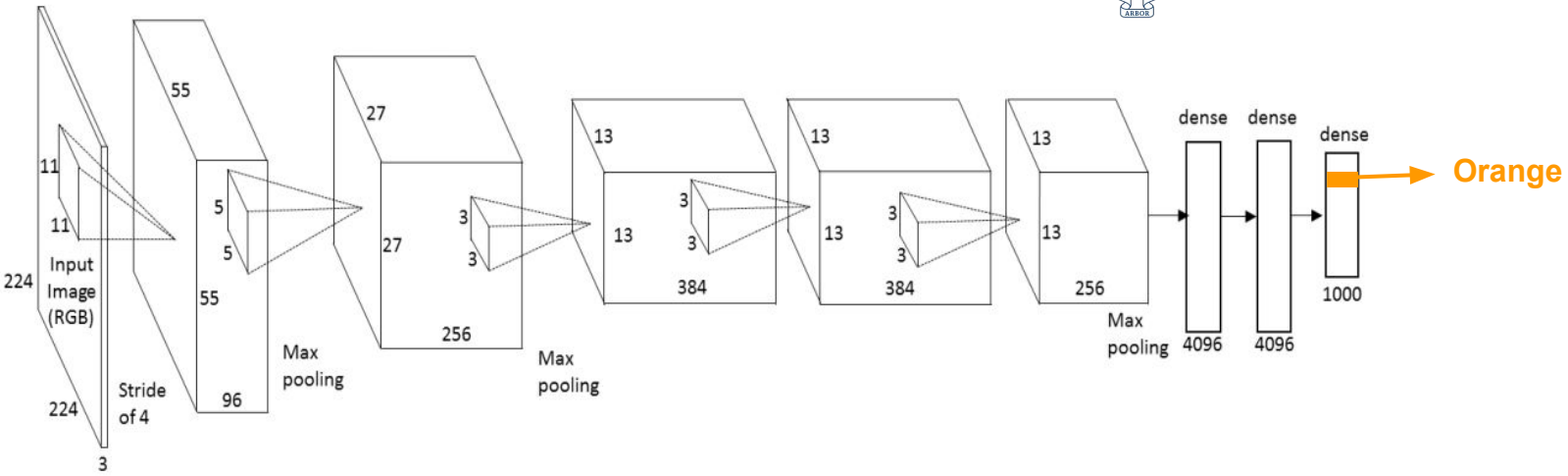
You can also check @boredyannlecun on Twitter...

Convolutional Neural Network (CNN)

AlexNet

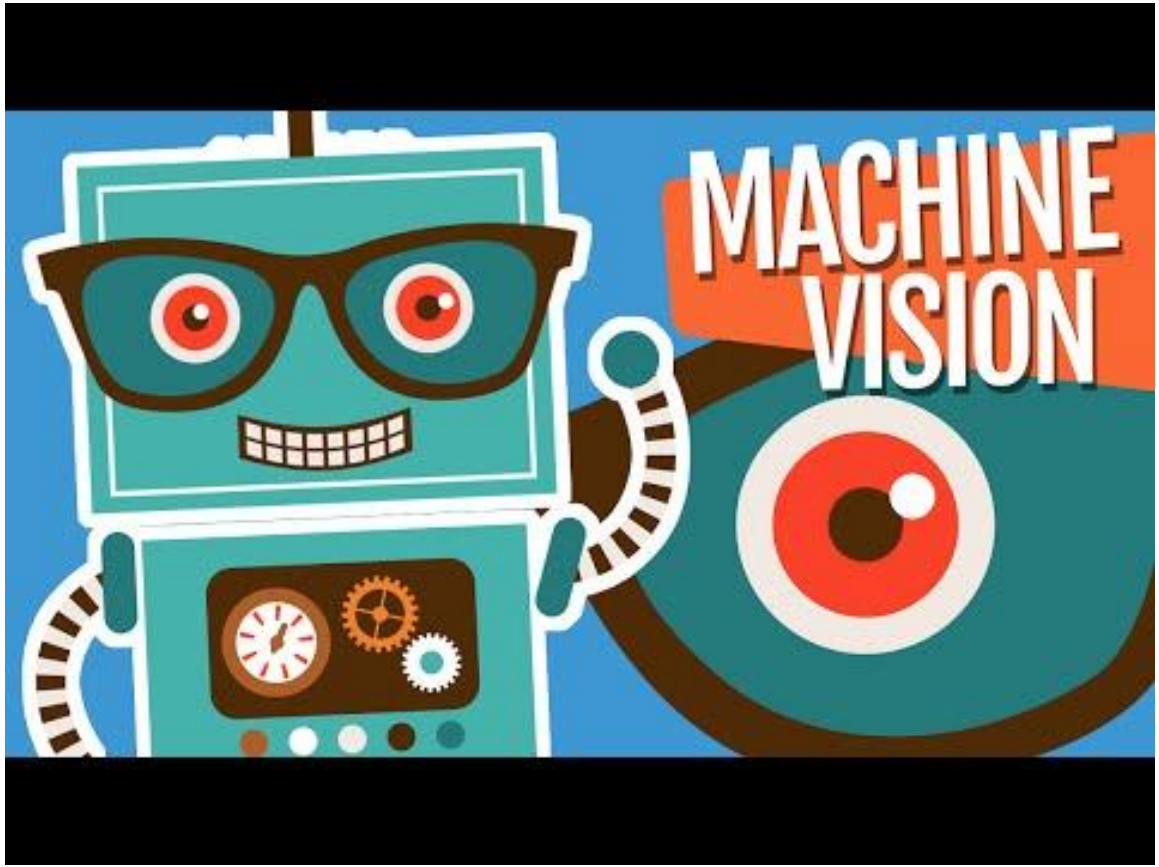
UNIVERSITY OF TORONTO





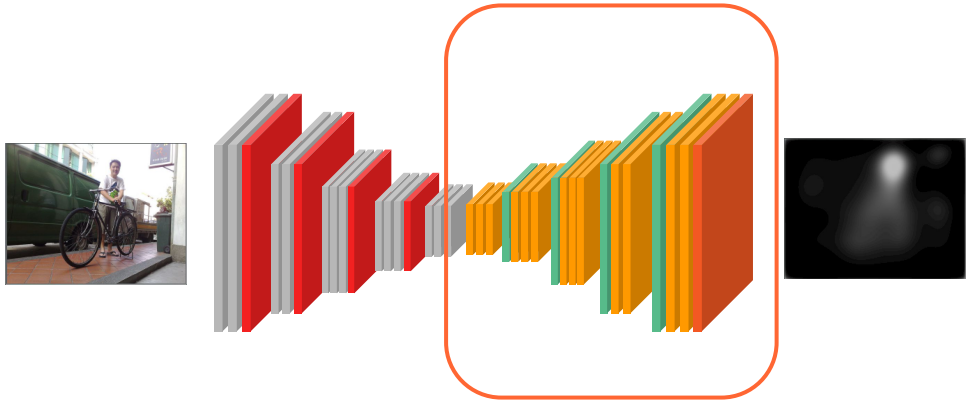
A Krizhevsky, I Sutskever, GE Hinton "Imagenet classification with deep convolutional neural networks" Part of: Advances in Neural Information Processing Systems 25 (NIPS 2012)

Convolutional Neural Network (CNN)

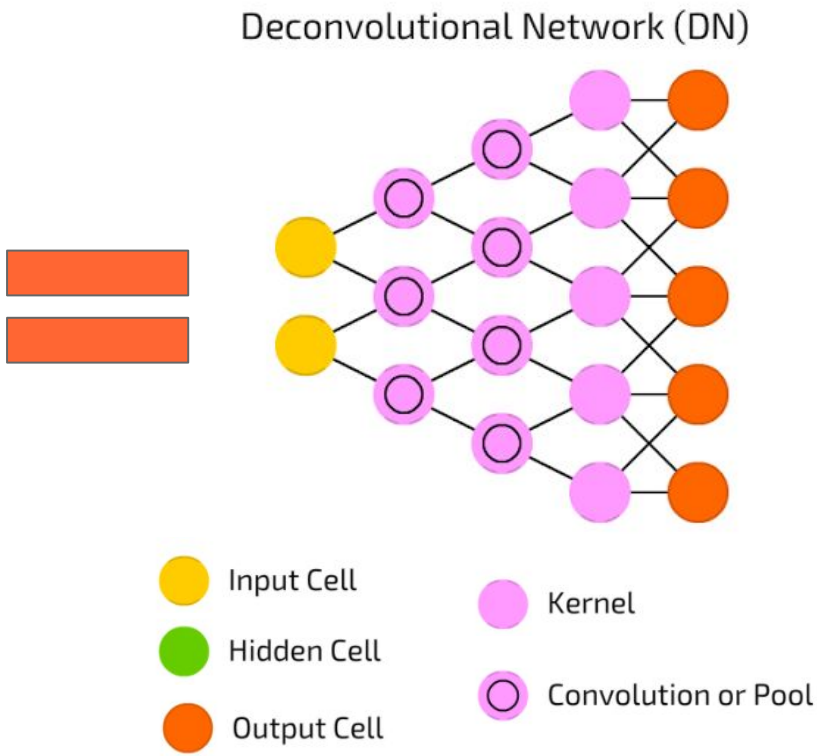


Deep Learning TV, [“Convolutional Neural Networks - Ep. 8”]

Deconvolutional Neural Network (Deconv)

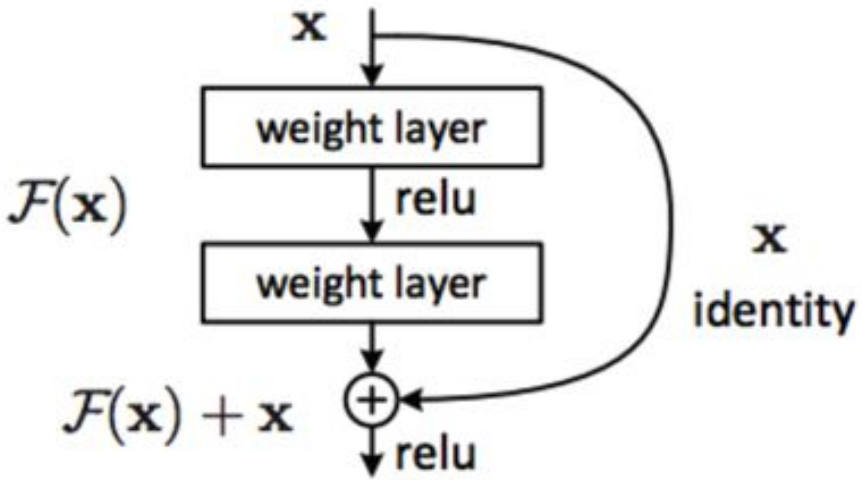


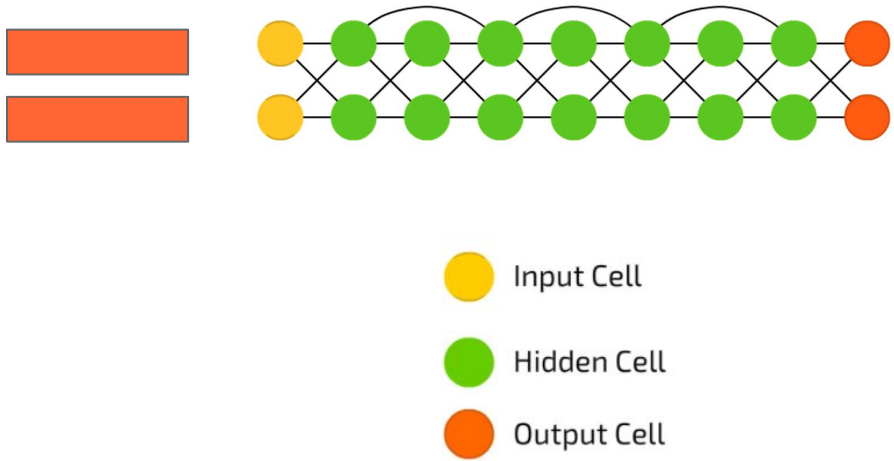
Further details:
D2L7, “Segmentation”



Junting Pan, SalGAN (2017)
F. Van Veen, “The Neural Network Zoo” (2016)

