

INTRODUCTION TO DEEP LEARNING

Winter School at UPC TelecomBCN Barcelona. 22-30 January 2018.



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Supporters



aws educate



+ info: <https://telecombcn-dl.github.io/2018-idl/>

<http://bit.ly/idl2018>



#DLUPC

Day 4 Lecture 4

The Neural Network Zoo (& some research at UPC)



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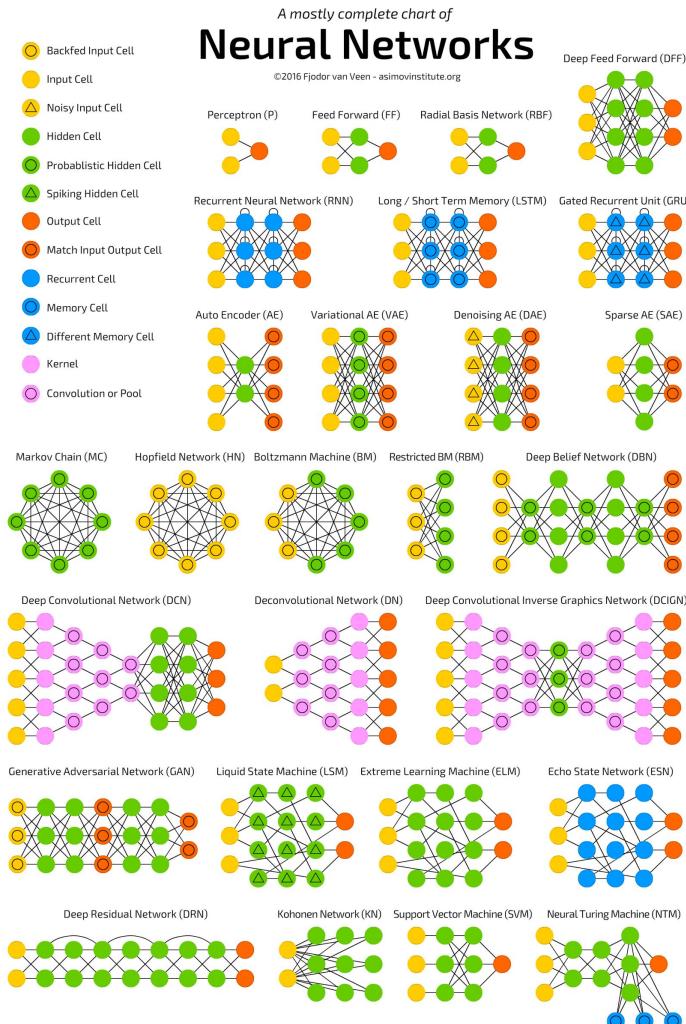
Associate Professor
Universitat Politècnica de Catalunya
Technical University of Catalonia



Acknowledgements



Fjodor Van Veen,
“The Neural Network Zoo”
The Asimov Institute (2016)



Acknowledgements

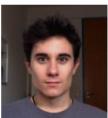
Phd



Amaia
Salvador



Miriam
Bellver



Víctor
Campos



Dèlia
Fernández



Eduard
Ramon



Amanda
Duarte



Marc
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Fran
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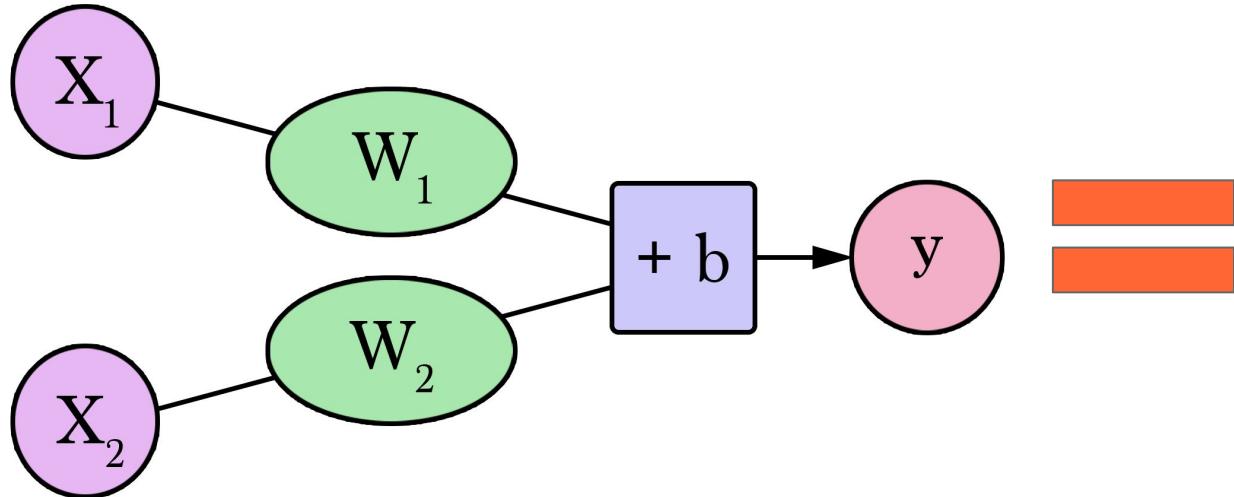
Janna
Escur



