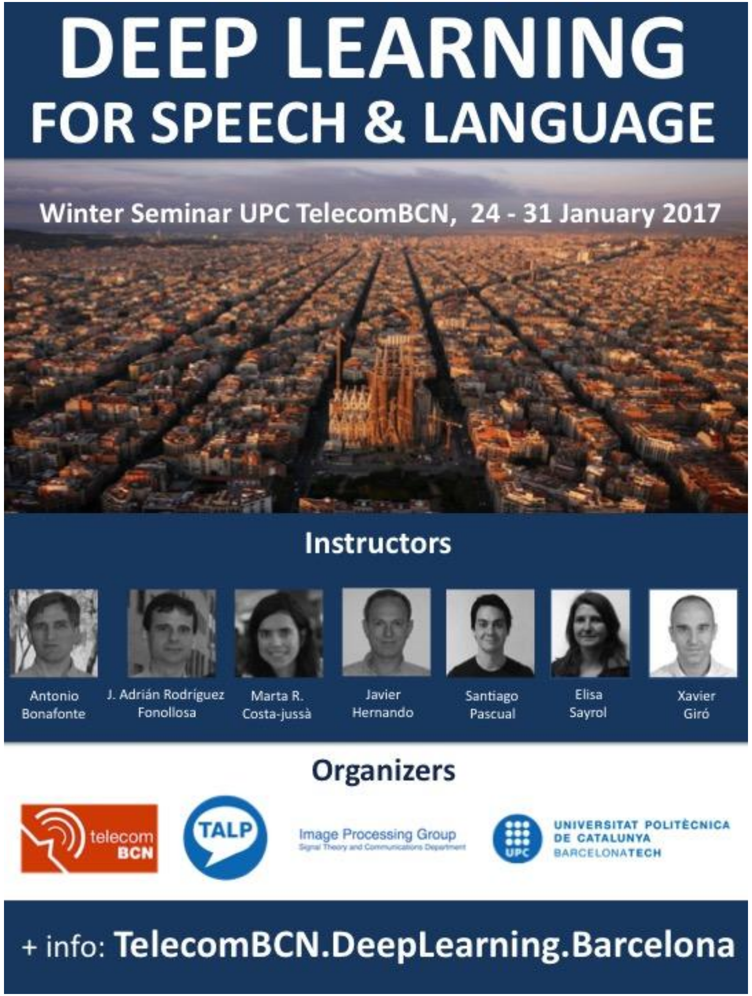


[course site]

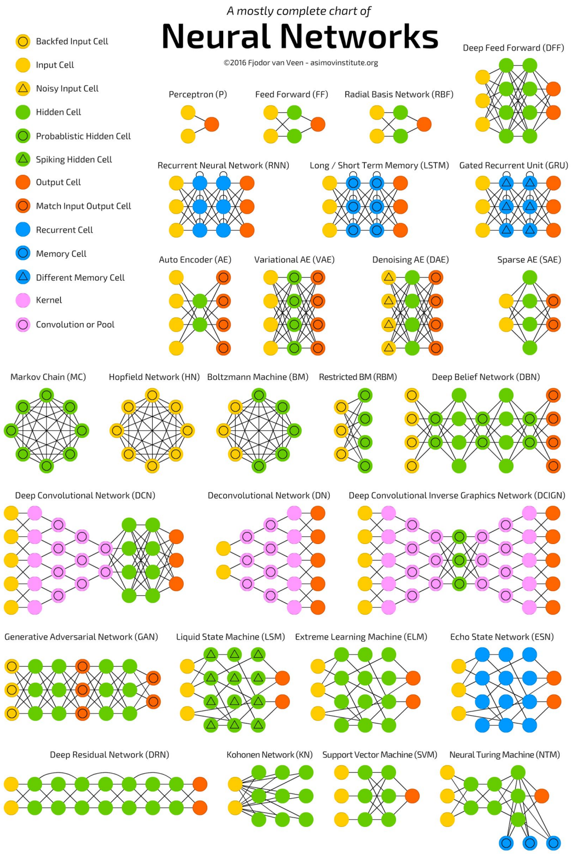
Day 1 Lecture 4

Basic Deep Architectures

Xavier Giró-i-Nieto

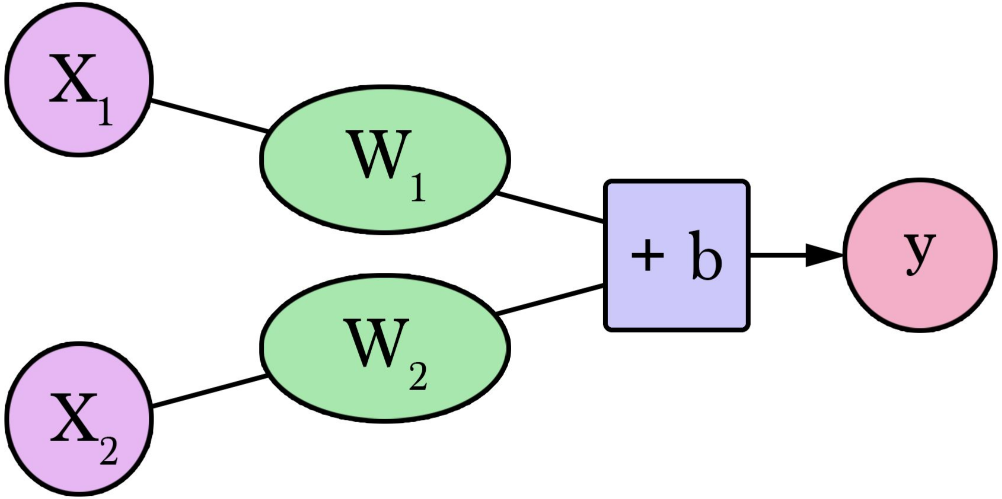
UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Department of Signal Theory and Communications
Image Processing Group

The Full Story



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

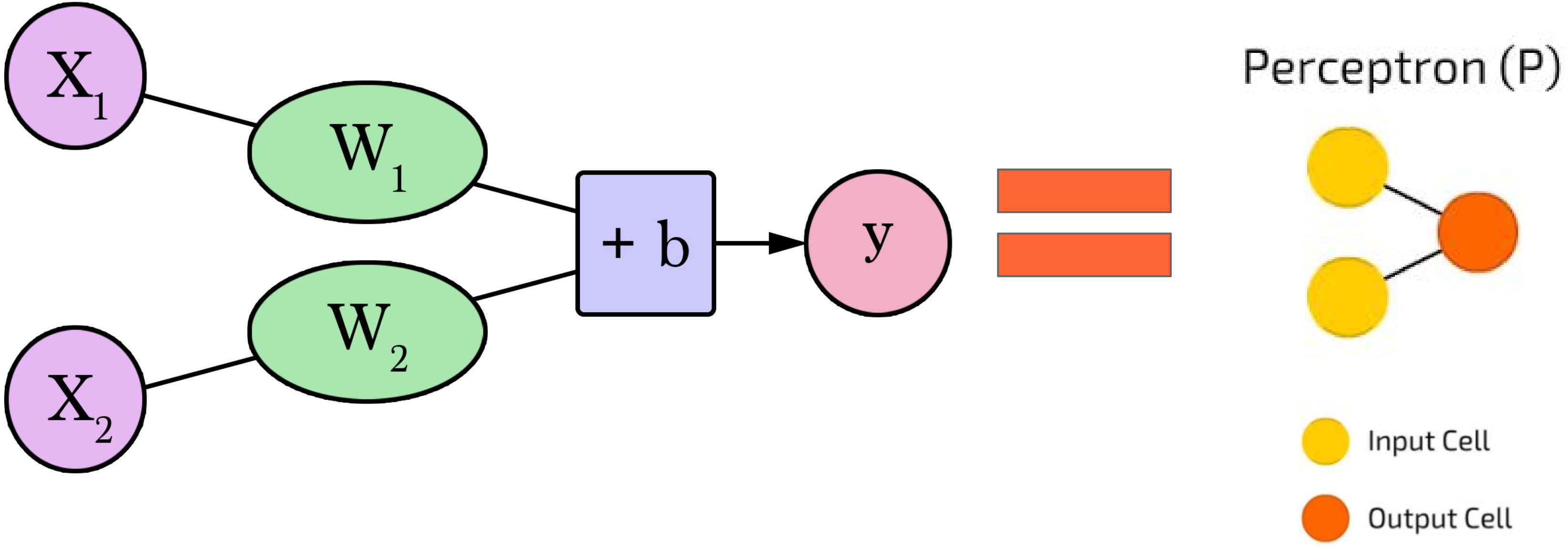
Previously... A Perceptron



$$y = W_1 x_1 + W_2 x_2 + b$$

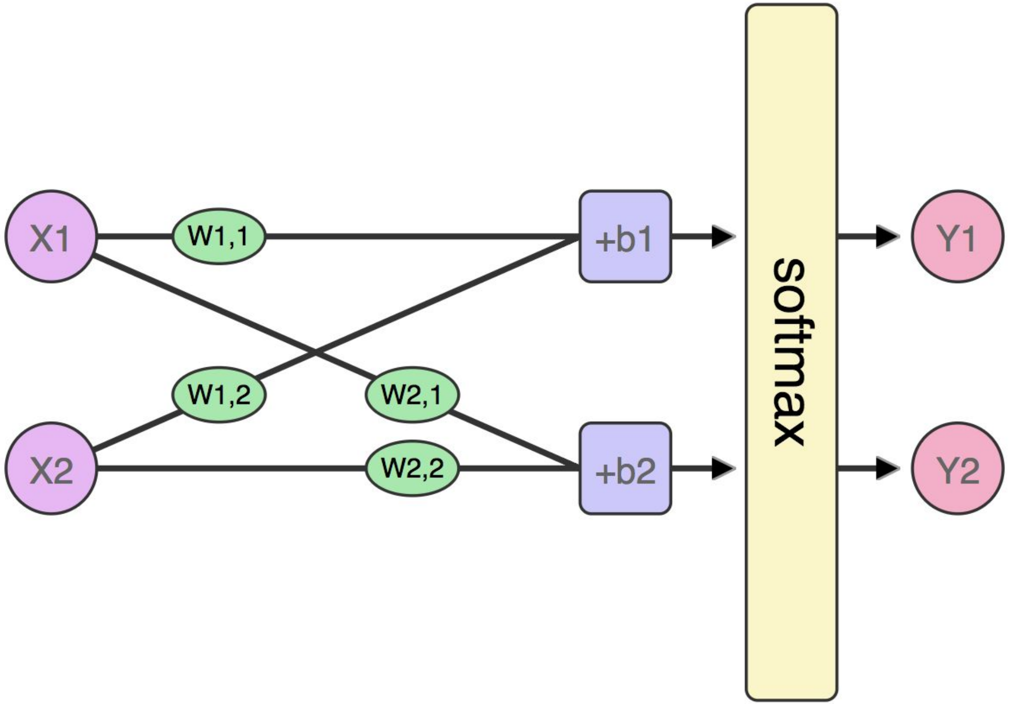
J. Alammar, "A visual and interactive guide to the Basics of Neural Networks" (2016)