Deep Residual Learning / Skip connections





F. Van Veen, "The Neural Network Zoo" (2016)

Deep Residual Learning / Skip connections

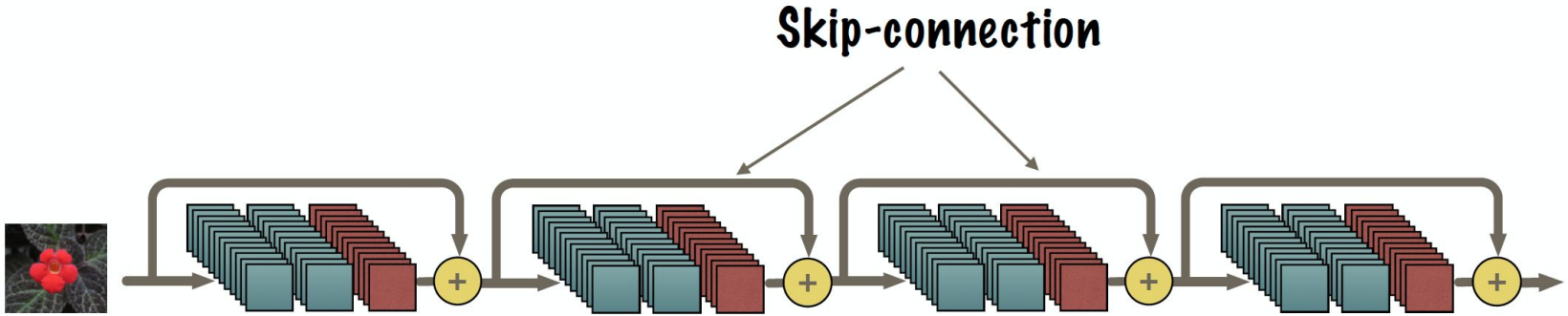
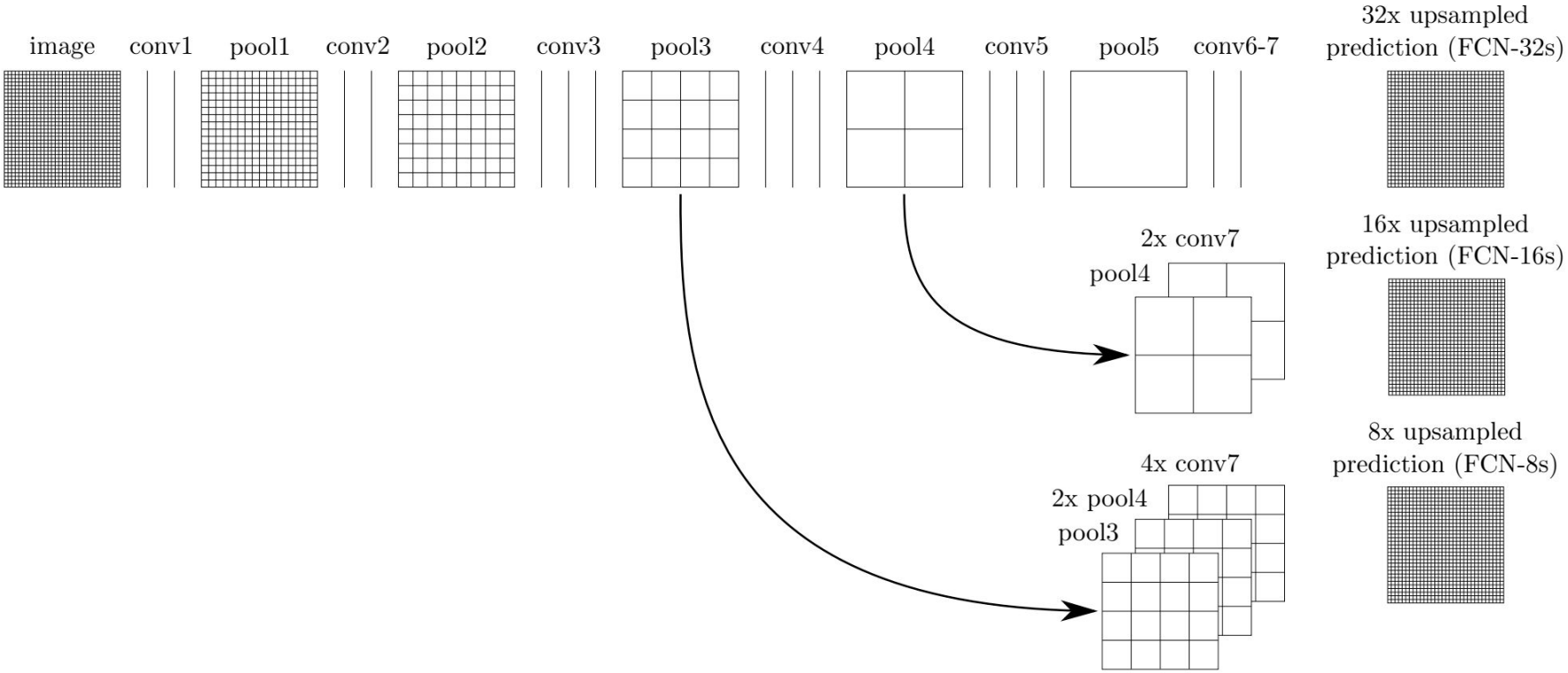


Figure: Kilian Weinberger

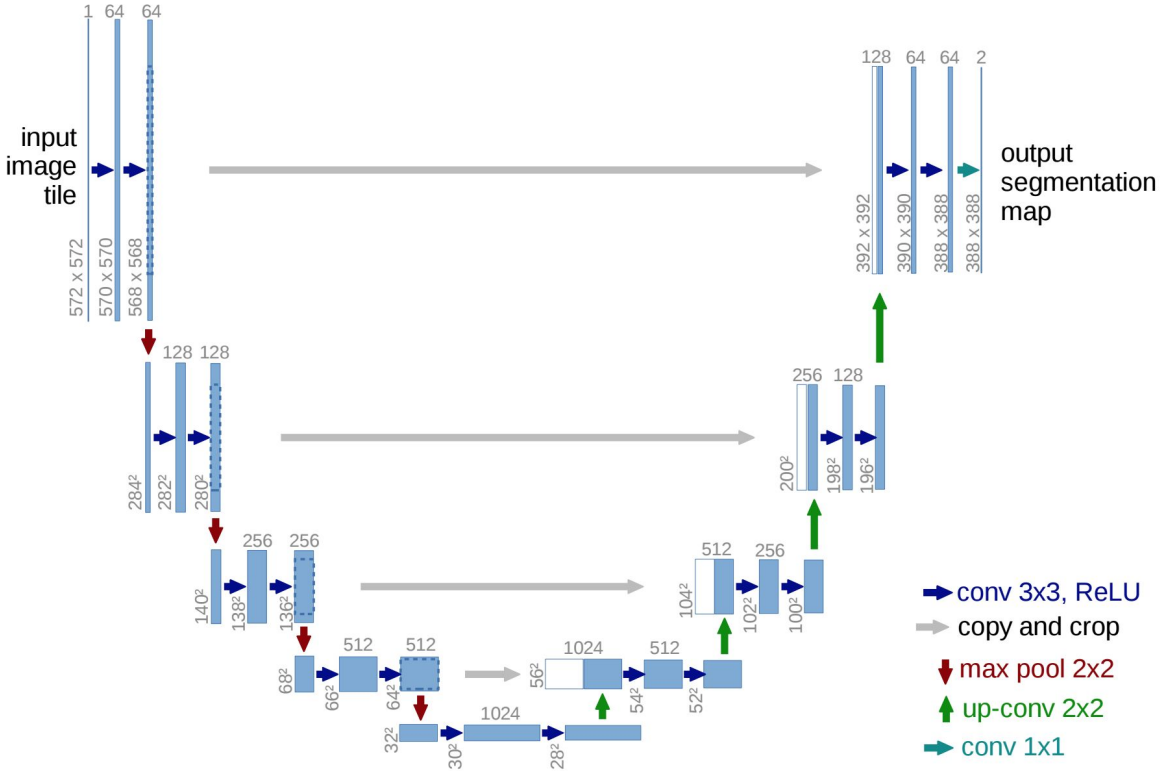
Deep Residual Learning / Skip connections



Long, Jonathan, Evan Shelhamer, and Trevor Darrell. "Fully convolutional networks for semantic segmentation." CVPR 2015 & PAMI 2016.

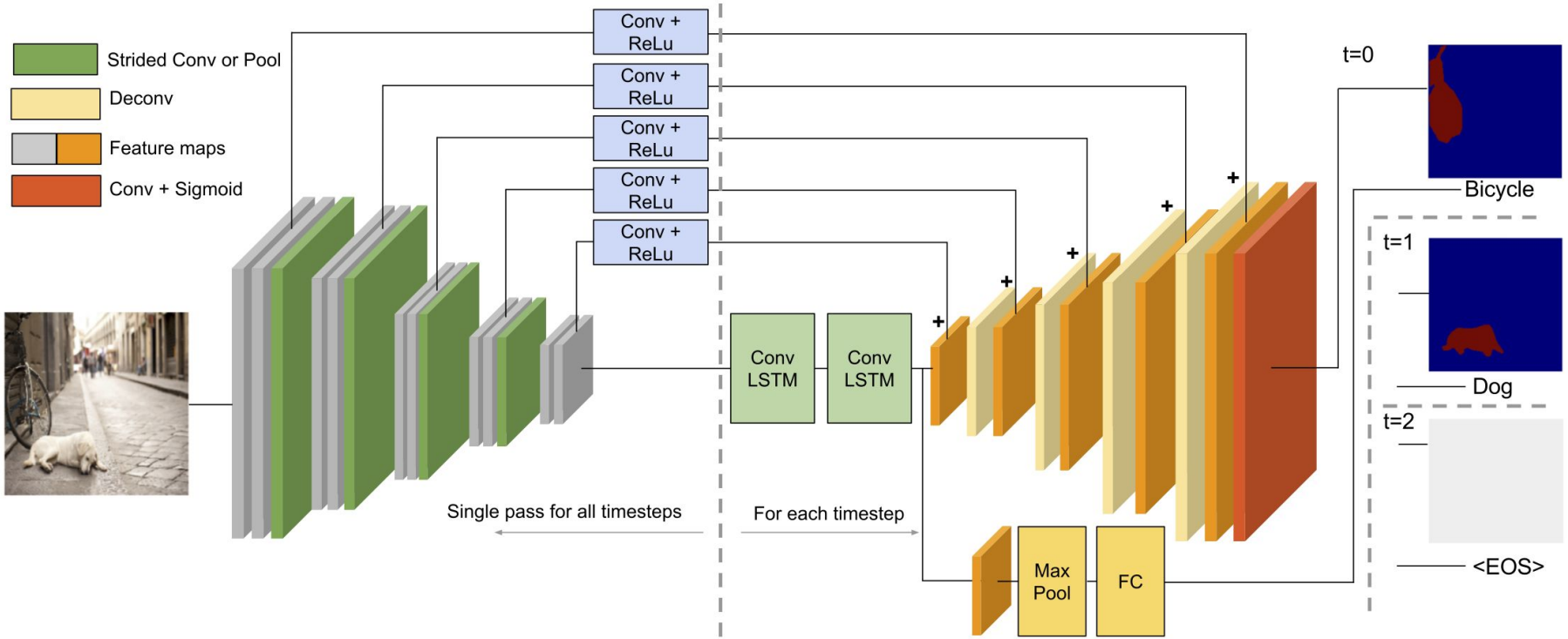
Deep Residual Learning / Skip connections

U-Net



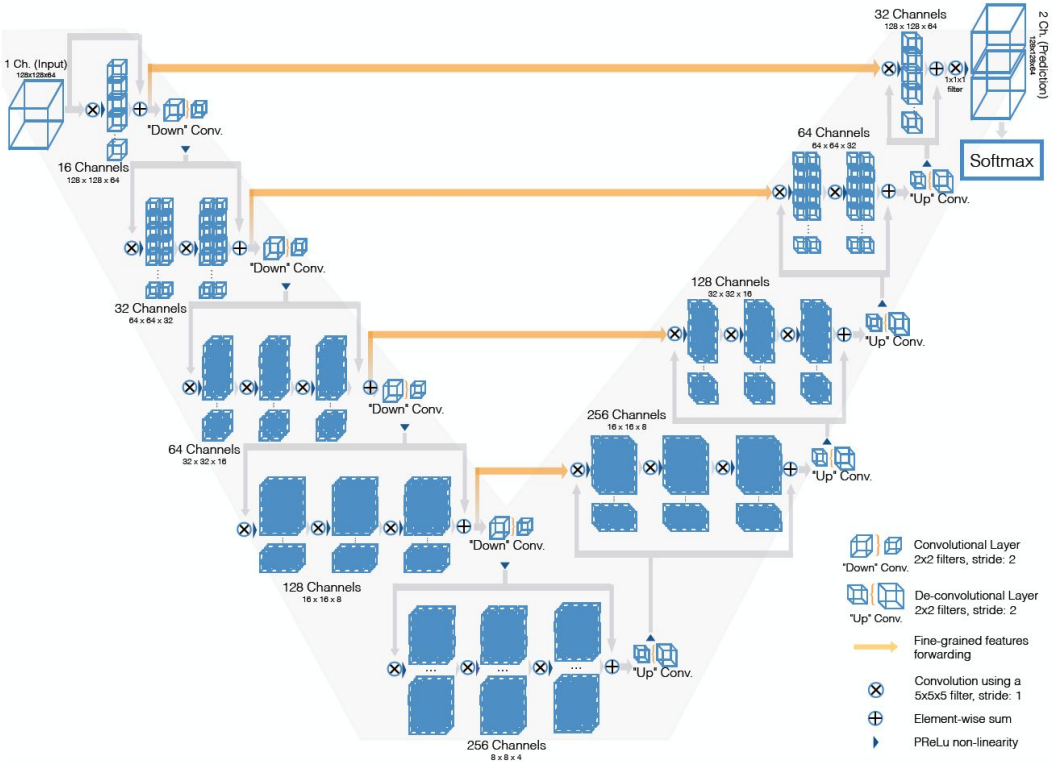
Ronneberger, Olaf, Philipp Fischer, and Thomas Brox. "U-net: Convolutional networks for biomedical image segmentation." In International Conference on Medical Image Computing and Computer-Assisted Intervention, pp. 234-241. Springer.

Deep Residual Learning / Skip connections



Deep Residual Learning / Skip connections

V-Net

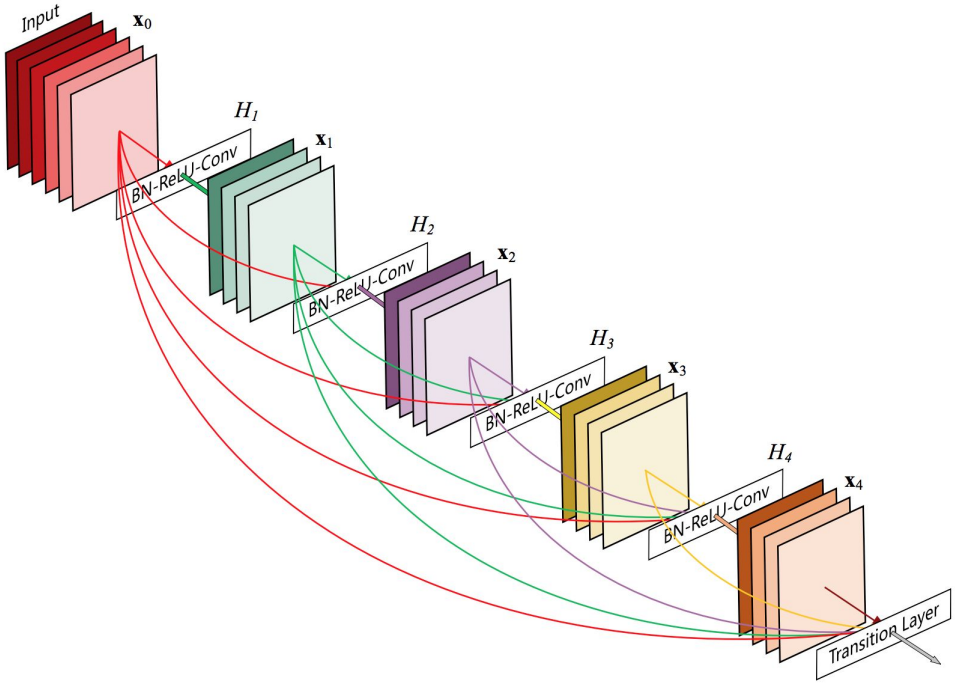


Milletari, Fausto, Nassir Navab, and Seyed-Ahmad Ahmadi. "V-net: Fully convolutional neural networks for volumetric medical image segmentation." In 3D Vision (3DV), 2016 Fourth International Conference on, pp. 565-571. IEEE, 2016.