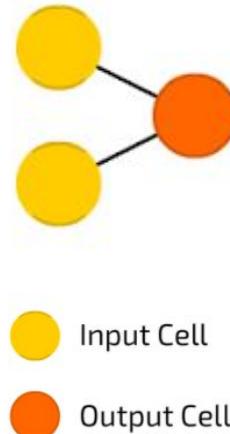
Miquel
Oller

BSc

A Perceptron

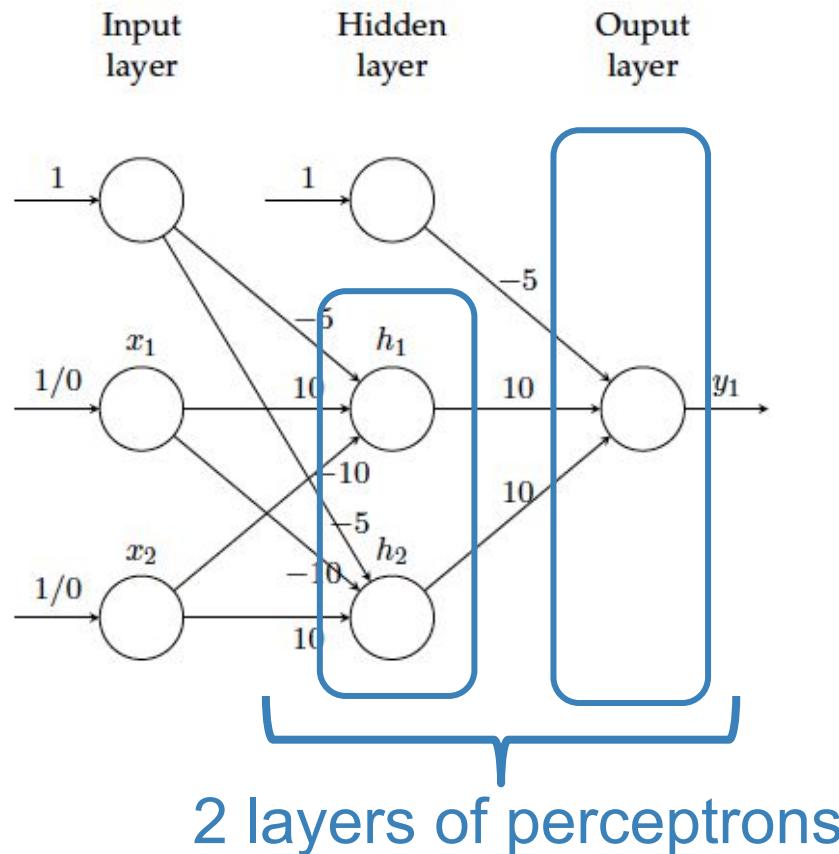


Perceptron (P)

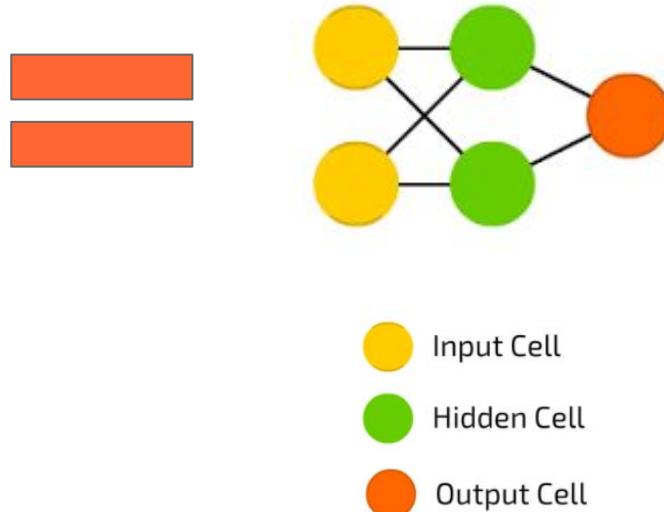


J. Alammar, [“A visual and interactive guide to the Basics of Neural Networks”](#) (2016)
F. Van Veen, [“The Neural Network Zoo”](#) (2016)