Previously... A Perceptron



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

Two Perceptrons + Softmax classifier

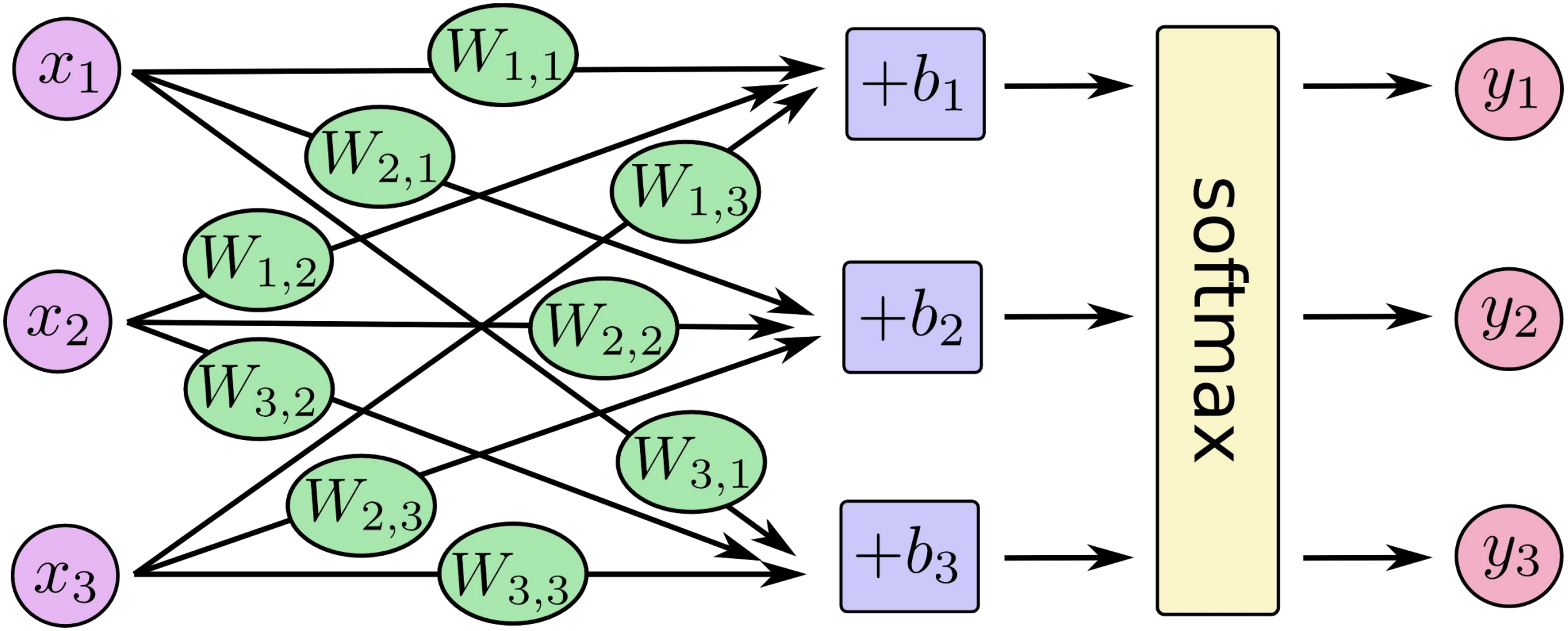


$$\text{evidence}_i = \sum_j W_{i,\,j} x_j + b_i$$

$$\text{softmax}(x)_i = \frac{\exp(x_i)}{\sum_j \exp(x_j)}$$

J. Alammar, [“A visual and interactive guide to the Basics of Neural Networks”] (2016)

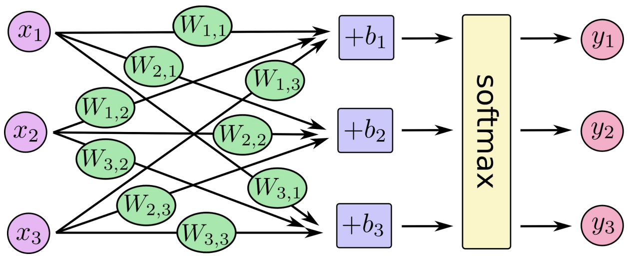
Three perceptrons + Softmax classifier



TensorFlow, “MNIST for ML beginners”

Three perceptrons + Softmax classifier

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \text{softmax}\begin{pmatrix} W_{1,1}x_1 + W_{1,2}x_2 + W_{1,3}x_3 + b_1 \\ W_{2,1}x_1 + W_{2,2}x_2 + W_{2,3}x_3 + b_2 \\ W_{3,1}x_1 + W_{3,2}x_2 + W_{3,3}x_3 + b_3 \end{pmatrix}$$

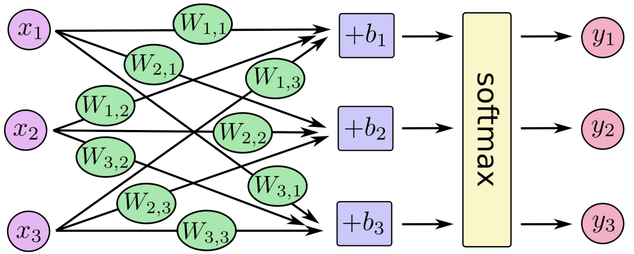


TensorFlow, [“MNIST for ML beginners”]

Three perceptrons + Softmax classifier

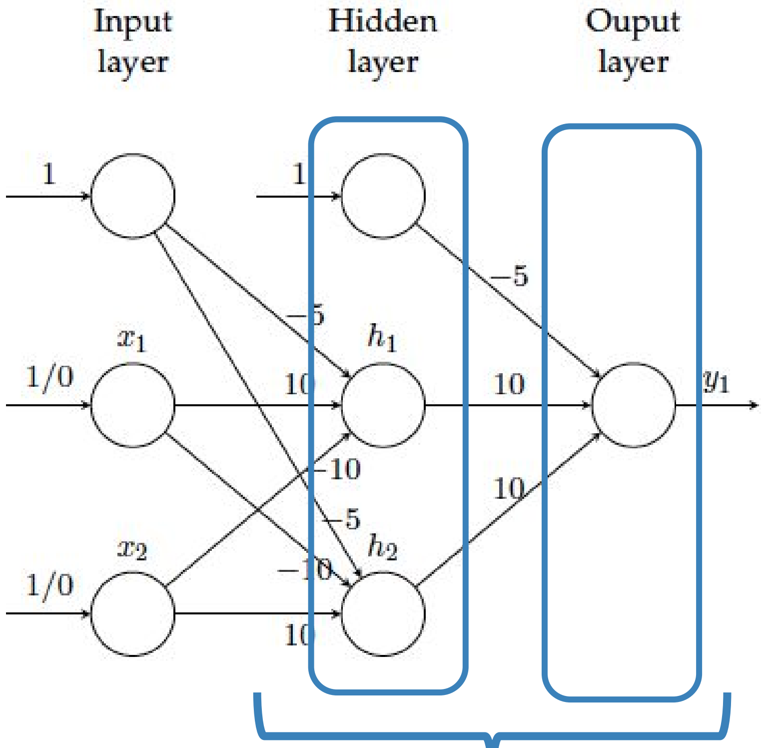
$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \text{softmax}\left(\begin{bmatrix} W_{1,1} & W_{1,2} & W_{1,3} \\ W_{2,1} & W_{2,2} & W_{2,3} \\ W_{3,1} & W_{3,2} & W_{3,3} \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix} \right)$$

$$y = \text{softmax}(Wx + b)$$



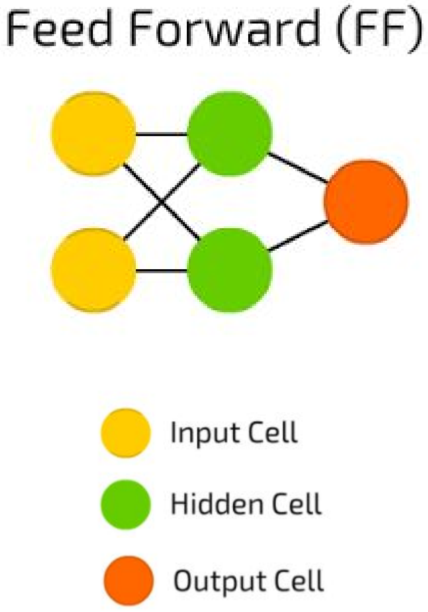
TensorFlow, [“MNIST for ML beginners”]