Dense connections

Connect every layer to every other layer of the same filter size.

DenseNet

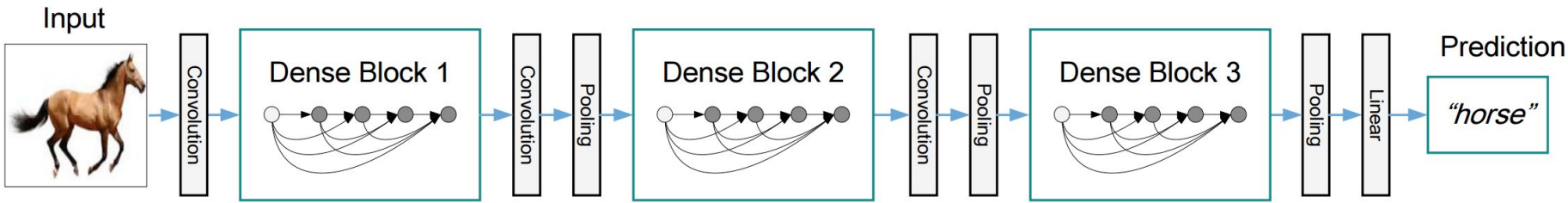


Dense Block of 5-layers
with a growth rate of k=4

Huang, Gao, Zhuang Liu, Kilian Q. Weinberger, and Laurens van der Maaten. "Densely connected convolutional networks." *arXiv preprint arXiv:1608.06993* (2016). [code]

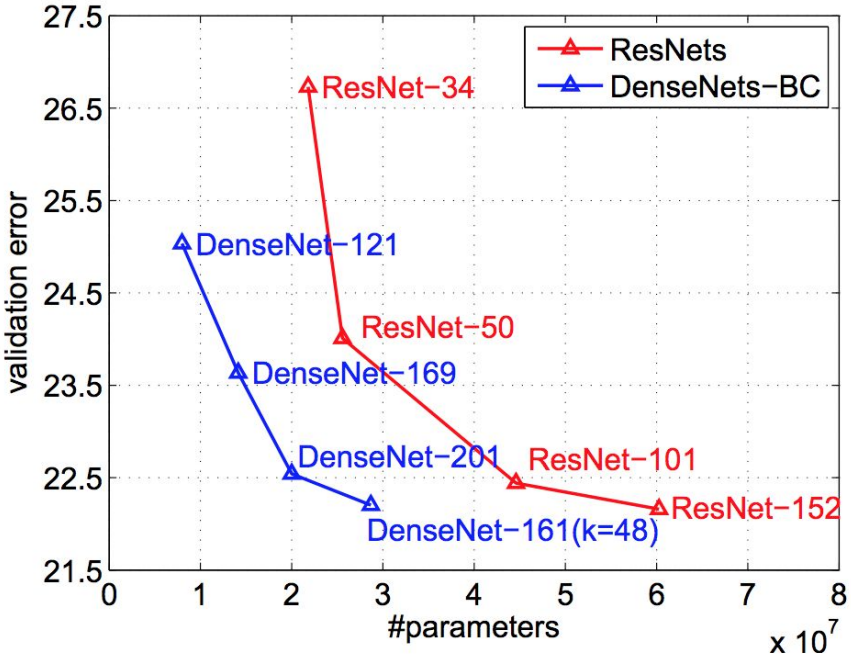
Dense connections

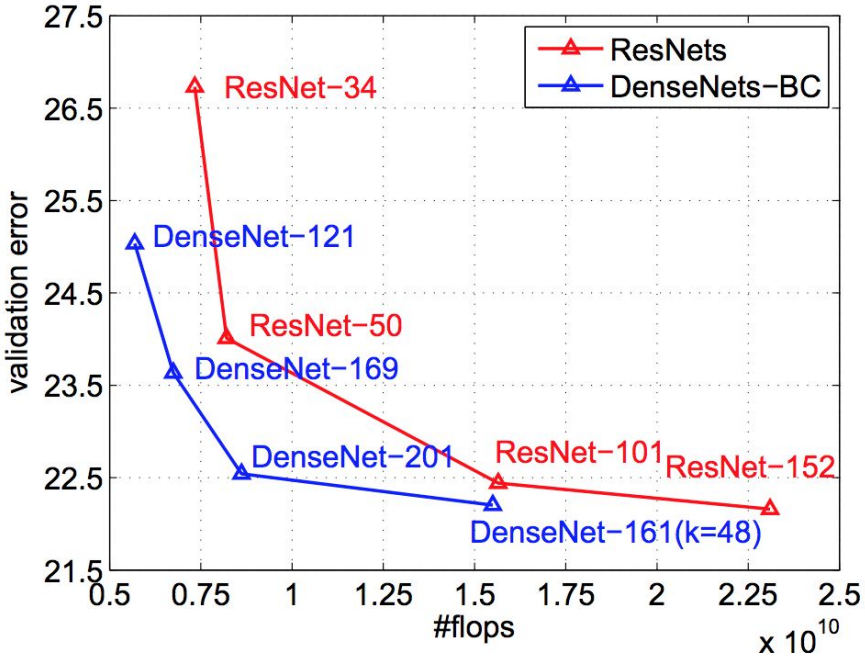
DenseNet



Huang, Gao, Zhuang Liu, Kilian Q. Weinberger, and Laurens van der Maaten. "Densely connected convolutional networks." *arXiv preprint arXiv:1608.06993* (2016). [code]

Dense connections





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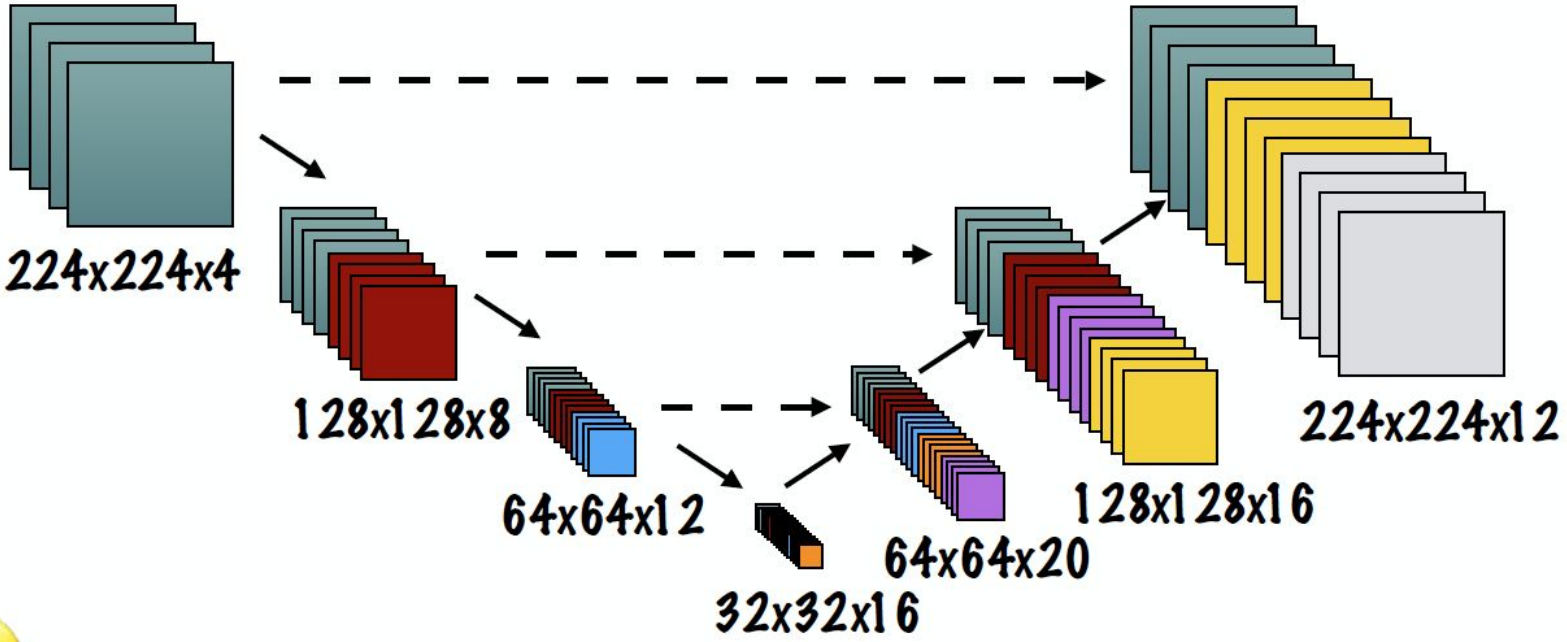
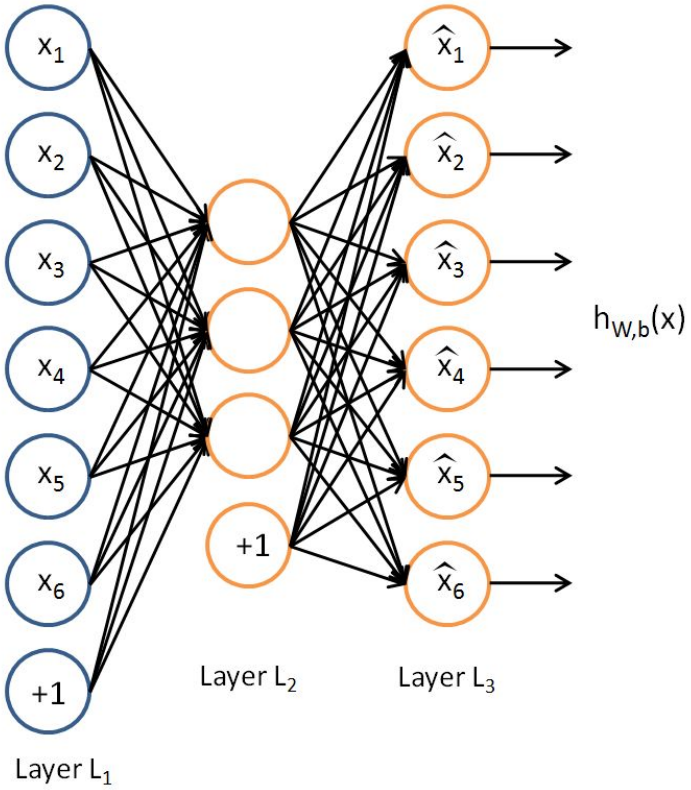
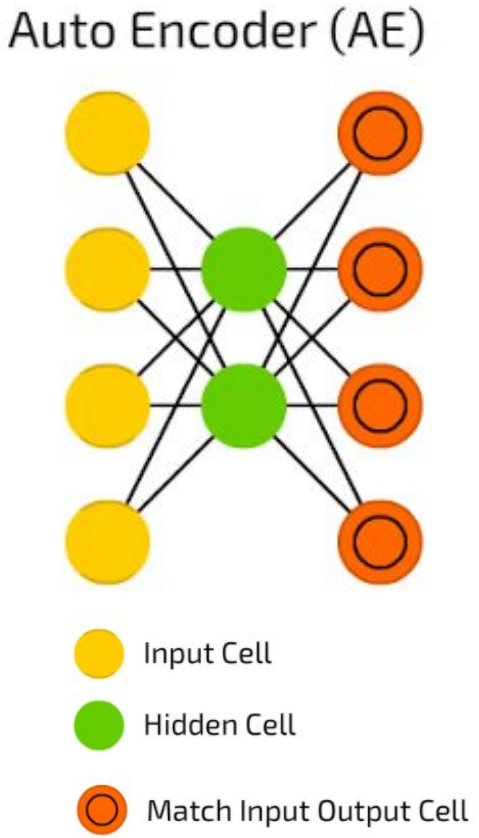
Dense connections



Jégou, Simon, Michal Drozdzal, David Vazquez, Adriana Romero, and Yoshua Bengio. "The One Hundred Layers Tiramisu: Fully Convolutional DenseNets for Semantic Segmentation." arXiv preprint arXiv:1611.09326 (2016). [code] [slides]

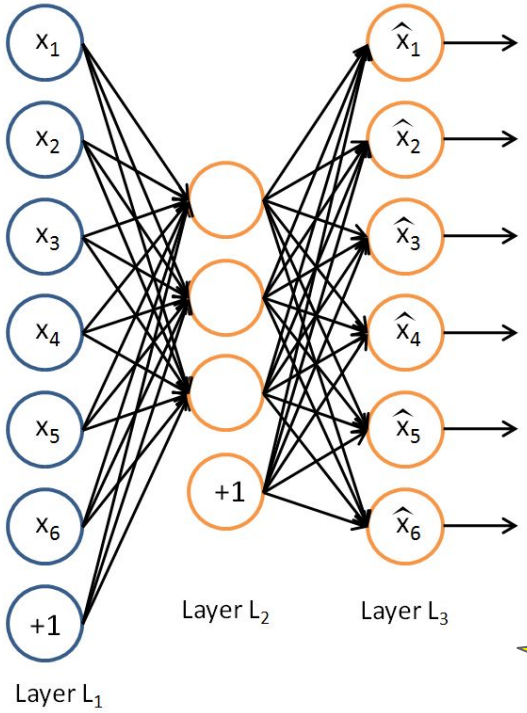
Autoencoder (AE)