Neural Network = Multi Layer Perceptron

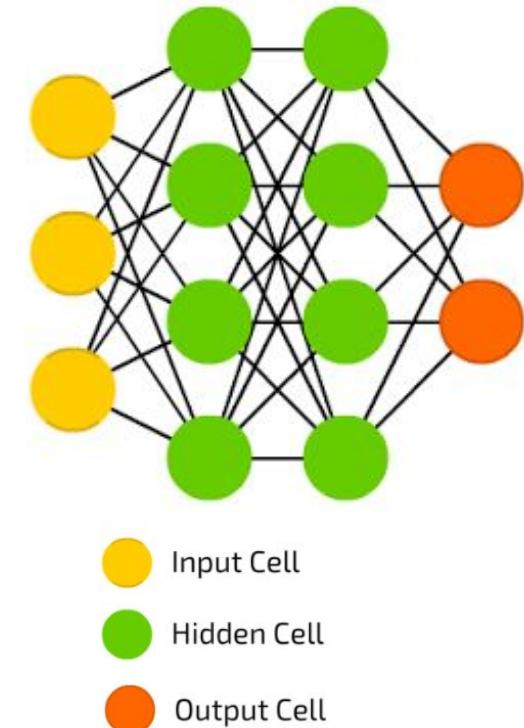
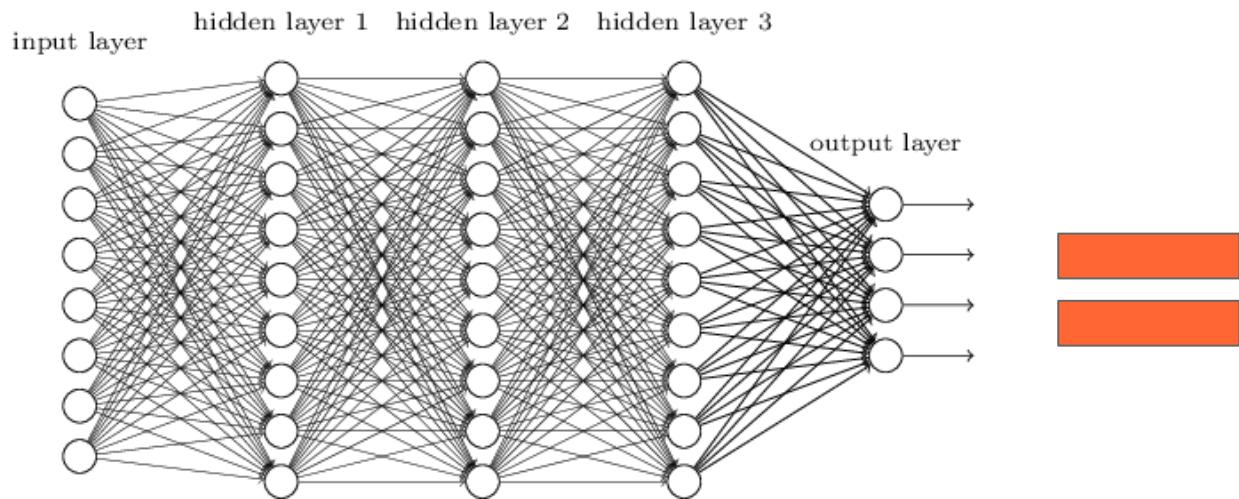


Feed Forward (FF)



Deep Neural Network (DNN)