Neural Network = Multi Layer Perceptron



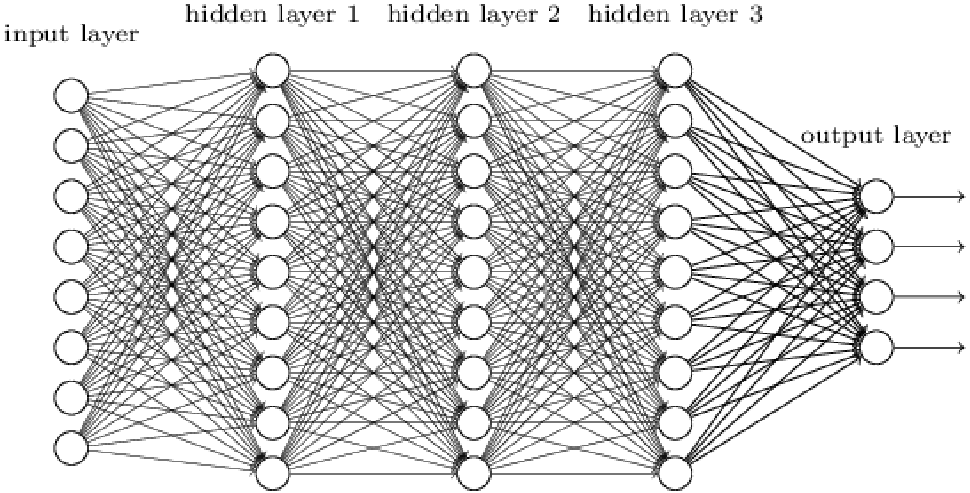
2 layers of perceptrons

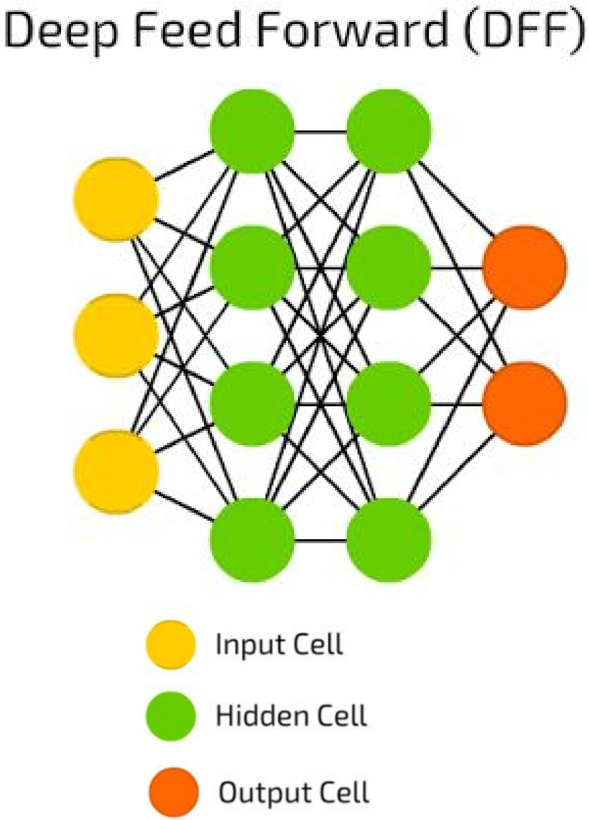
=



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

Deep Neural Network (DNN)

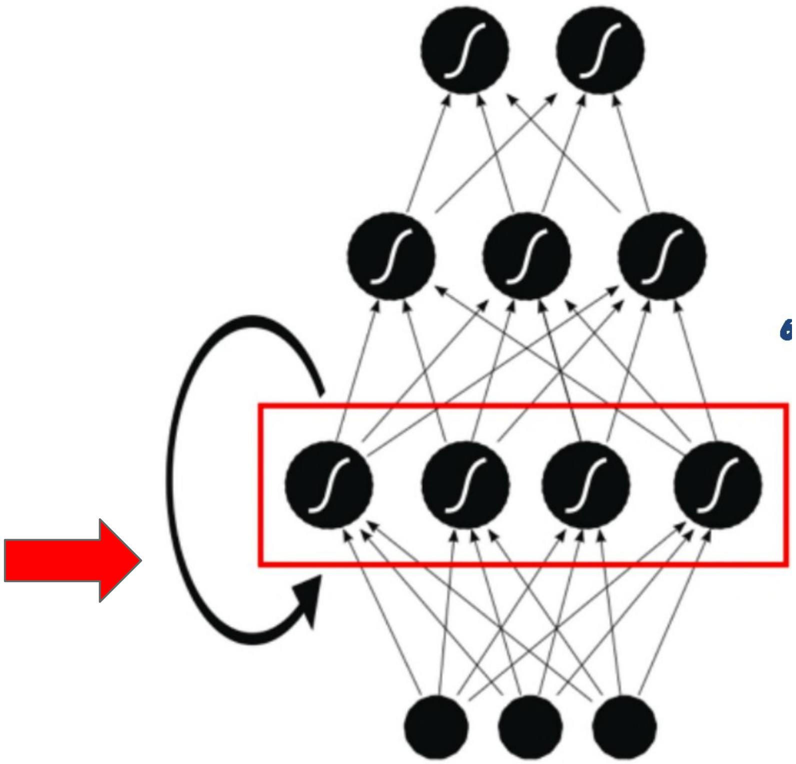




F. Van Veen, [“The Neural Network Zoo”]() (2016)

Recurrent Neural Network (RNN)

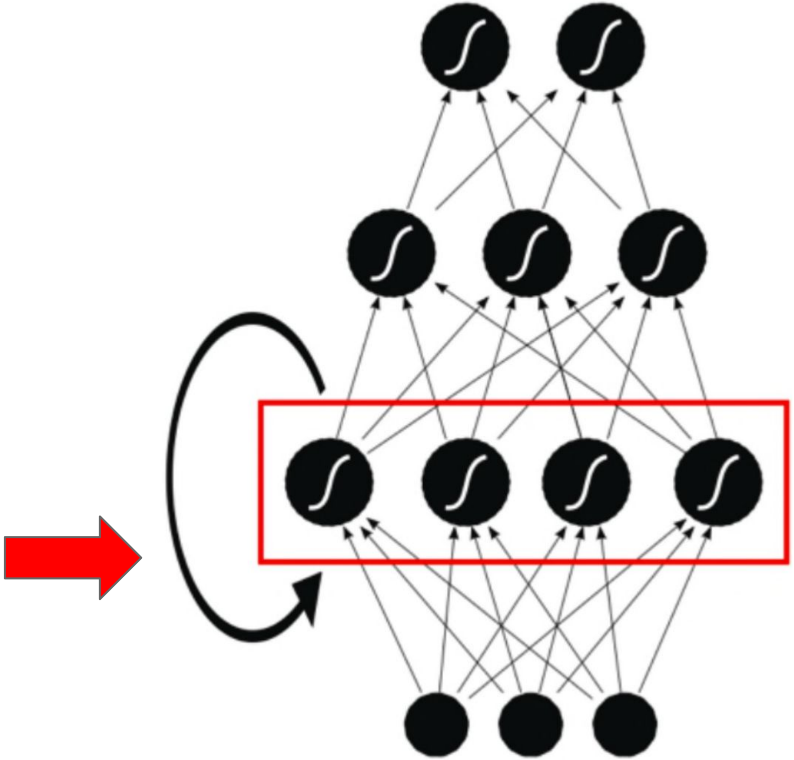
The hidden layers and the output depend from previous states of the hidden layers



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

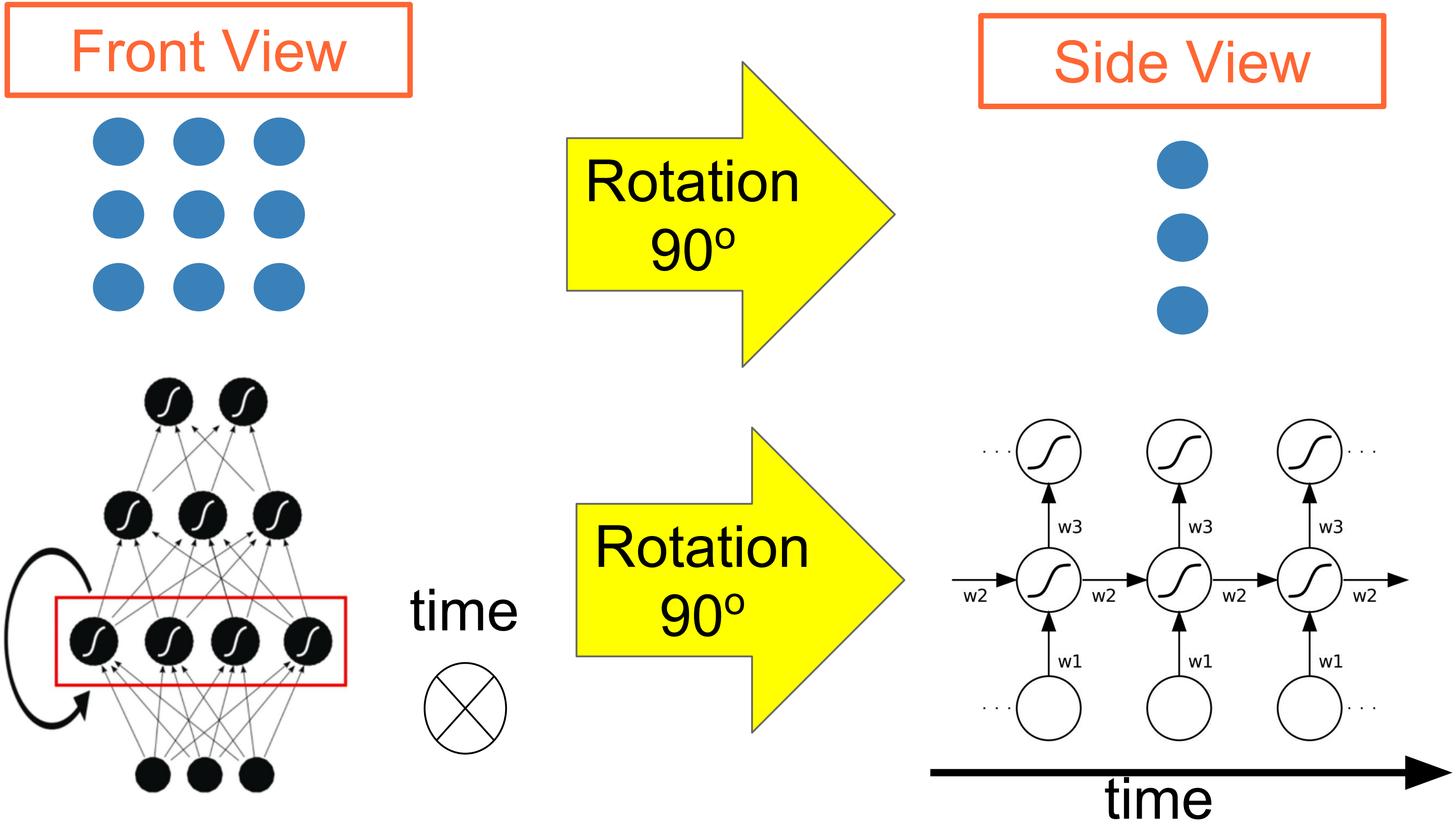
Recurrent Neural Network (RNN)