F. Van Veen, [“The Neural Network Zoo”](#) (2016)

Autoencoder (AE)



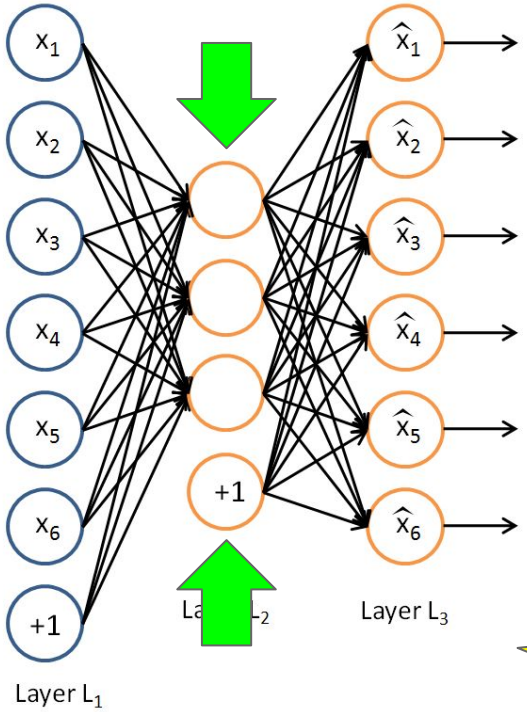
Autoencoders:

- Predict at the output the same input data.
- Do not need labels:

Unsupervised learning

[“Deep Learning Tutorial”](), Dept. Computer Science, Stanford

Autoencoder (AE)



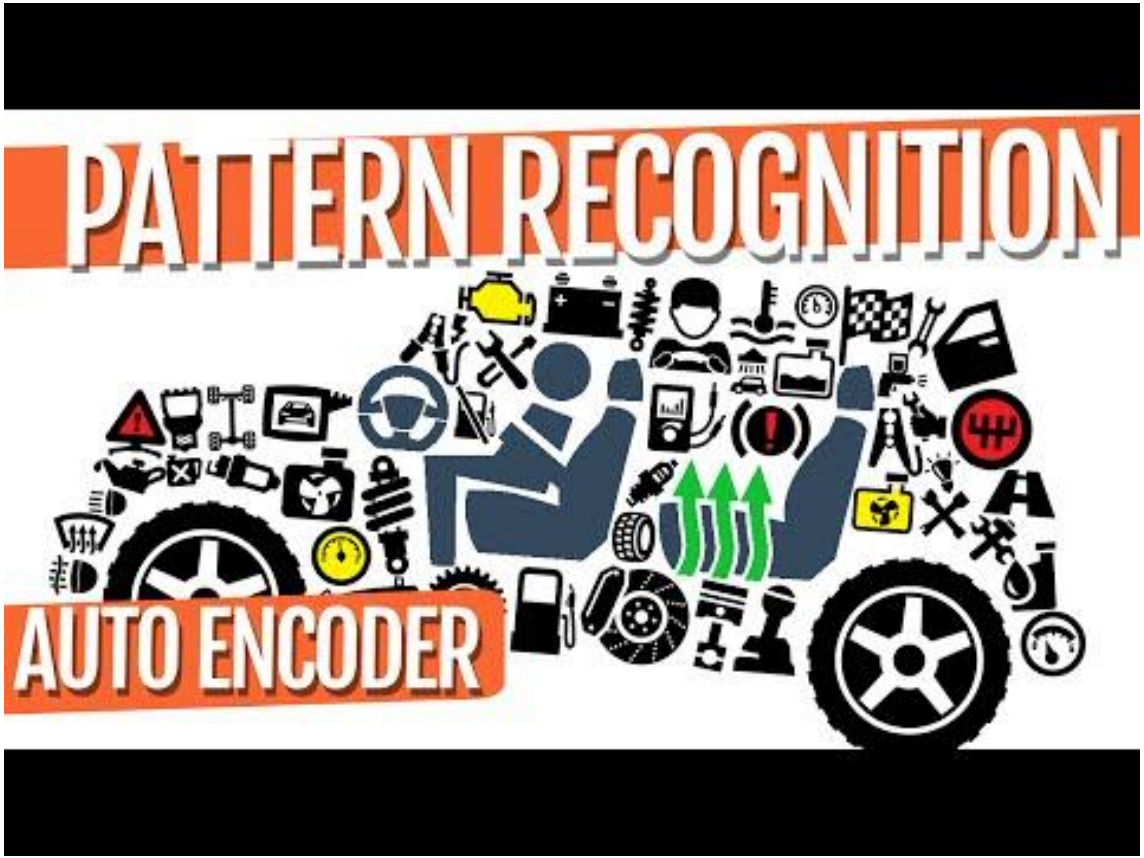
Dimensionality reduction:

- Use hidden layer as a feature extractor of the desired size.

Unsupervised learning

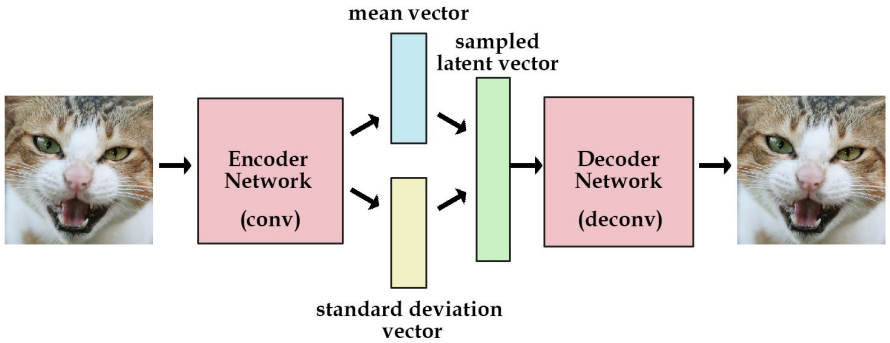
"Deep Learning Tutorial", Dept. Computer Science, Stanford

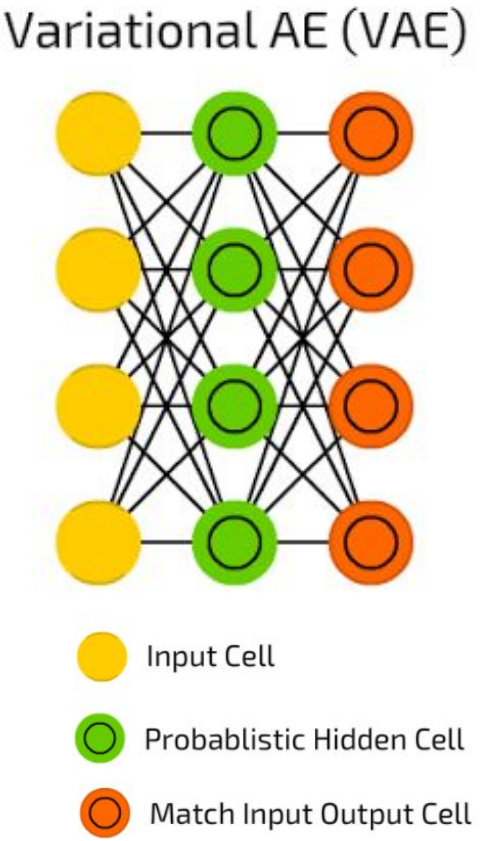
Autoencoder (AE)



Deep Learning TV, [“Autoencoders - Ep. 10”]

Variational Autoencoder (VAE)

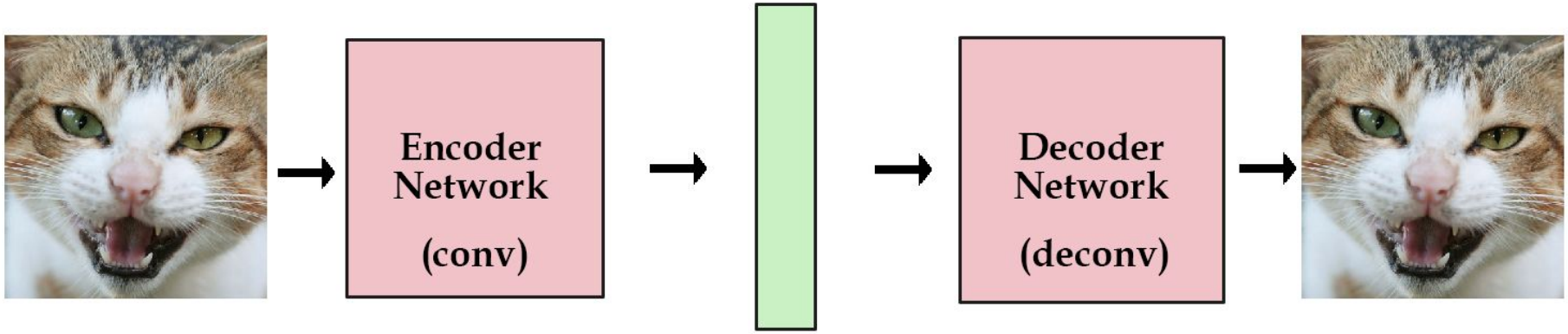




F. Van Veen, "The Neural Network Zoo" (2016)

Variational Autoencoder (VAE)

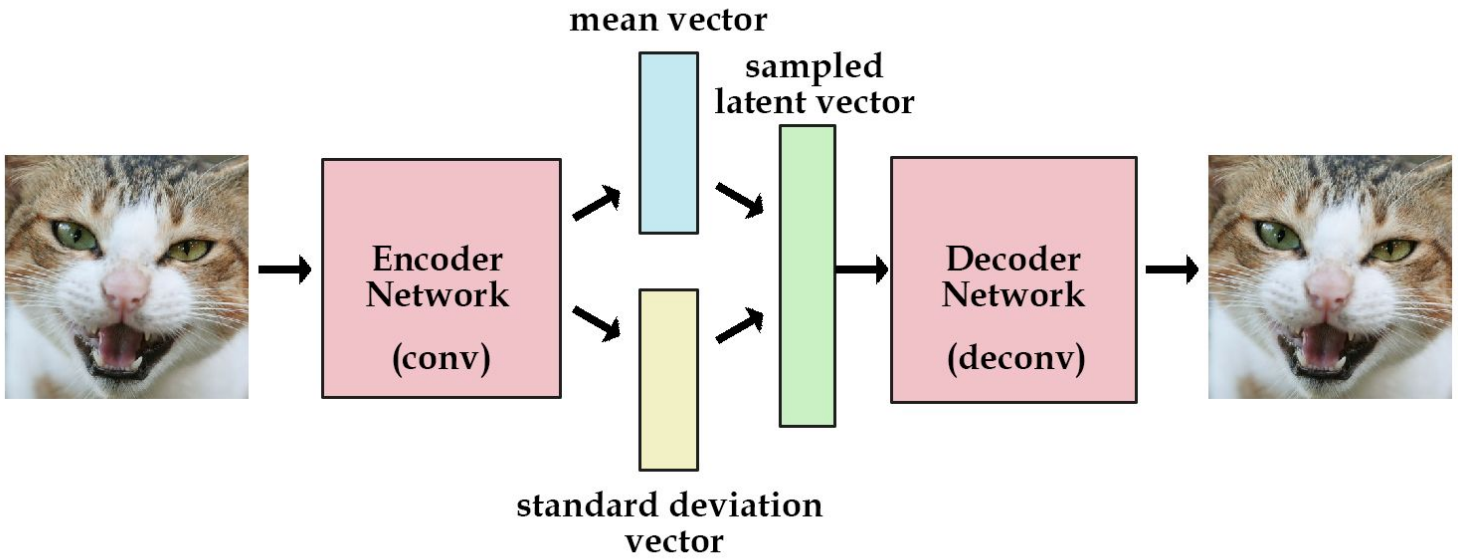
The latent vector learned in the hidden layer of the basic autoencoder (in green)...



Kevin Frans, "Variational Autoencoders explained" (2016)

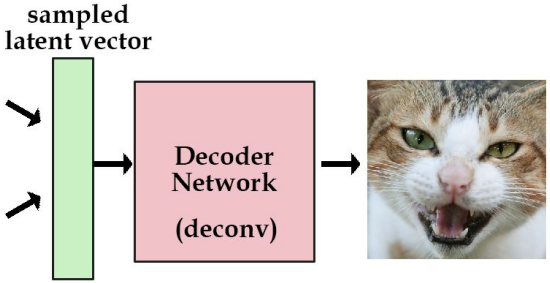
Variational Autoencoder (VAE)

...is forced to follow a unit Gaussian distribution in VAEs.



Kevin Frans, "Variational Autoencoders explained" (2016)

Variantional Autoencoder (VAE)



Generative model:

- Create new samples by drawing from a Gaussian distribution.