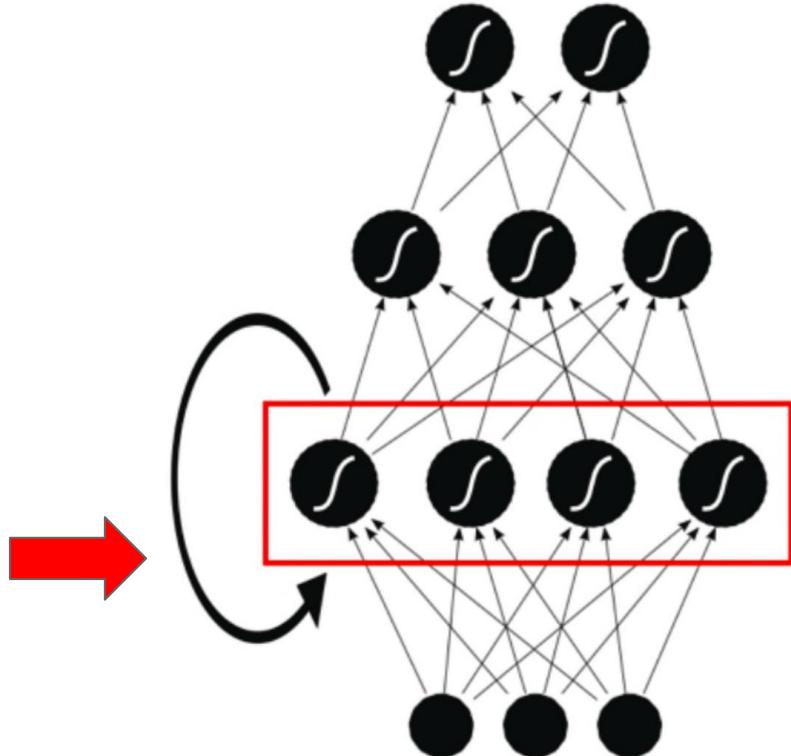
Deep Feed Forward (DFF)



Recurrent Neural Network (RNN)

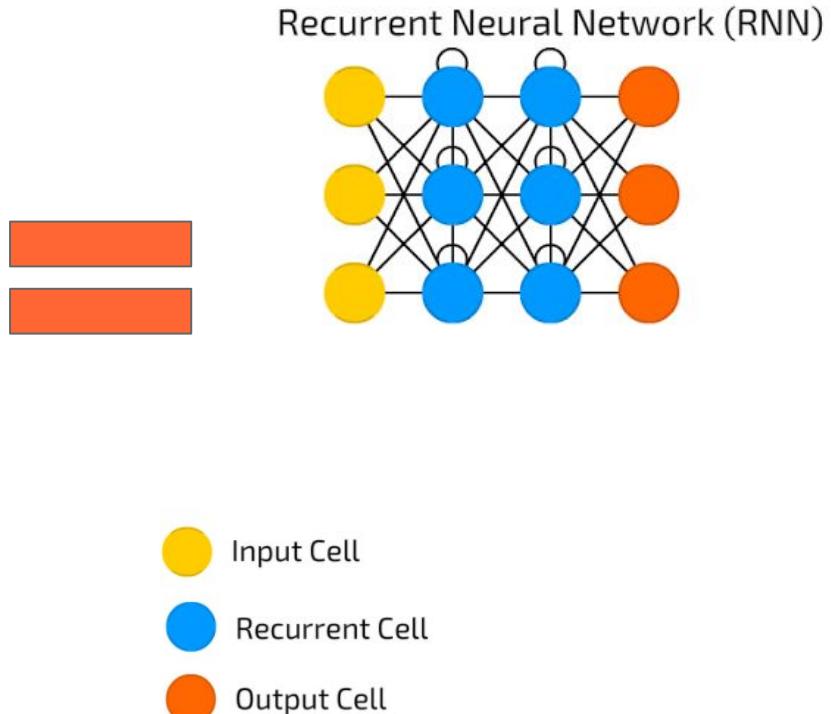
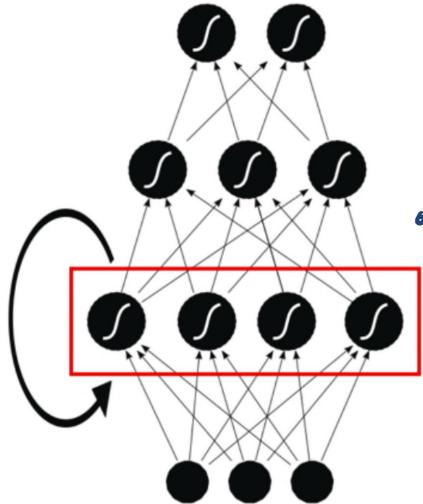