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

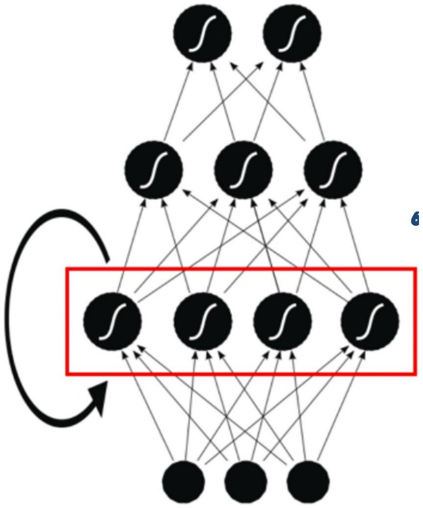


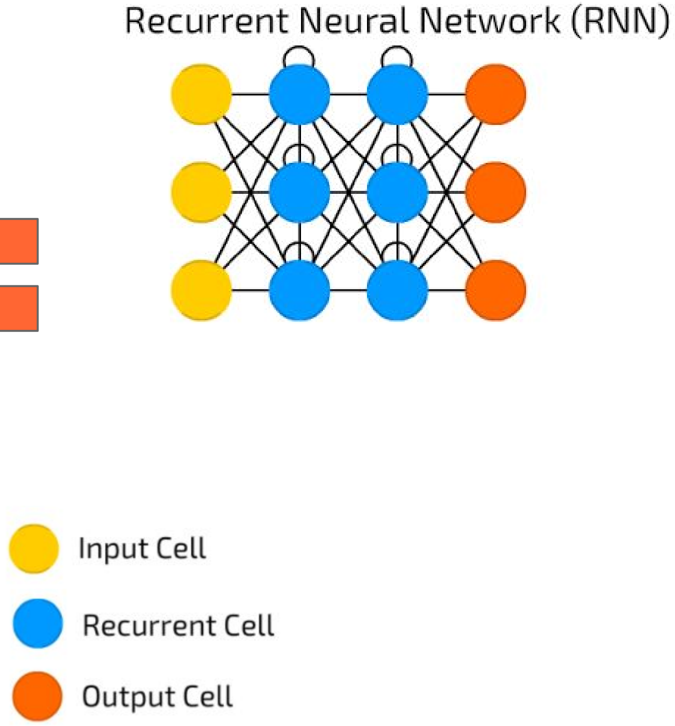
Alex Graves, [“Supervised Sequence Labelling with Recurrent Neural Networks”]

Recurrent Neural Network (RNN)



Recurrent Neural Network (RNN)

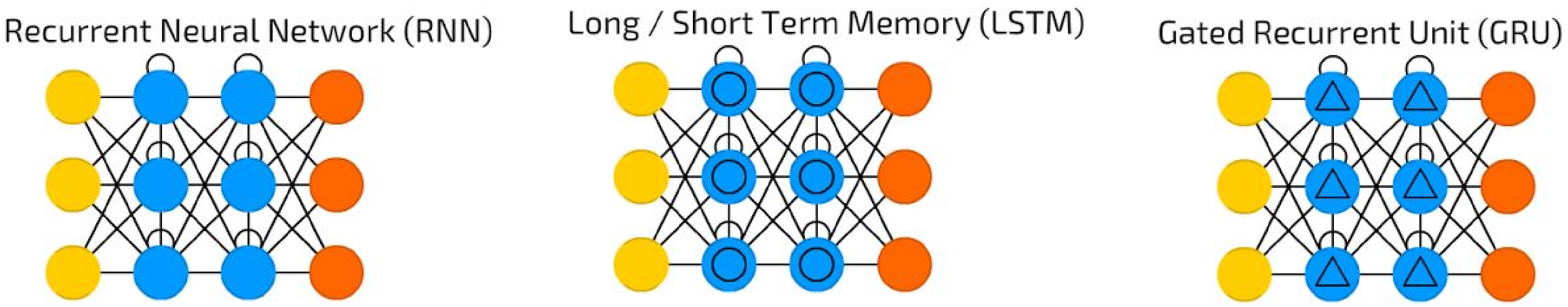


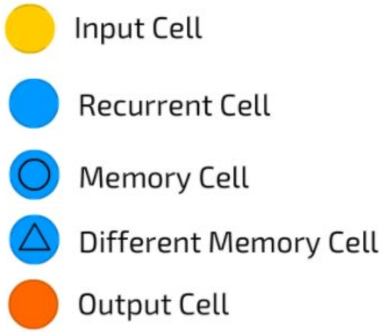


More details:
D2L2, “Recurrent Neural Networks”

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

Recurrent Neural Network (RNN)





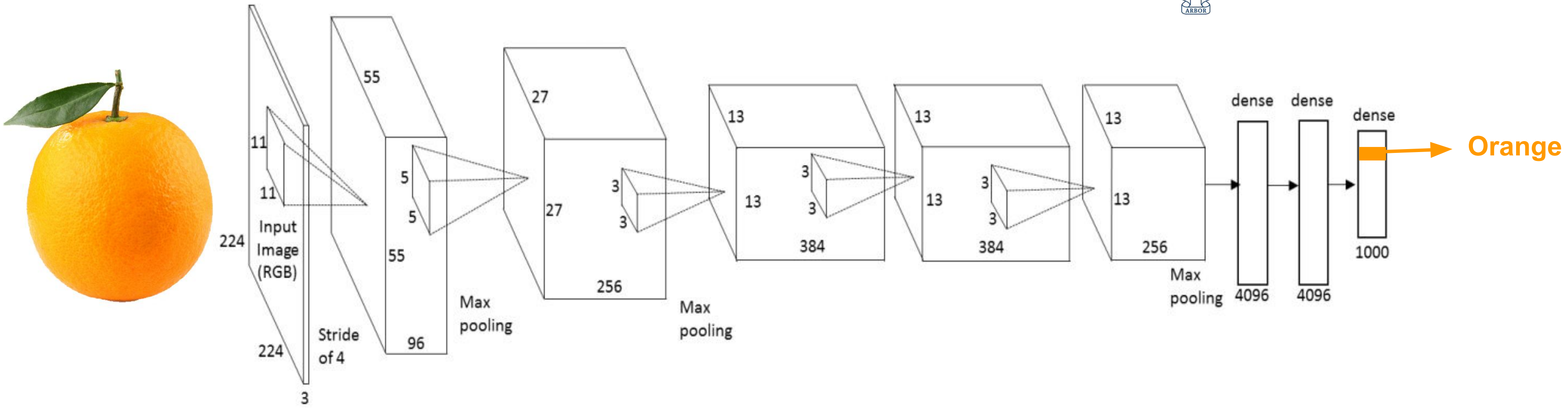
More details:
D2L2, “Recurrent Neural Networks”

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

Recurrent Neural Network (RNN)

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

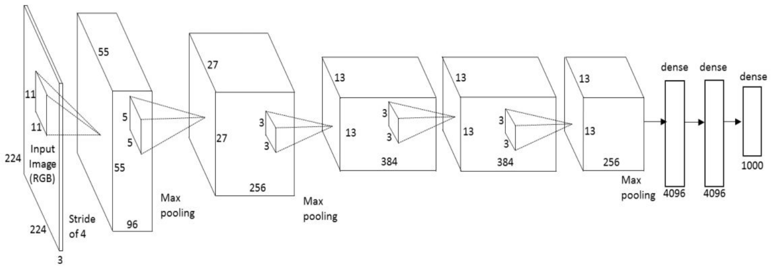
Convolutional Neural Network (CNN)

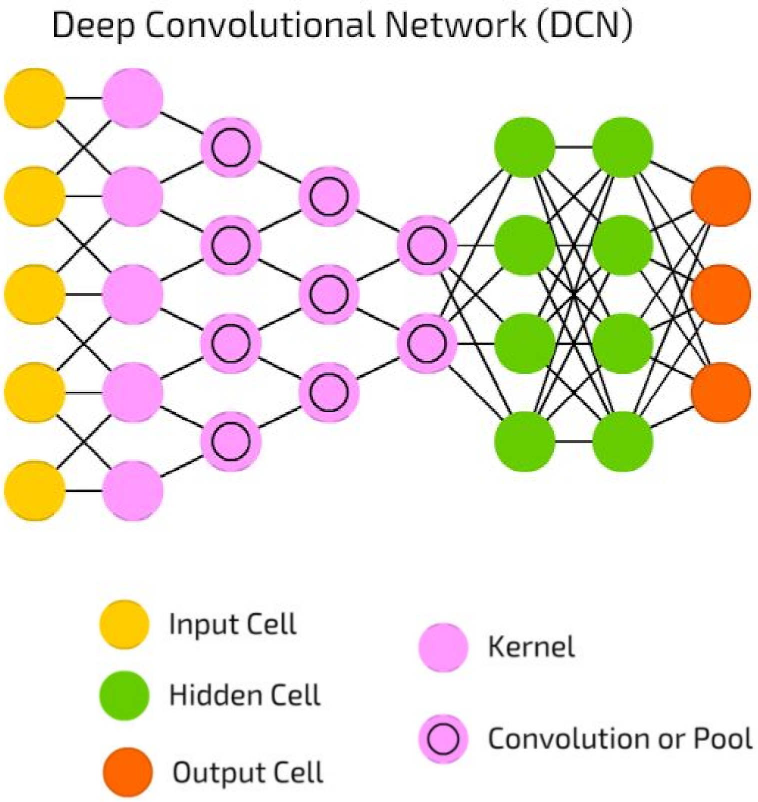


A Krizhevsky, I Sutskever, GE Hinton "Imagenet classification with deep convolutional neural networks" Part of: Advances in Neural Information Processing Systems 25 (NIPS 2012)

Slide credit: Junting Pan, "Visual Saliency Prediction using Deep Learning Techniques" (ETSETB-UPC 2015)

Convolutional Neural Network (CNN)