Unsupervised learning

"Deep Learning Tutorial", Dept. Computer Science, Stanford

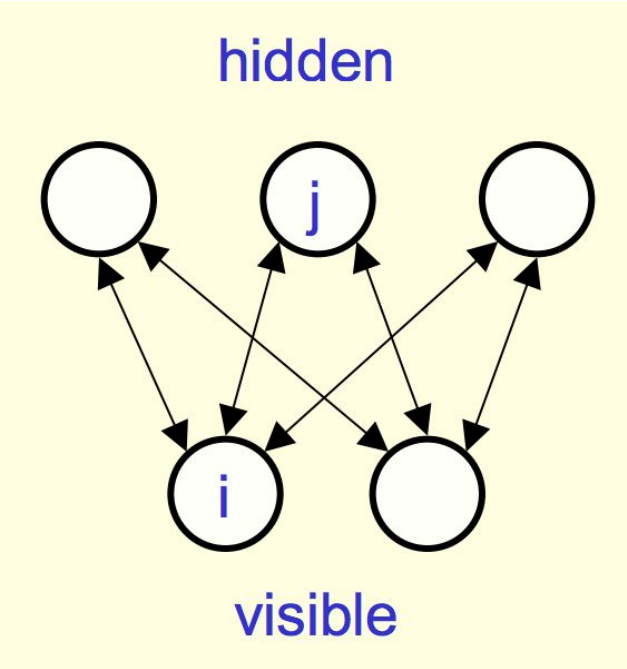
Variantional Autoencoder (VAE)

Alec Radford, [“Face manifold from conv/deconv variational autoencoder”](#) (2015)

Restricted Boltzmann Machine (RBM)

F. Van Veen, [“The Neural Network Zoo”](#) (2016)

Restricted Boltzmann Machine (RBM)



- Shallow two-layer net.
- Restricted=No two nodes in a layer share a connection
- Bipartite graph.
- Bidirectional graph
  - Shared weights.
  - Different biases.

Figure: Geoffrey Hinton (2013)

Salakhutdinov, Ruslan, Andriy Mnih, and Geoffrey Hinton. "Restricted Boltzmann machines for collaborative filtering." Proceedings of the 24th international conference on Machine learning. ACM, 2007.

Restricted Boltzmann Machine (RBM)

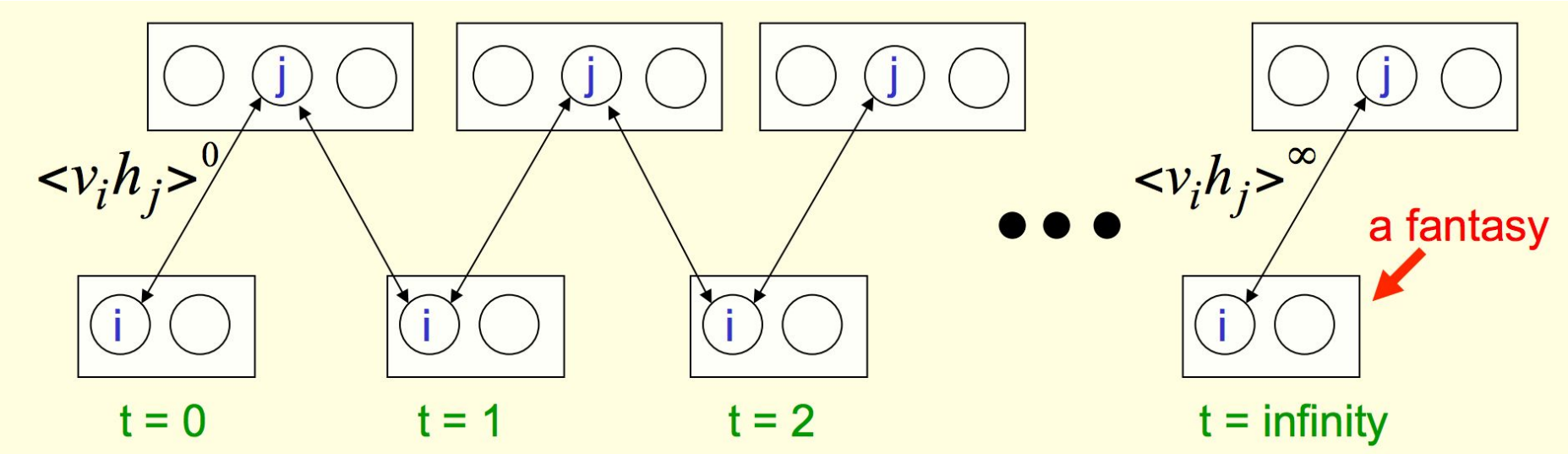


Figure: Geoffrey Hinton (2013)

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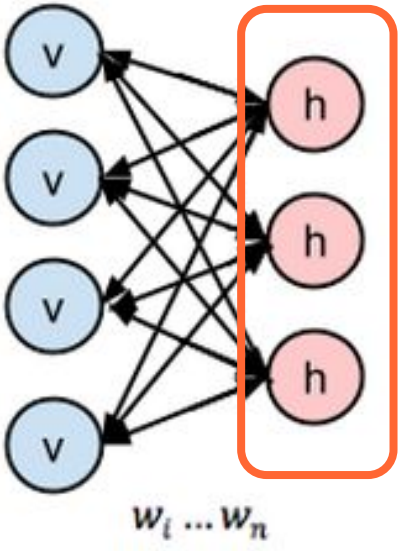
Restricted Boltzmann Machine (RBM)



RBMs are a specific type of **autoencoder**.

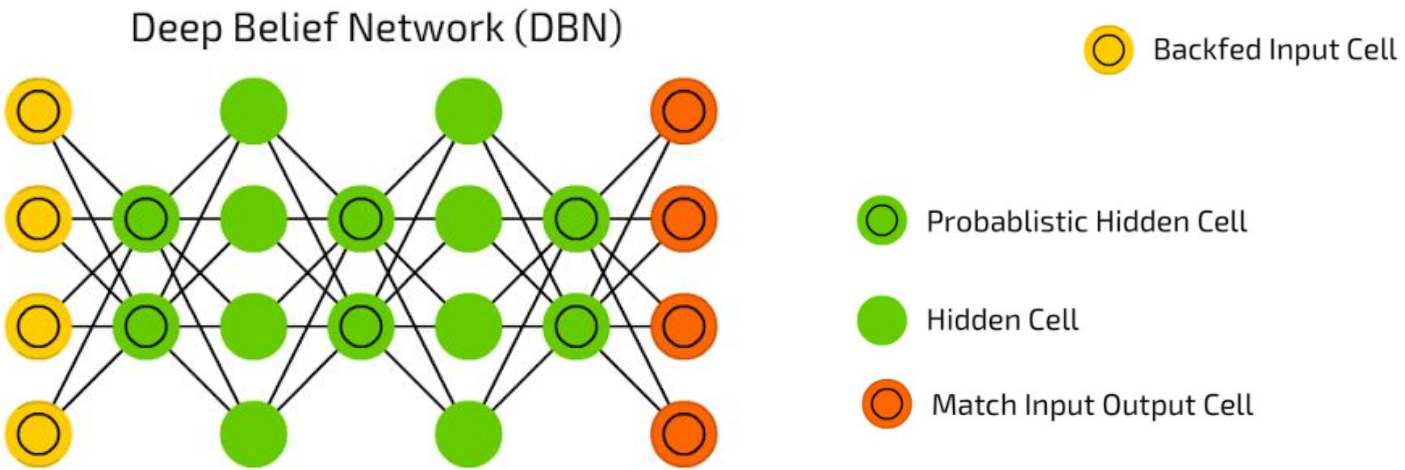
Unsupervised learning

DeepLearning4j, "A Beginner's Tutorial for Restricted Boltzmann Machines".

Restricted Boltzmann Machine (RBM)

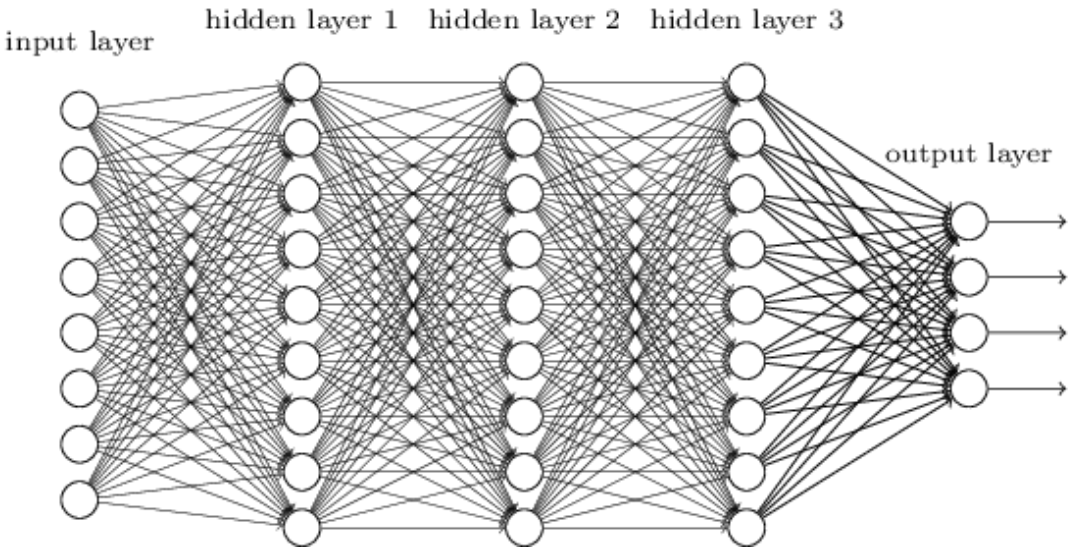
Deep Learning TV, [“Restricted Boltzmann Machines”](#).

Deep Belief Networks (DBN)



F. Van Veen, [“The Neural Network Zoo”](#) (2016)

Deep Belief Networks (DBN)

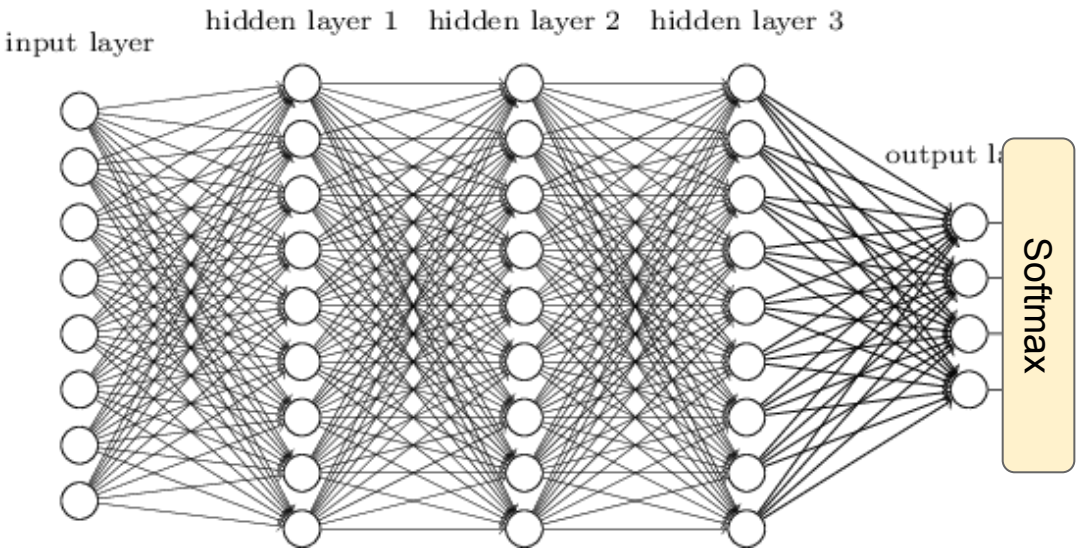


- Architecture like an MLP.
- Training as a stack of RBMs…
- ...so they do not need labels:

Unsupervised learning

Hinton, Geoffrey E., Simon Osindero, and Yee-Whye Teh. "A fast learning algorithm for deep belief nets." Neural computation 18, no. 7 (2006): 1527-1554.

Deep Belief Networks (DBN)

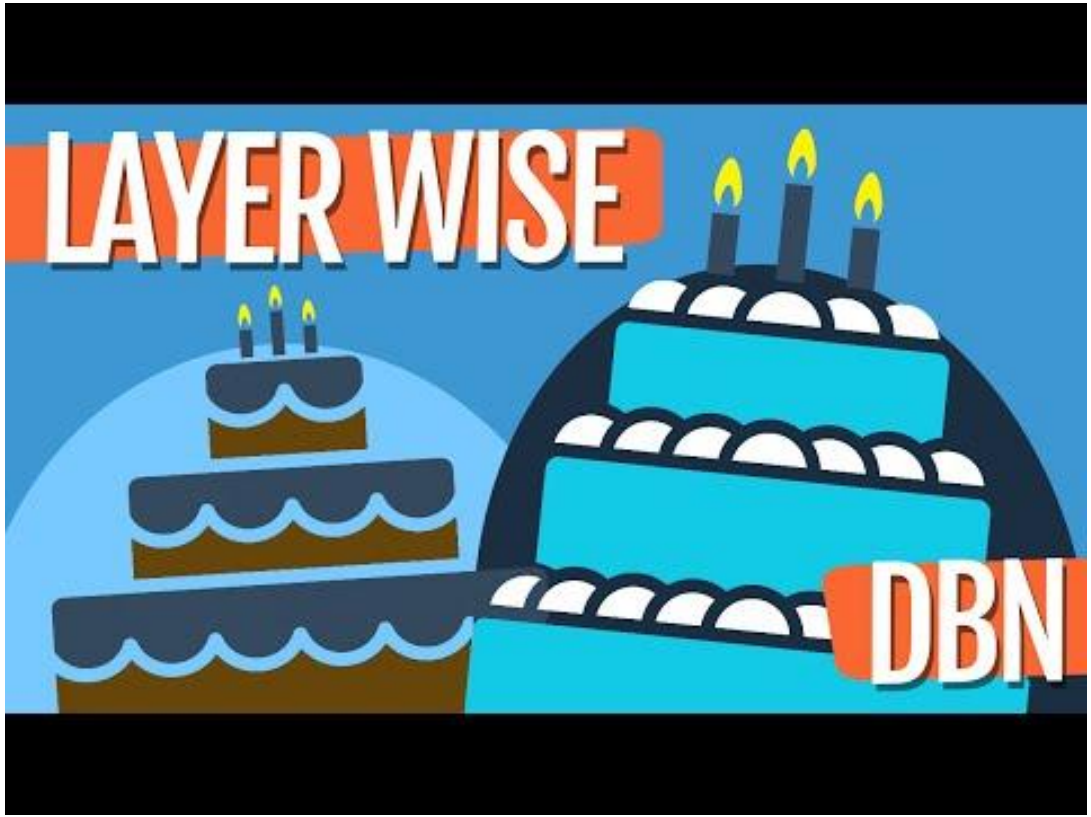


After the DBN is trained, it can be fine-tuned with a **reduced amount of labels** to solve a supervised task with superior performance.