The hidden layers and the output depend from previous states of the hidden layers



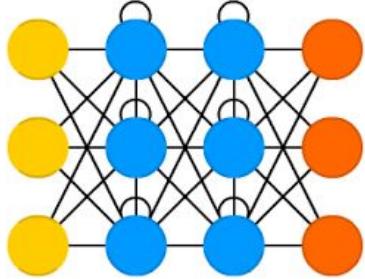
Alex Graves, "[Supervised Sequence Labelling with Recurrent Neural Networks](#)"

Recurrent Neural Network (RNN)

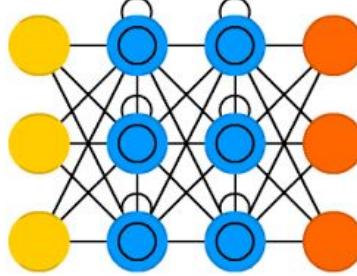


Recurrent Neural Network (RNN)

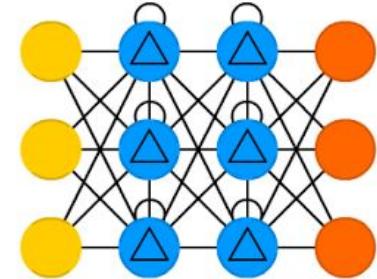
Recurrent Neural Network (RNN)



Long / Short Term Memory (LSTM)



Gated Recurrent Unit (GRU)



- Input Cell
- Recurrent Cell
- Memory Cell
- Different Memory Cell
- Output Cell

Recurrent Neural Network (RNN)

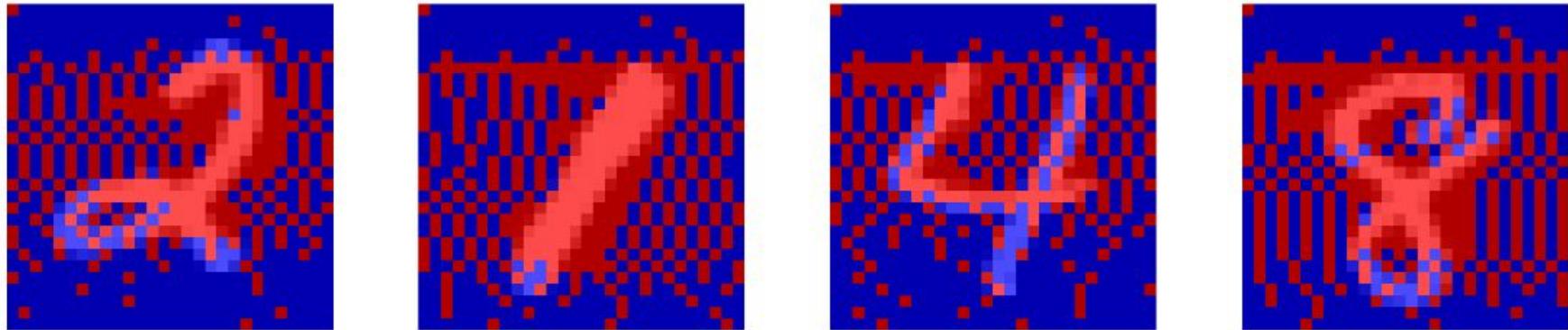
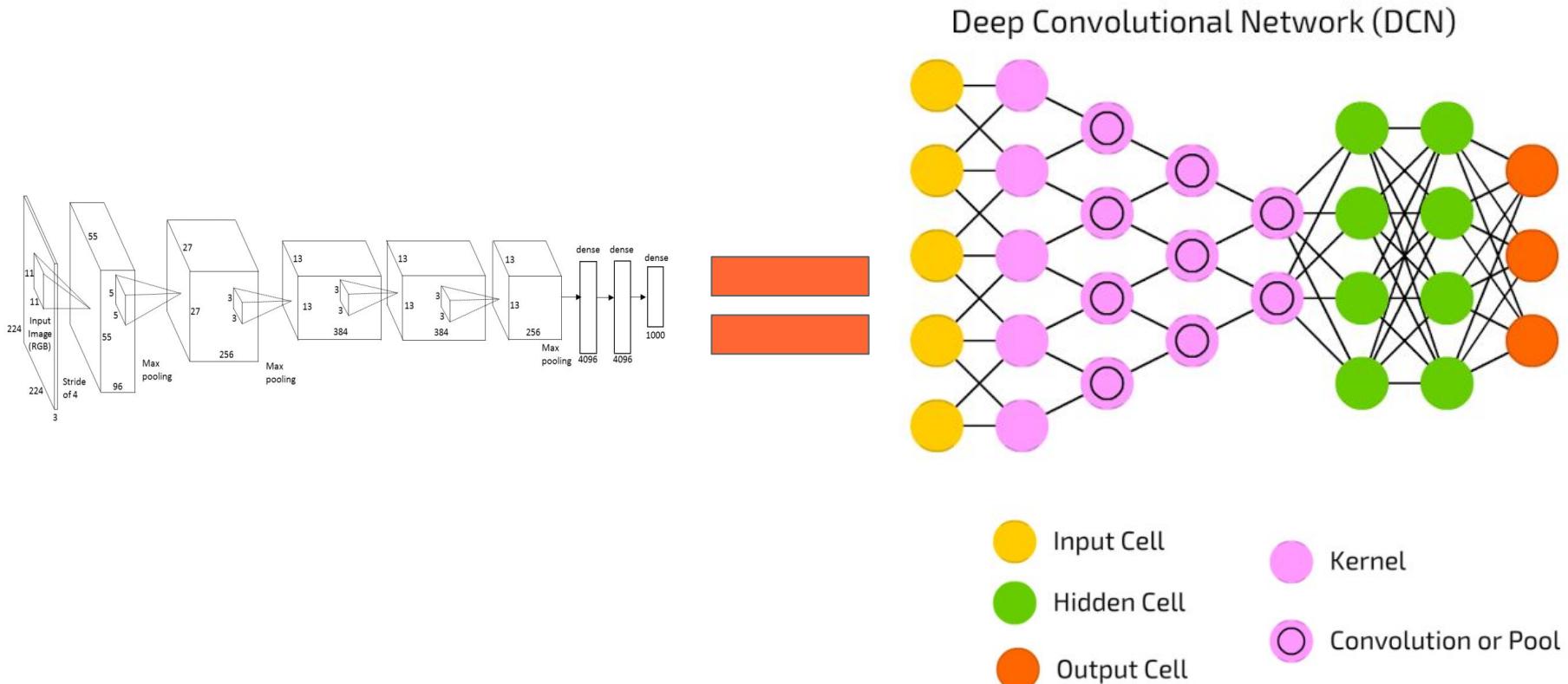