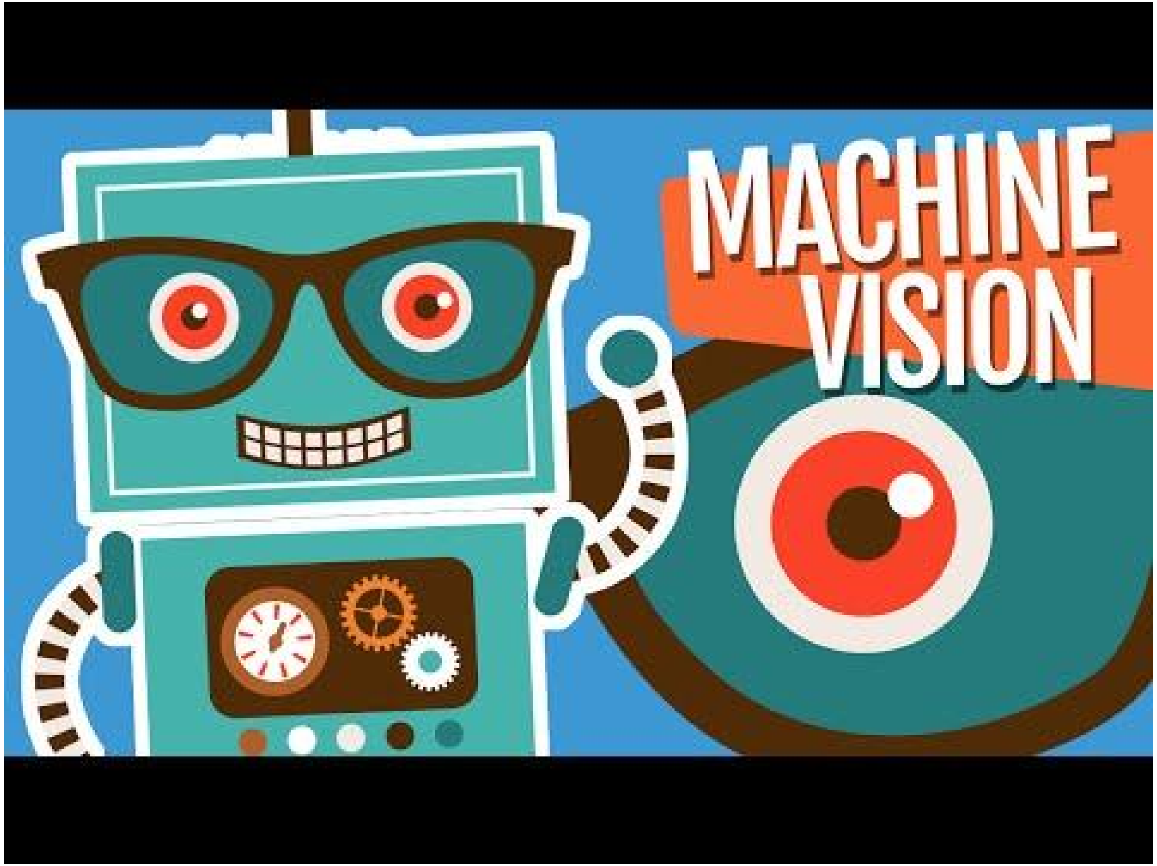




More details:
D1L3, [“Convolutional Neural Networks”]

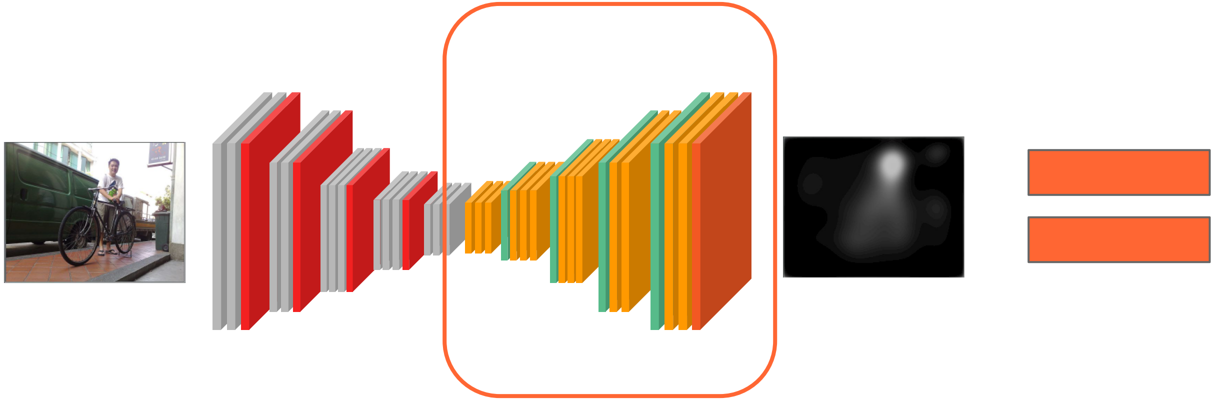
F. Van Veen, [“The Neural Network Zoo”] (2016)

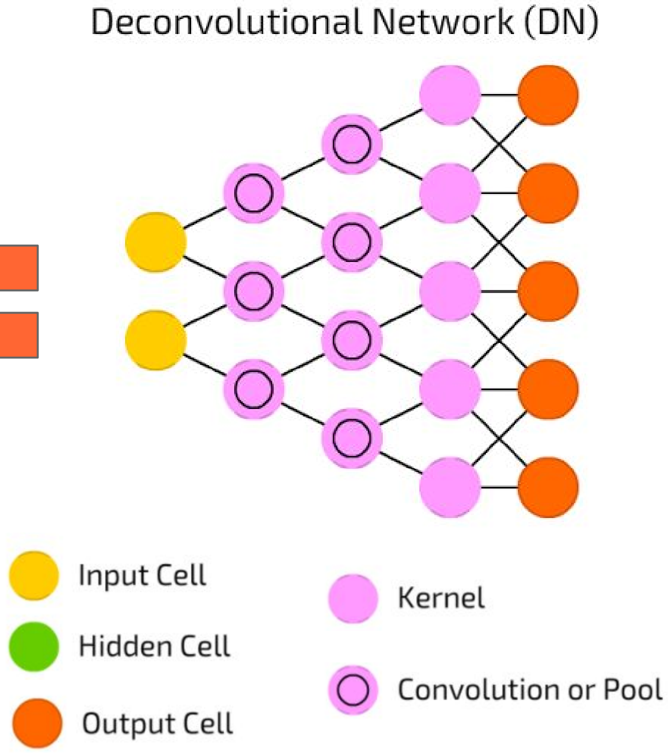
Convolutional Neural Network (CNN)



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

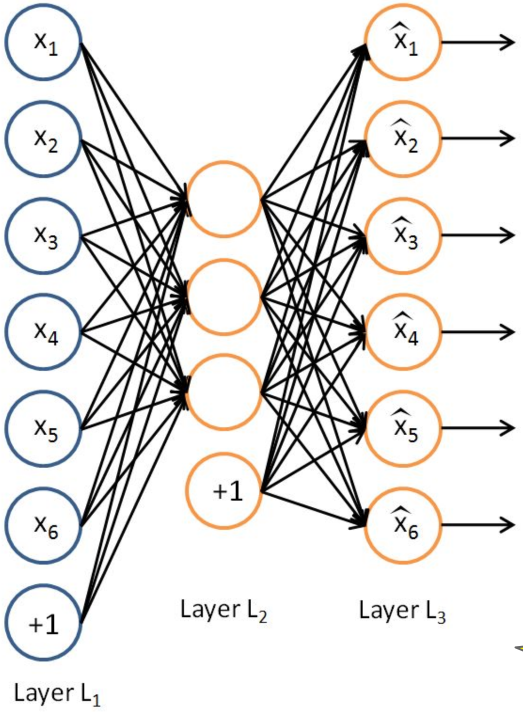
Deconvolutional Neural Network (Deconv)





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

Autoencoder (AE)



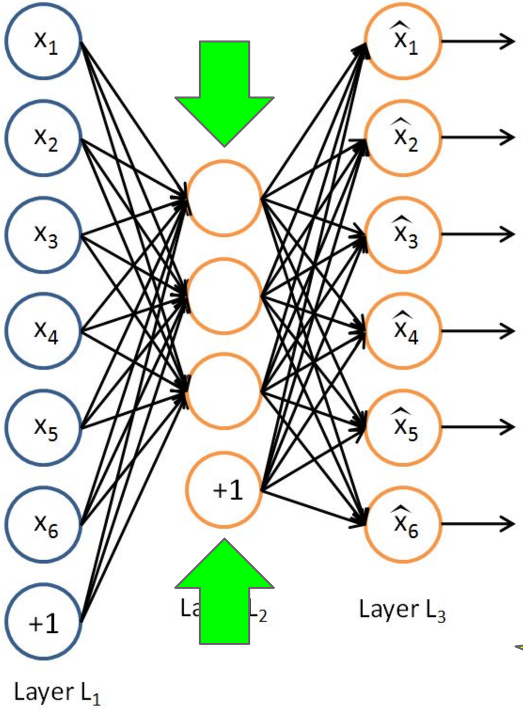
Autoencoders:

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

Unsupervised learning

“Deep Learning Tutorial”, Dept. Computer Science, Stanford

Autoencoder (AE)



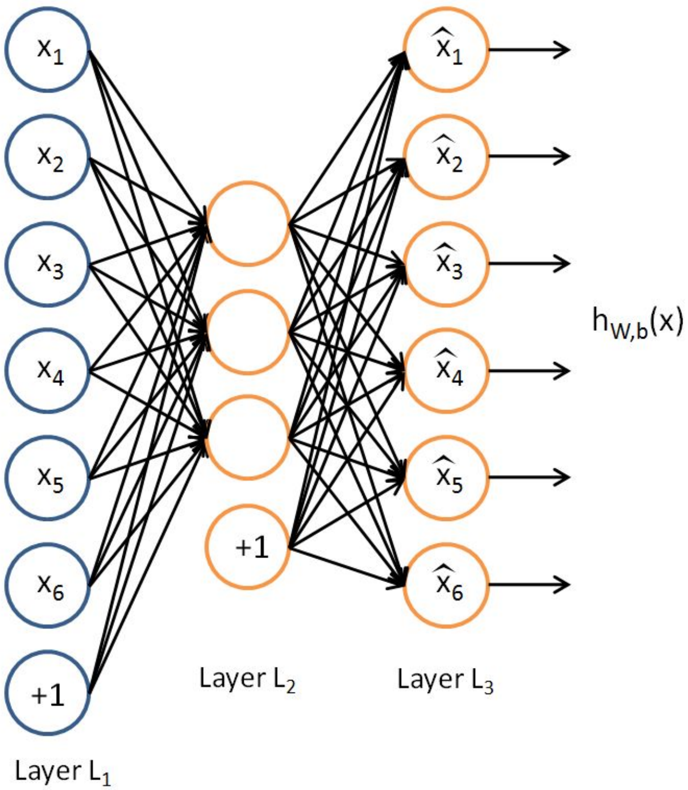
Dimensionality reduction:

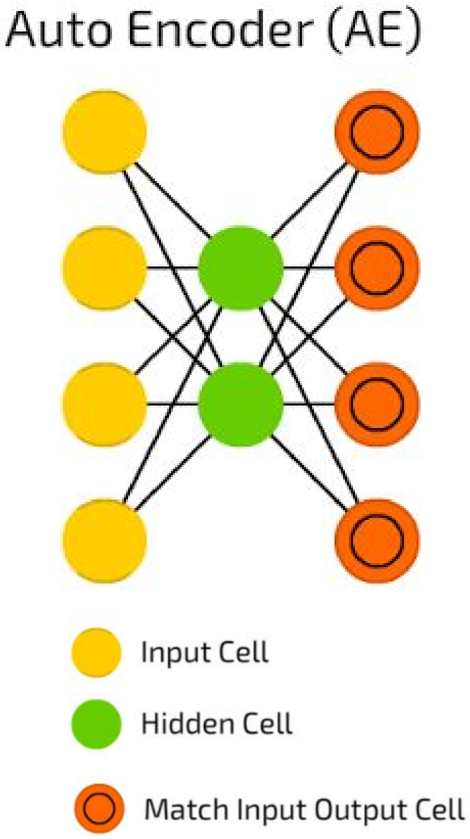
- Use hidden layer as a feature extractor of the desired size.