Supervised learning

Hinton, Geoffrey E., Simon Osindero, and Yee-Whye Teh. "A fast learning algorithm for deep belief nets." Neural computation 18, no. 7 (2006): 1527-1554.

Deep Belief Networks (DBN)



Deep Learning TV, “Deep Belief Nets”

Deep Belief Networks (DBN)

Geoffrey Hinton, "Introduction to Deep Learning & Deep Belief Nets" (2012)
Geoorey Hinton, "Tutorial on Deep Belief Networks". NIPS 2007.

Deep Belief Networks (DBN)

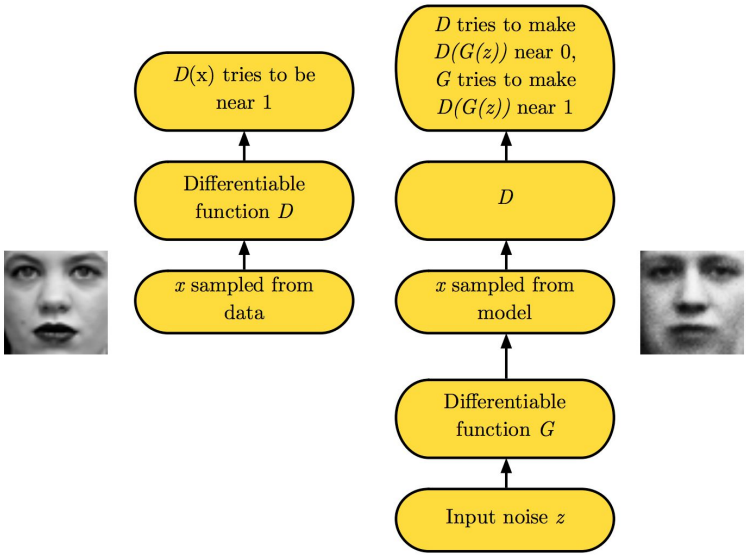
Geoffrey Hinton

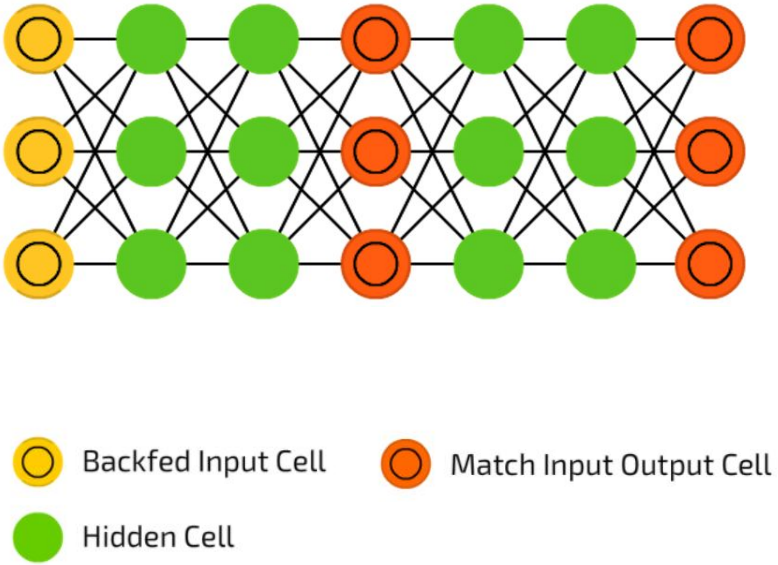
UNIVERSITY OF TORONTO

Research at Google

Adversarial Networks

Further details:
D2L3, “Generative”



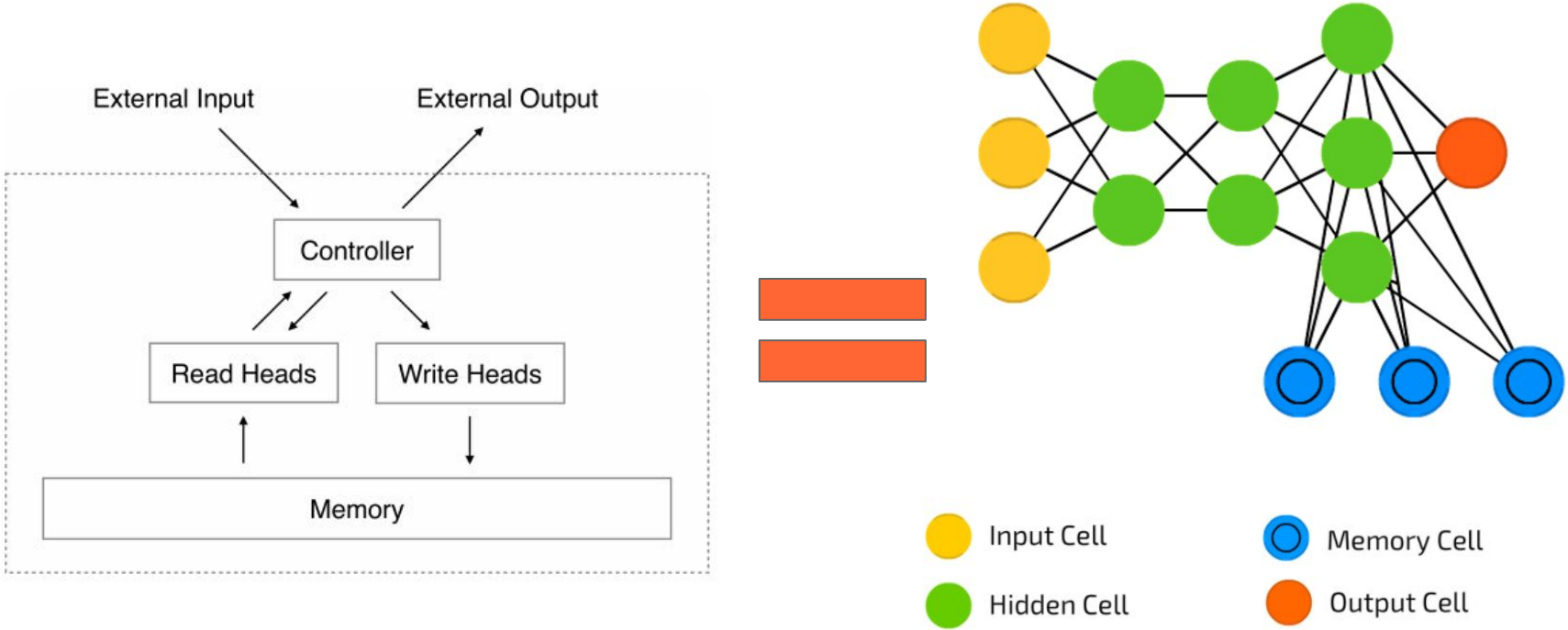


Goodfellow, Ian, Jean Pouget-Abadie, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair, Aaron Courville, and Yoshua Bengio. "Generative adversarial nets." NIPS 2014

Goodfellow, Ian. "NIPS 2016 Tutorial: Generative Adversarial Networks." *arXiv preprint arXiv:1701.00160* (2016).

F. Van Veen, “The Neural Network Zoo” (2016)

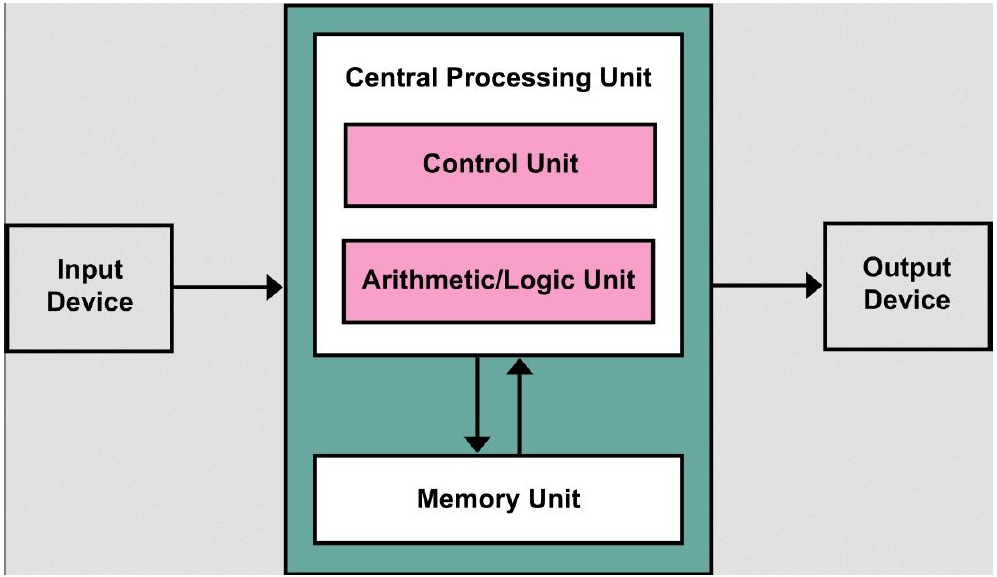
Differentiable Neural Computers (DNC)



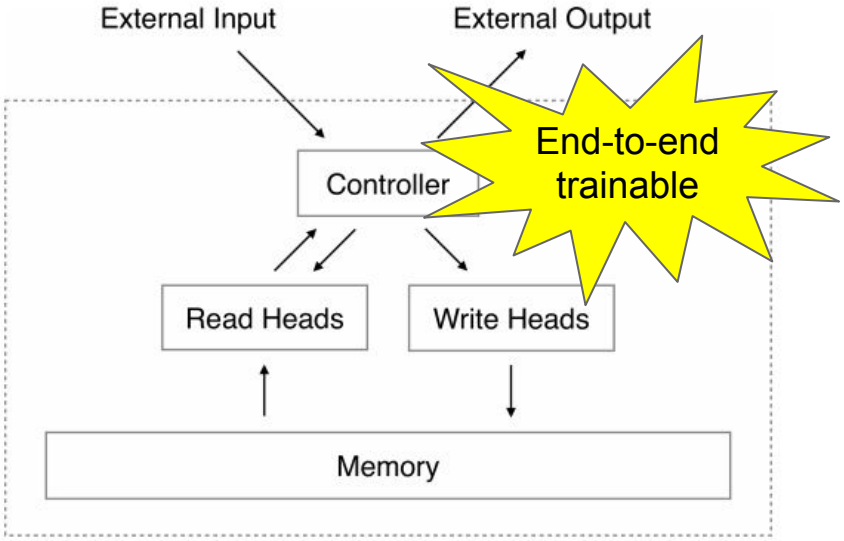
Graves, Alex, Greg Wayne, and Ivo Danihelka. "Neural turing machines." *arXiv preprint arXiv:1410.5401* (2014). [slides] [code]

F. Van Veen, "The Neural Network Zoo" (2016)

Differentiable Neural Computers (DNC)



von Neumann architecture (1952)

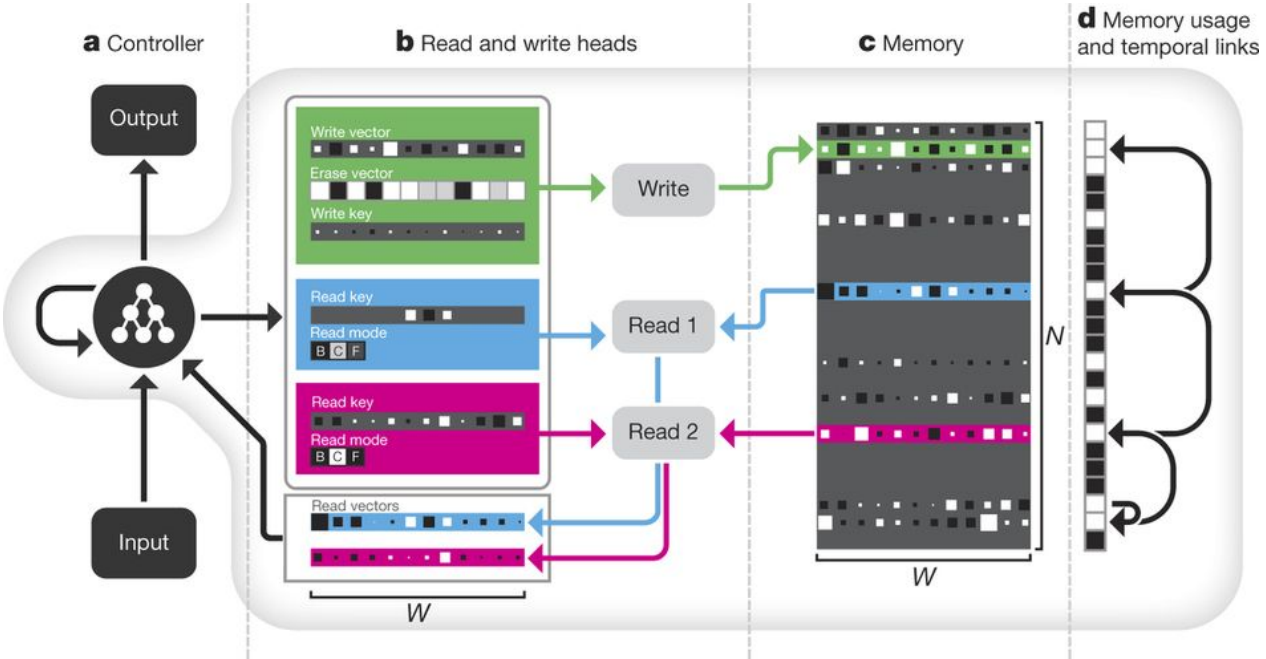


Neural Turing Machine (2014)

Graves, Alex, Greg Wayne, and Ivo Danihelka. "Neural turing machines." *arXiv preprint arXiv:1410.5401* (2014). [slides] [code]