Figure 3: Sample usage examples for the Skip LSTM with $\lambda = 10^{-4}$ on the test set of MNIST. Red pixels are used, whereas blue ones are skipped.

Recurrent Neural Network (RNN)

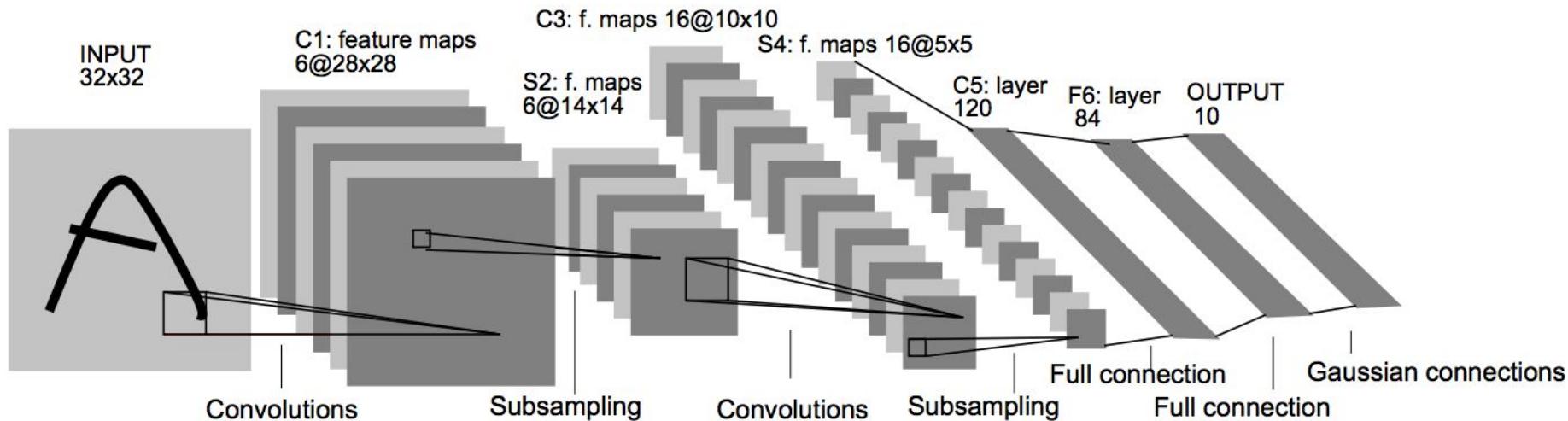


Convolutional Neural Network (CNN)