Unsupervised learning

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

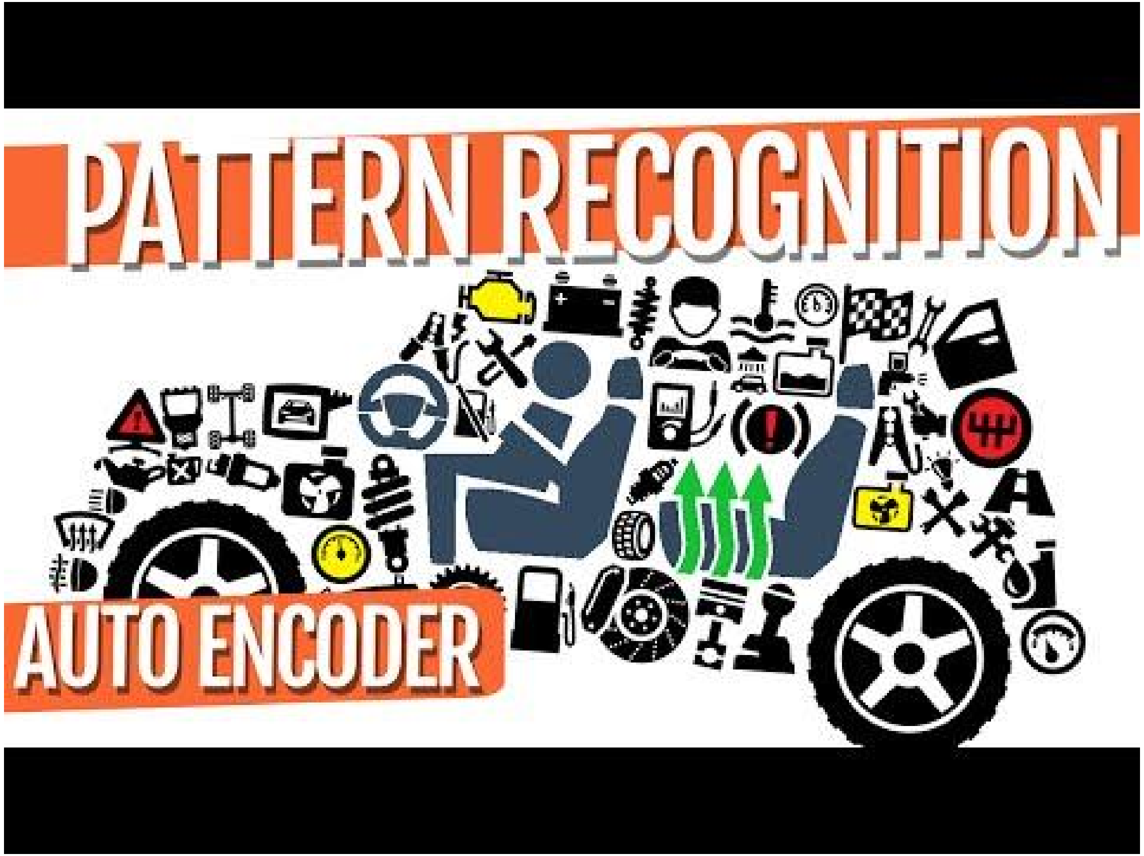
Autoencoder (AE)





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

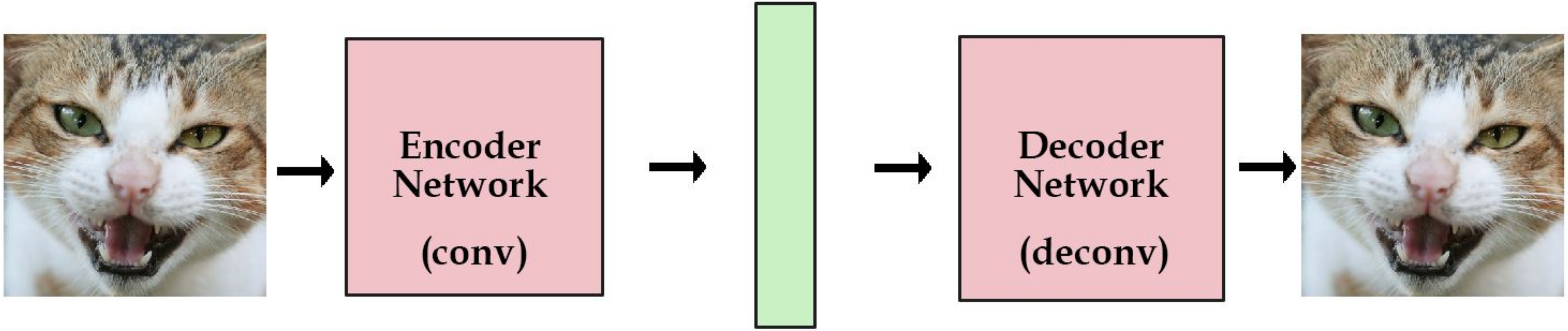
Autoencoder (AE)



Deep Learning TV, “Autoencoders - Ep. 10”

Variational Autoencoder (VAE)

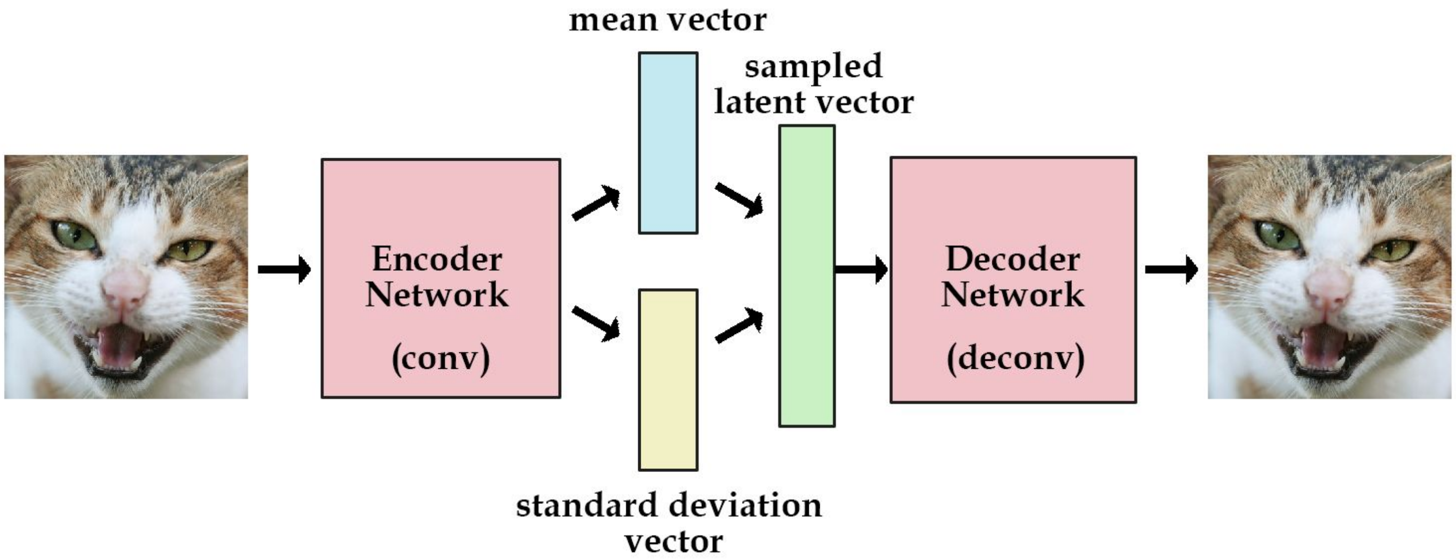
The latent vector learned in the hidden layer of the basic autoencoder (in green)...



Kevin Frans, [“Variational Autoencoders explained”]() (2016)

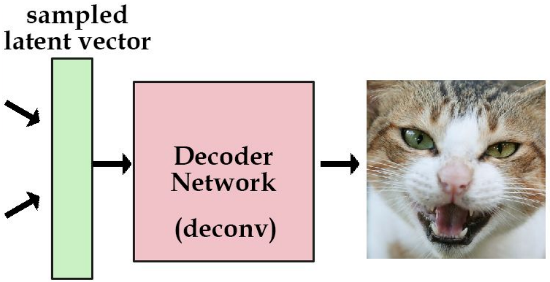
Variational Autoencoder (VAE)

...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.