Differentiable Neural Computers (DNC)

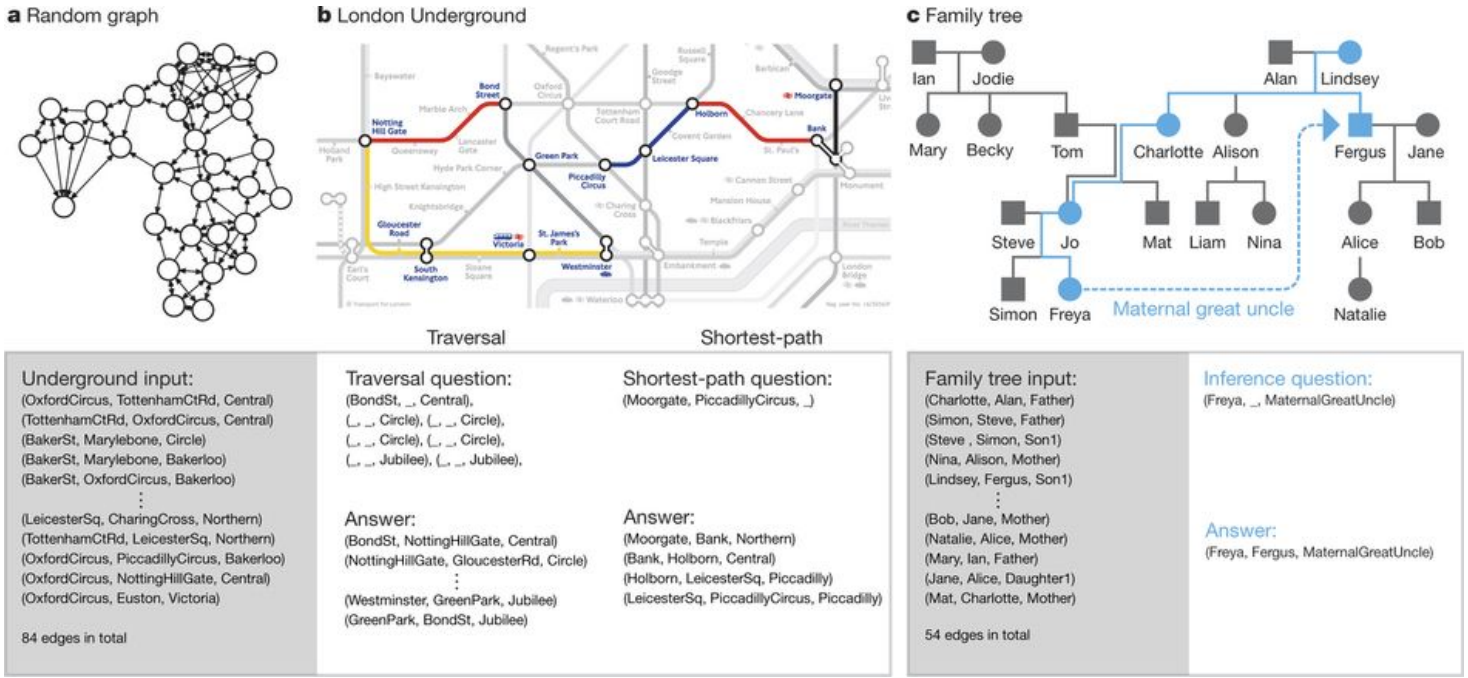
Add a trainable external memory to a neural network.



Graves, Alex, Greg Wayne, Malcolm Reynolds, Tim Harley, Ivo Danihelka, Agnieszka Grabska-Barwińska, Sergio Gómez Colmenarejo et al. "Hybrid computing using a neural network with dynamic external memory." Nature 538, no. 7626 (2016): 471-476. [Post by DeepMind]

Differentiable Neural Computers (DNC)

DNC can solve tasks reading information from a trained memory.



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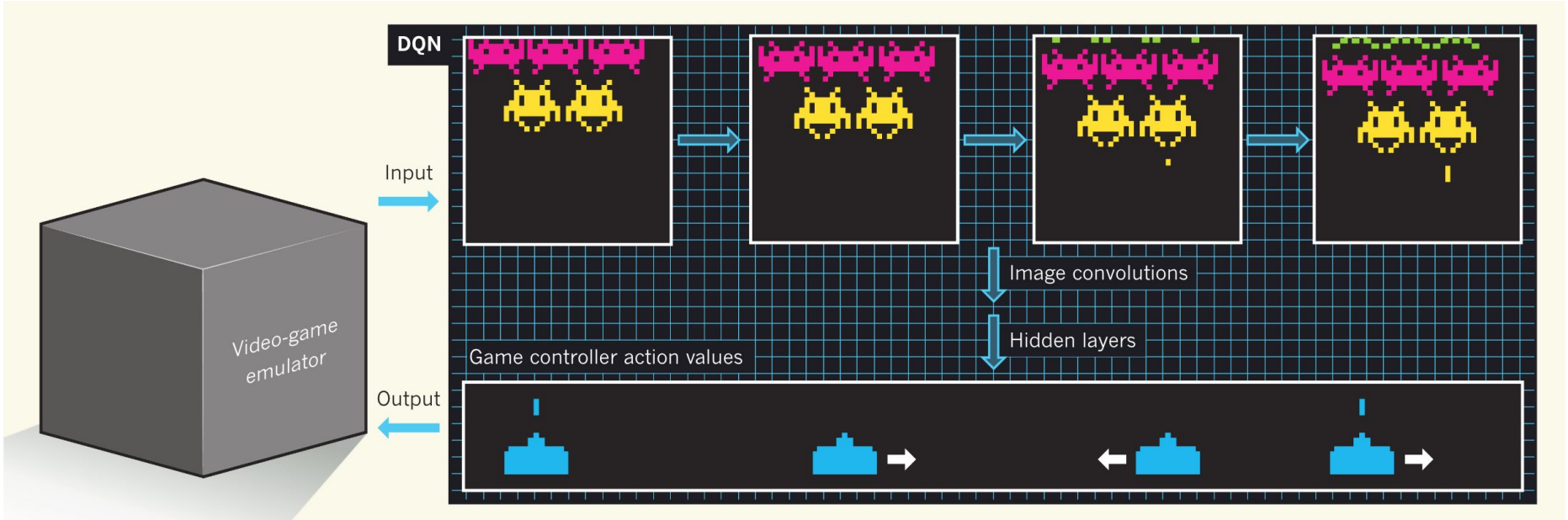
Reinforcement Learning (RL)

Mnih, Volodymyr, Koray Kavukcuoglu, David Silver, Alex Graves, Ioannis Antonoglou, Daan Wierstra, and Martin Riedmiller. "Playing atari with deep reinforcement learning." arXiv preprint arXiv:1312.5602 (2013).

Reinforcement Learning (RL)



Bernhard Schölkkopf, "Learning to see and act" Nature 2015.

Reinforcement Learning (RL)

Google DeepMind

Artificial intelligence (AI)

Google buys UK artificial intelligence startup Deepmind for £400m

Google makes its biggest EU purchase yet with the technology that aims to make computers think like humans

Samuel Gibbs

Monday 27 January 2014 13.23 GMT

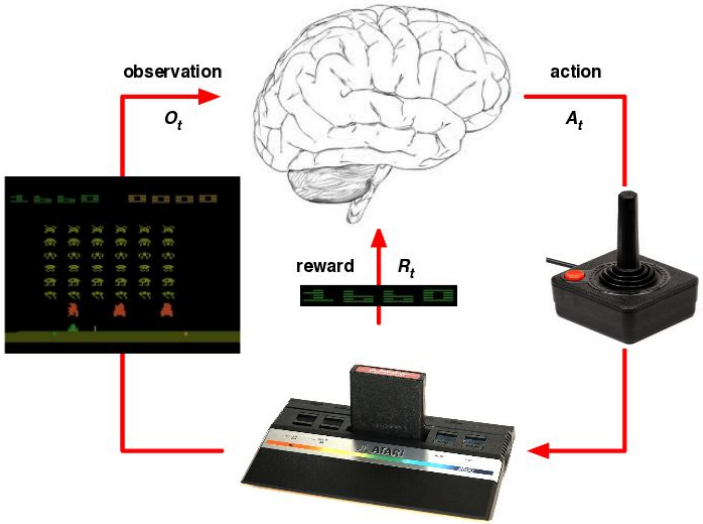
This article is 2 years old

1046 186

https://www.theguardian.com/technology/2014/jan/27/google-acquires-uk-artificial-intelligence-startup-deepmind

Reinforcement Learning (RL)

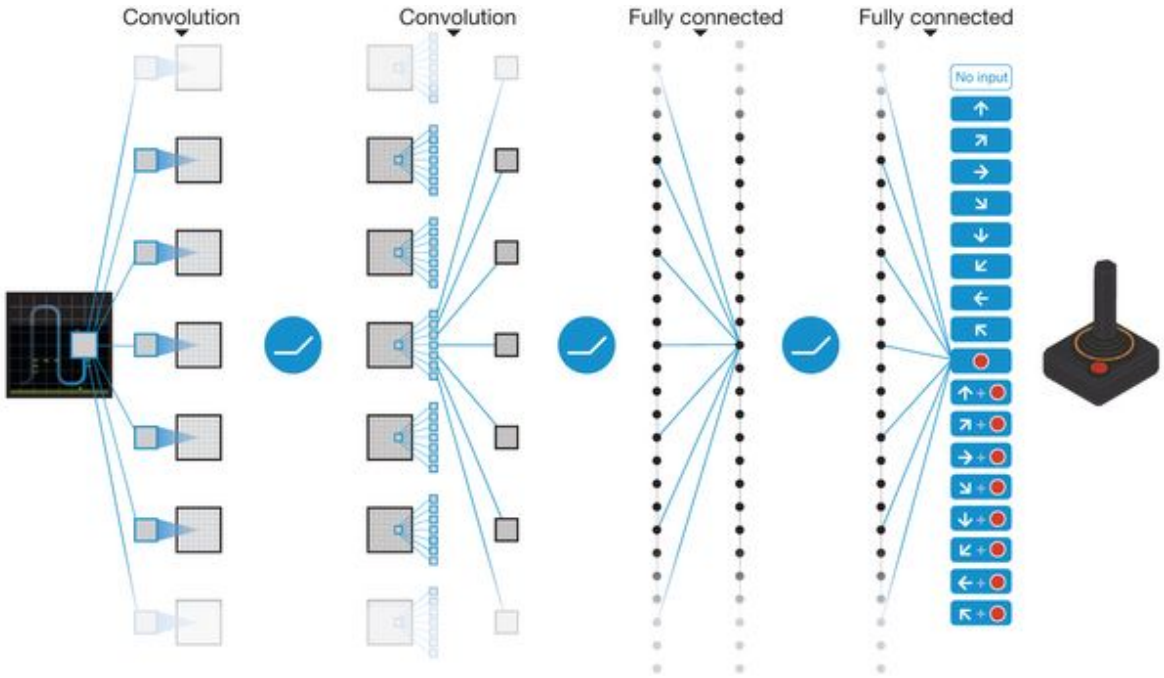
An agent that is a **decision-maker interacts** with the environment and learns through **trial-and-error**



Slide credit: UCL Course on RL by David Silver

Reinforcement Learning (RL)

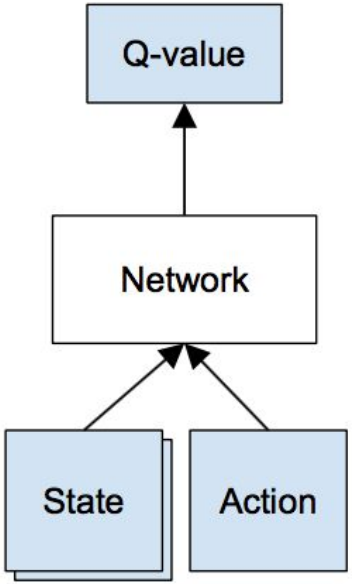
Deep Q-Network (DQN)



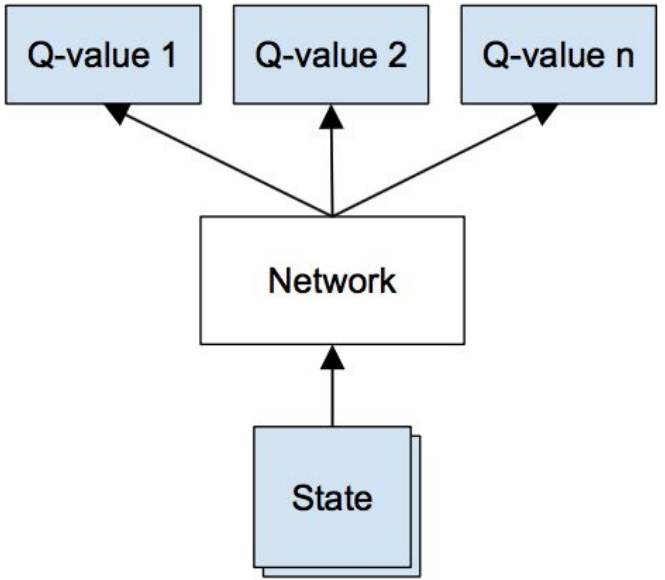
Mnih, Volodymyr, Koray Kavukcuoglu, David Silver, Andrei A. Rusu, Joel Veness, Marc G. Bellemare, Alex Graves et al. "Human-level control through deep reinforcement learning." *Nature* 518, no. 7540 (2015): 529-533.