Convolutional Neural Network (CNN)

LeNet-5



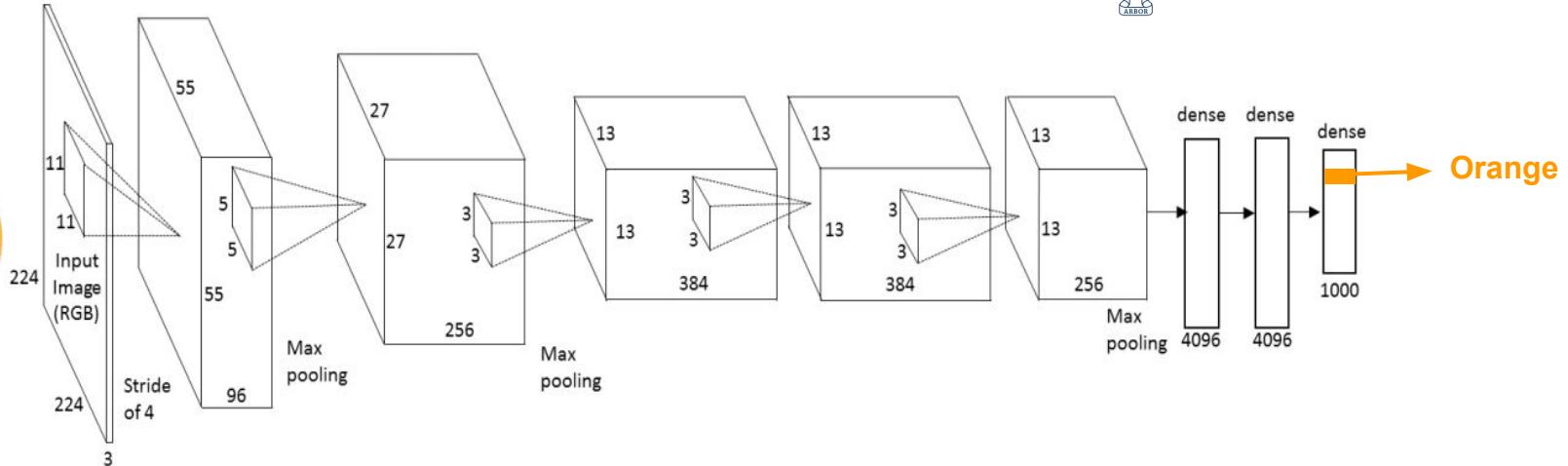
LeCun, Y., Bottou, L., Bengio, Y., & Haffner, P. (1998). [Gradient-based learning applied to document recognition](#). *Proceedings of the IEEE*, 86(11), 2278-2324.

Convolutional Neural Network (CNN)