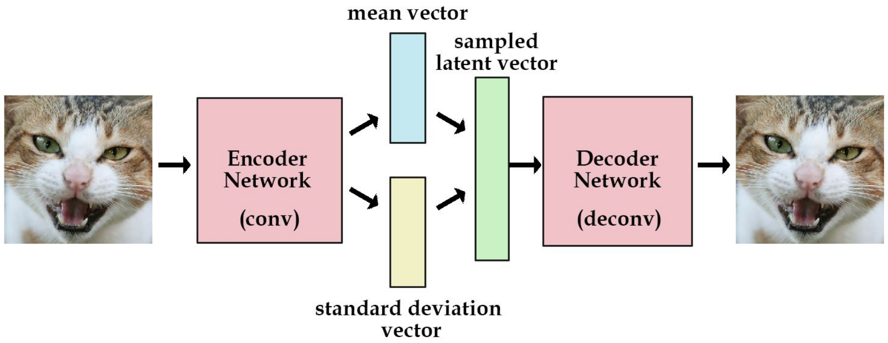
Unsupervised learning

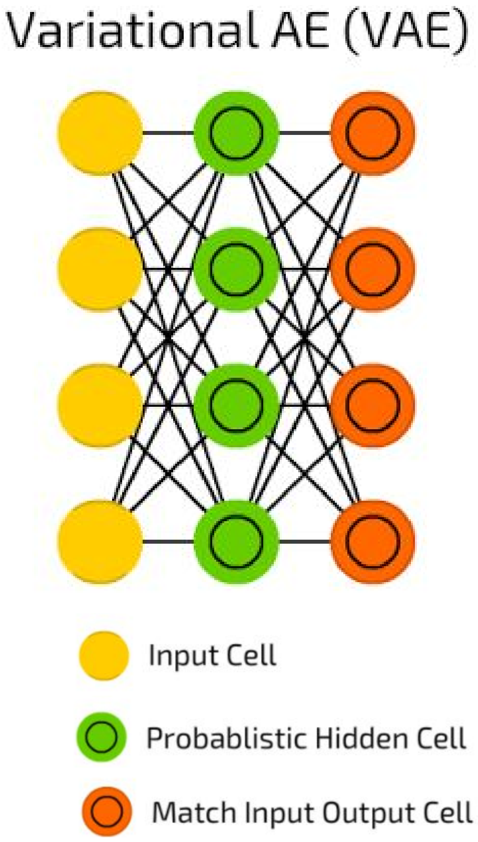
"Deep Learning Tutorial", Dept. Computer Science, Stanford

Variantional Autoencoder (VAE)

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

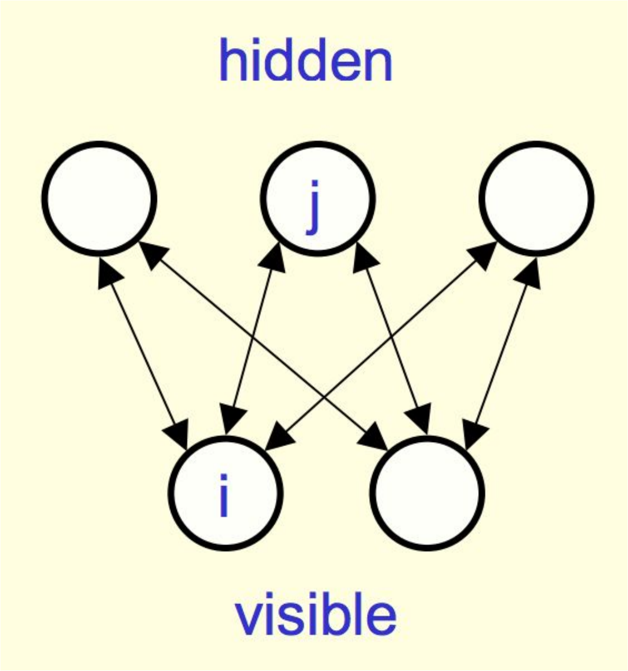
Variational Autoencoder (VAE)





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)

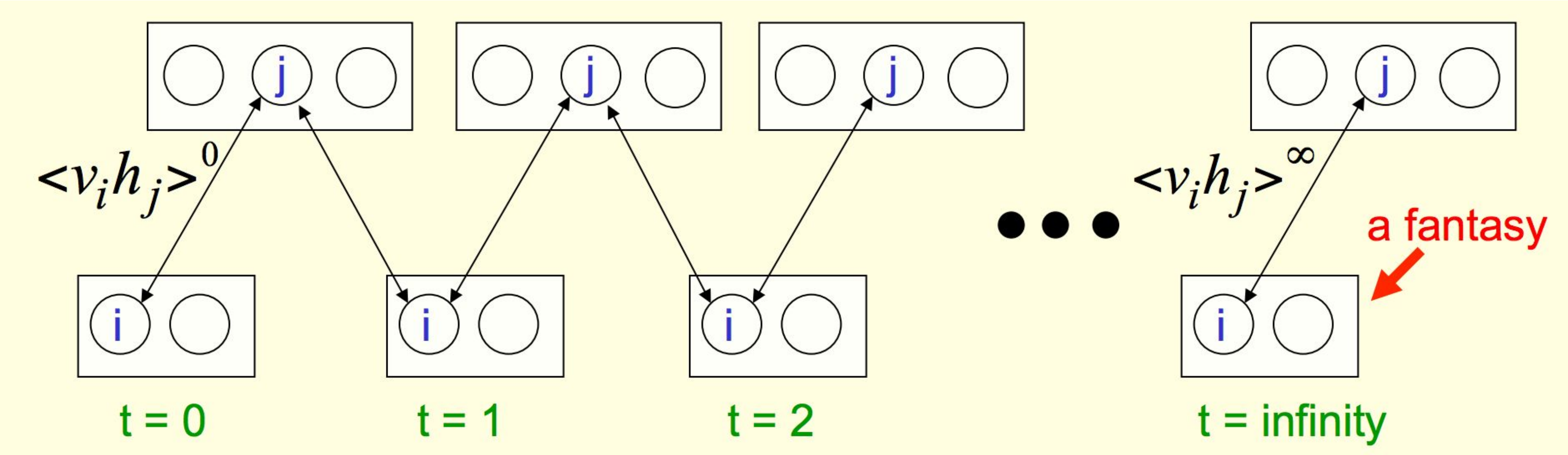
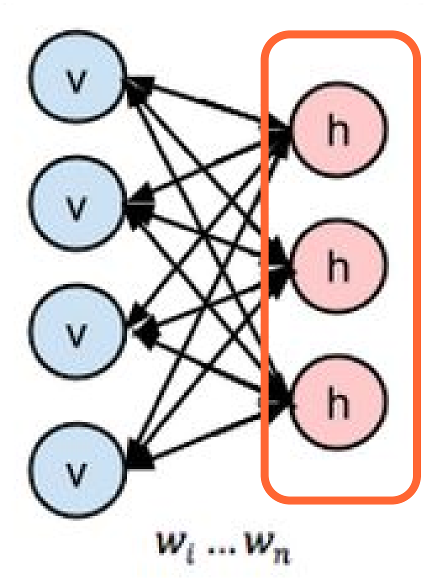


Figure: Geoffrey Hinton (2013)

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)

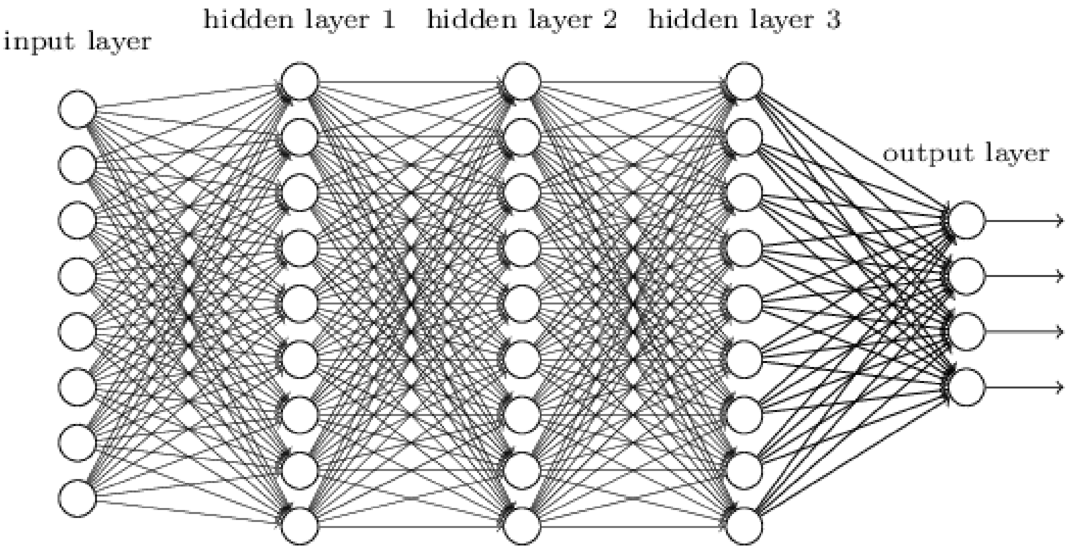


RBMs are a specific type of **autoencoder**.

Unsupervised learning

DeepLearning4j, [“A Beginner’s Tutorial for Restricted Boltzmann Machines”.]

Deep Belief Networks (DBN)

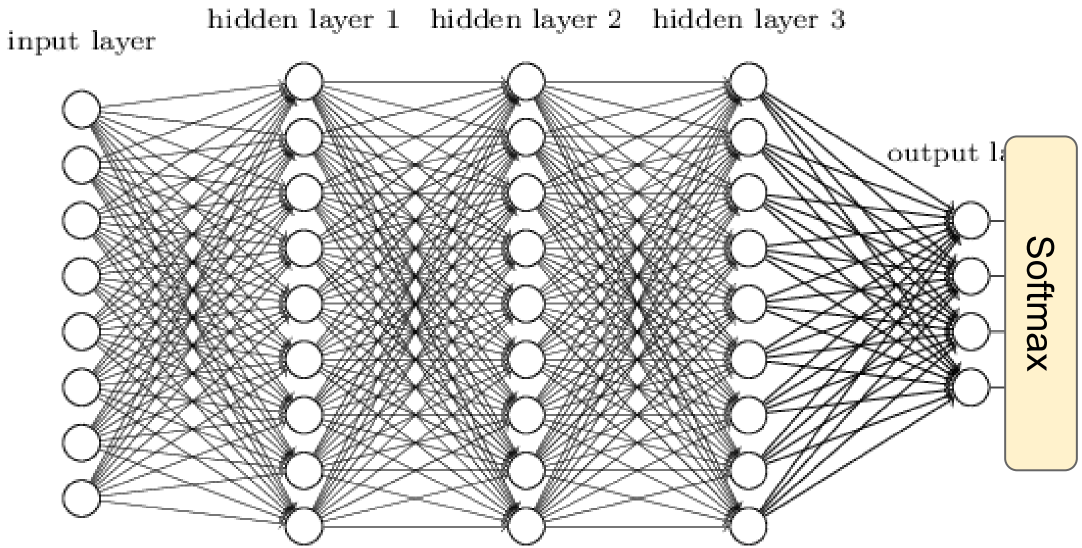


- Architecture like an MLP.
- Training as a stack of RBMs…
- ...so they do not need labels:

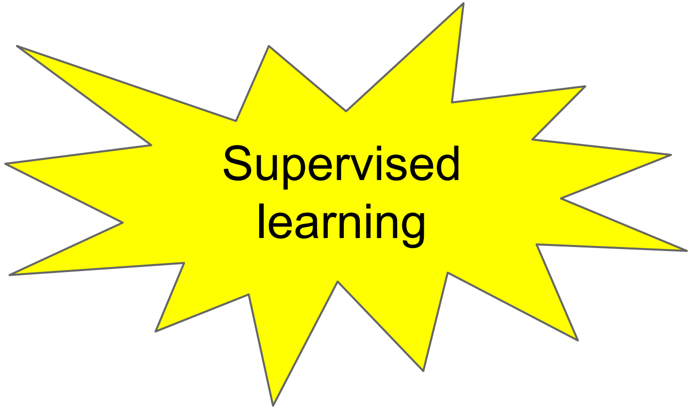
Unsupervised learning

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)

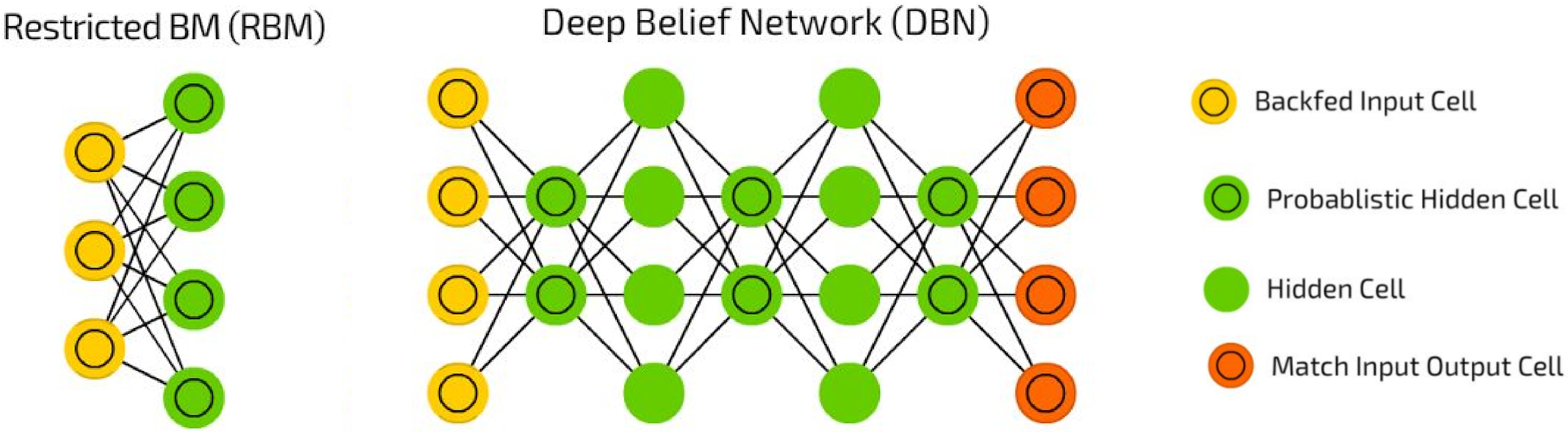


After the DBN is trained, it can be fine-tuned with a **reduced amount of labels** to solve a supervised task with superior performance.



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)



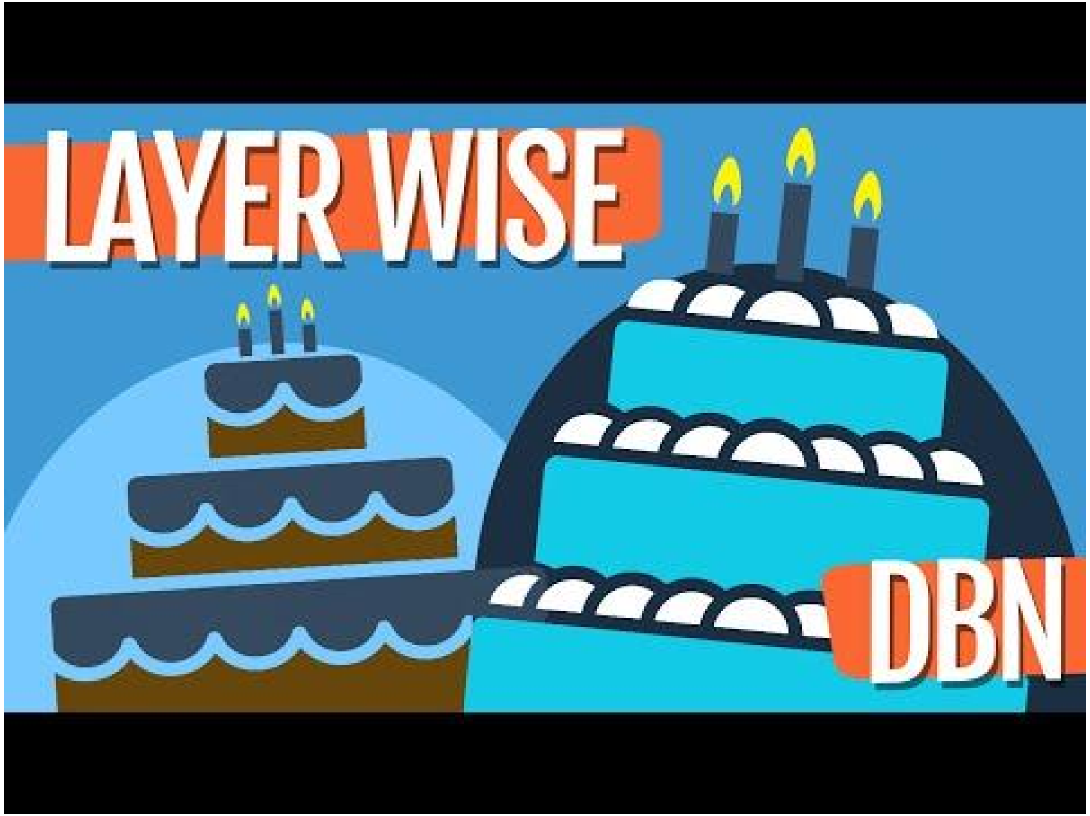
More details:
D2L1,"Deep Belief Networks"

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

Restricted Boltzmann Machine (RBM)

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

Deep Belief Networks (DBN)

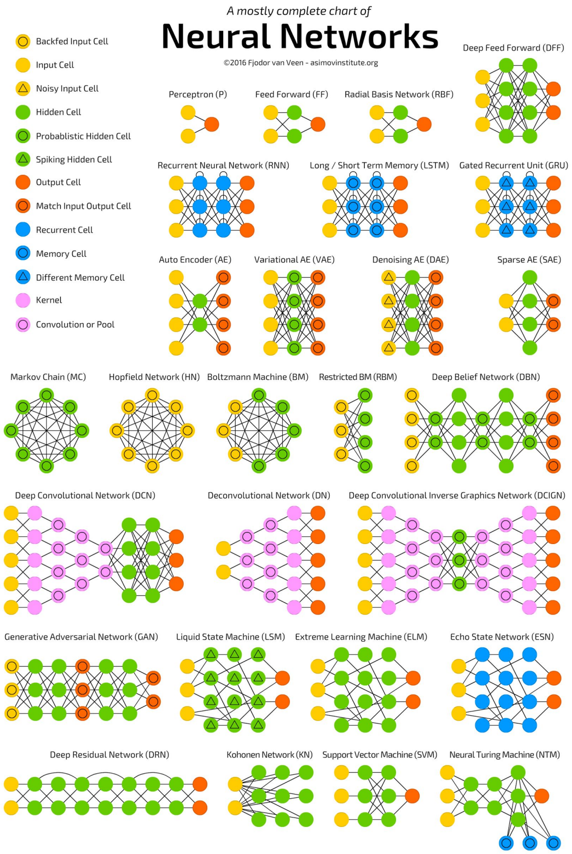


Deep Learning TV, [“Deep Belief Nets”]()

Deep Belief Networks (DBN)

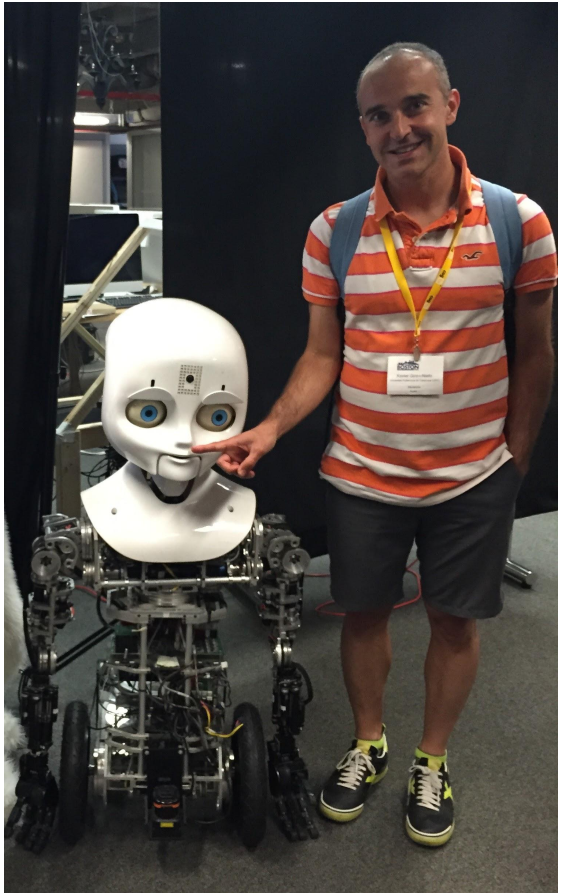
Geoffrey Hinton, "Introduction to Deep Learning & Deep Belief Nets" (2012)
Geoorey Hinton, "Tutorial on Deep Belief Networks". NIPS 2007.

The Full Story



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

Thanks ! Q&A ?



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