Reinforcement Learning (RL)

Deep Q-Network (DQN)



Naive DQN

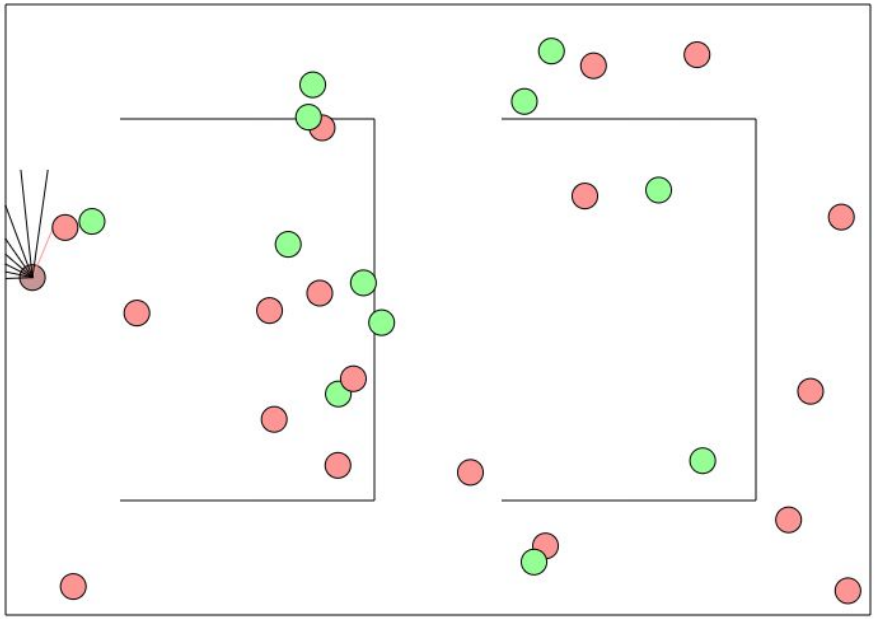


Refined DQN

Source: Tambet Matiisen, Demystifying Deep Reinforcement Learning (Nervana)

Reinforcement Learning (RL)

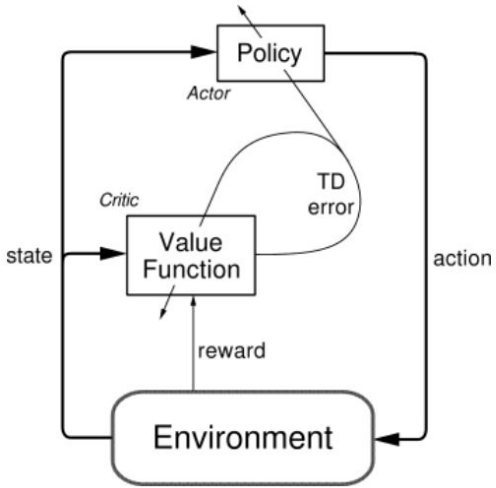
Deep Q-Network (DQN)

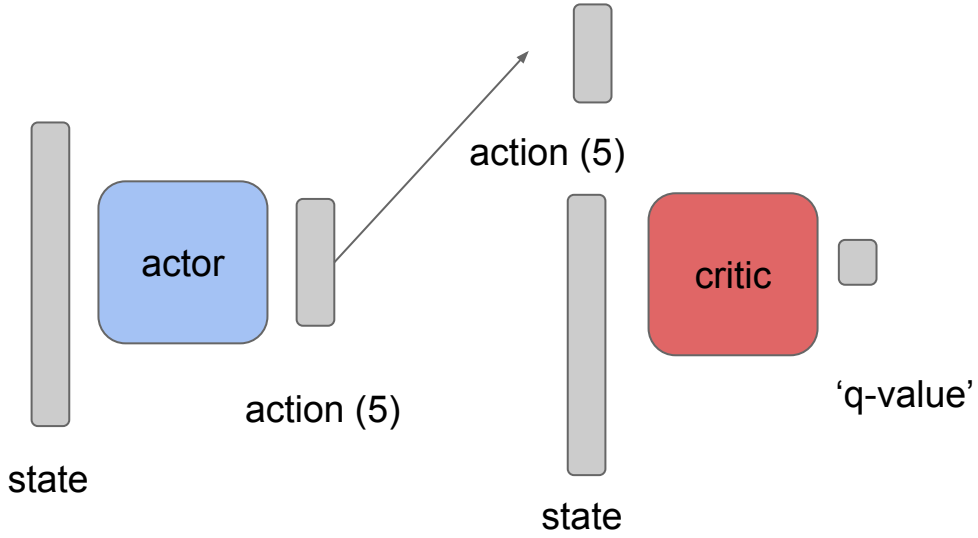


Andrej Karpathy, [“ConvNetJS Deep Q Learning Demo”]

Reinforcement Learning (RL)

Actor-Critic algorithm





actor performs an action

critic assesses how good the action was, and the gradients are used to train the actor and the critic

Slide credit: Míriam Bellver

Grondman, Ivo, Lucian Busoniu, Gabriel AD Lopes, and Robert Babuska. "A survey of actor-critic reinforcement learning: Standard and natural policy gradients." *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)* 42, no. 6 (2012): 1291-1307.

Reinforcement Learning (RL)

AlphaGo

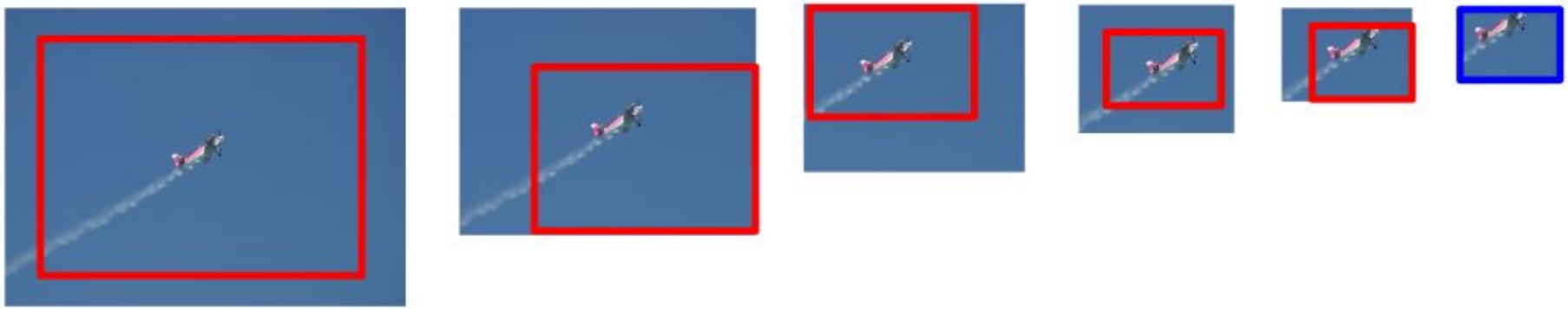
Google DeepMind

Silver, D., Huang, A., Maddison, C.J., Guez, A., Sifre, L., Van Den Driessche, G., Schrittwieser, J., Antonoglou, I., Panneershelvam, V., Lanctot, M. and Dieleman, S., 2016. Mastering the game of Go with deep neural networks and tree search. *Nature*, *529*(7587), pp.484-489

Reinforcement Learning (RL)

Greg Kohs, "AlphaGo" (2017)

Reinforcement Learning (RL)

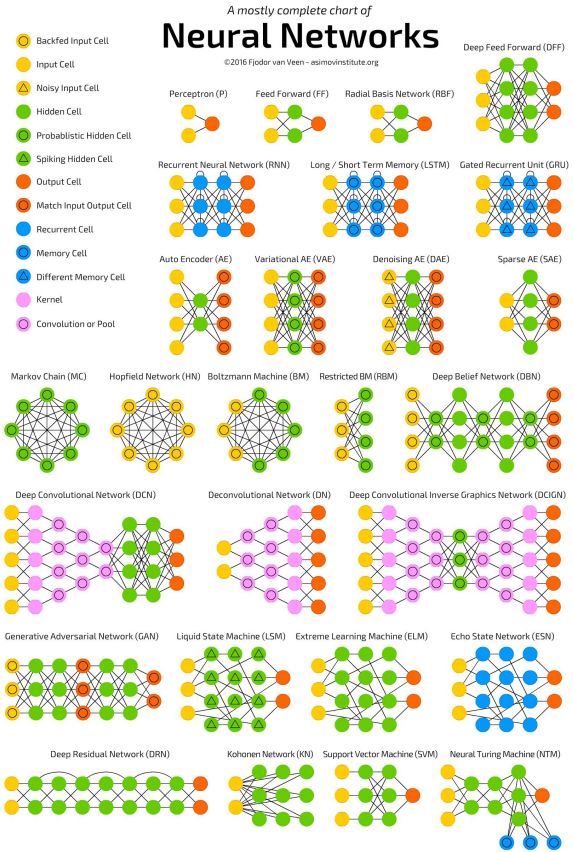


Miriam Bellver, Xavier Giro-i-Nieto, Ferran Marques, and Jordi Torres. "Hierarchical Object Detection with Deep Reinforcement Learning." Deep Reinforcement Learning Workshop NIPS 2016.

Reinforcement Learning (RL)

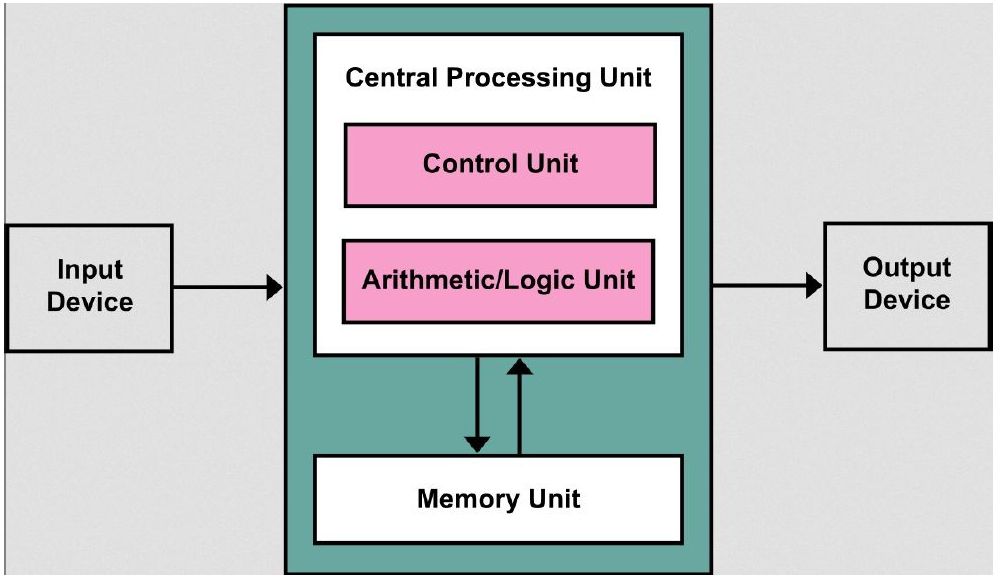
Deep Learning TV, [“Reinforcement learning - Ep. 30”]

The Full Story



F. Van Veen, [“The Neural Network Zoo”](#) (2016)

More architectures to come..



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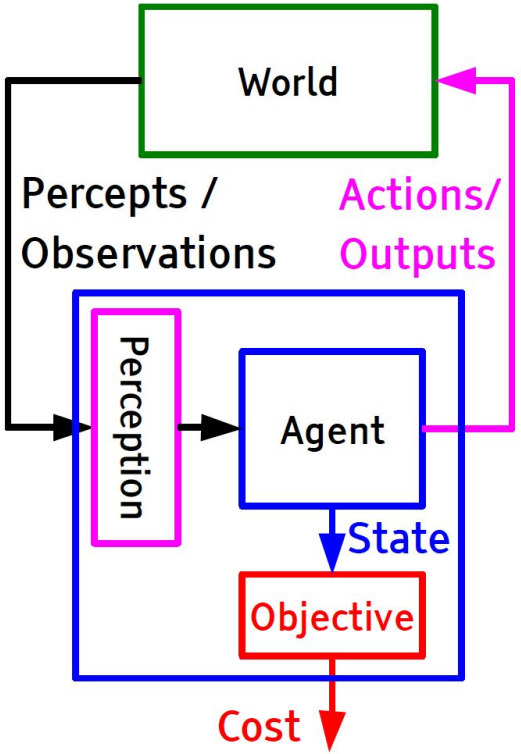
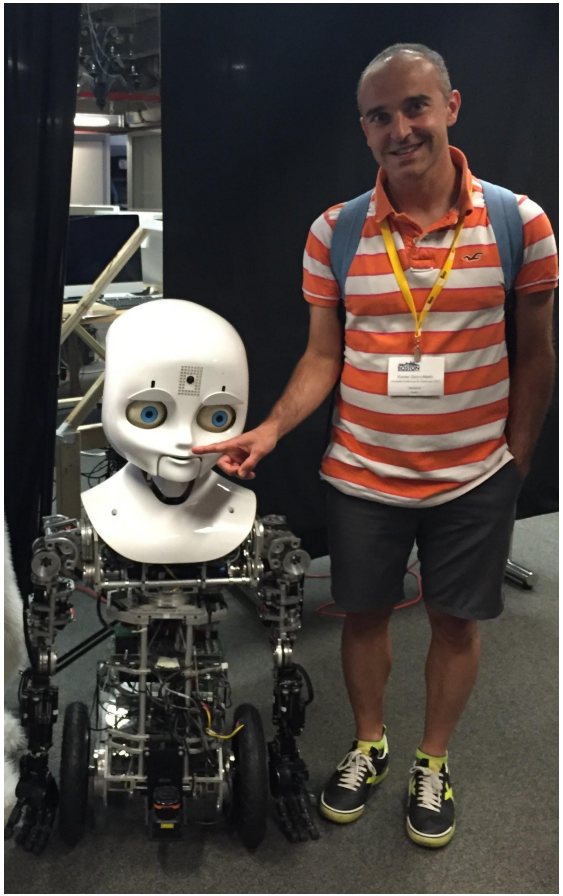


Yann LeCun, "A Path to AI", Beneficial AI 2017.

Thanks ! Q&A ?

#InsightDL2017



@DocXavi

/ProfessorXavi

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BARCELONATECH
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Image Processing Group

https://imatge.upc.edu/web/people/xavier-giro