AlexNet

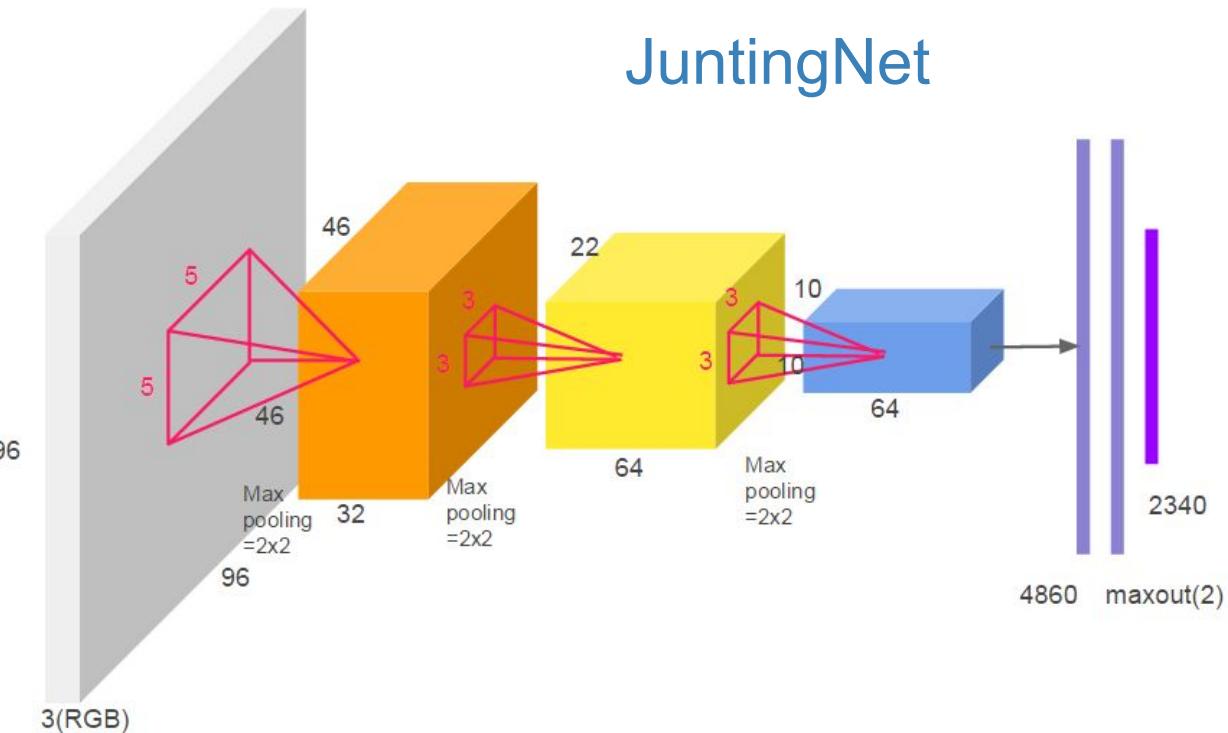


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A Krizhevsky, I Sutskever, GE Hinton “[Imagenet classification with deep convolutional neural networks](#)”
NIPS 2012.

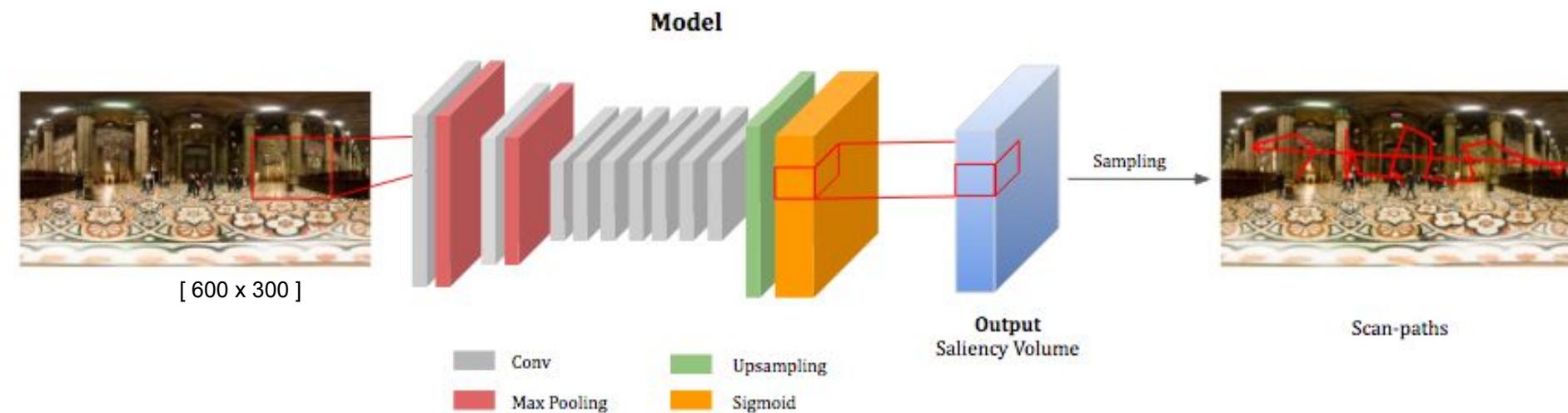
Convolutional Neural Network (CNN)



Junting Pan, Kevin McGuinness, Elisa Sayrol, Noel O'Connor, and Xavier Giro-i-Nieto. "[Shallow and Deep Convolutional Networks for Saliency Prediction.](#)" CVPR 2016.

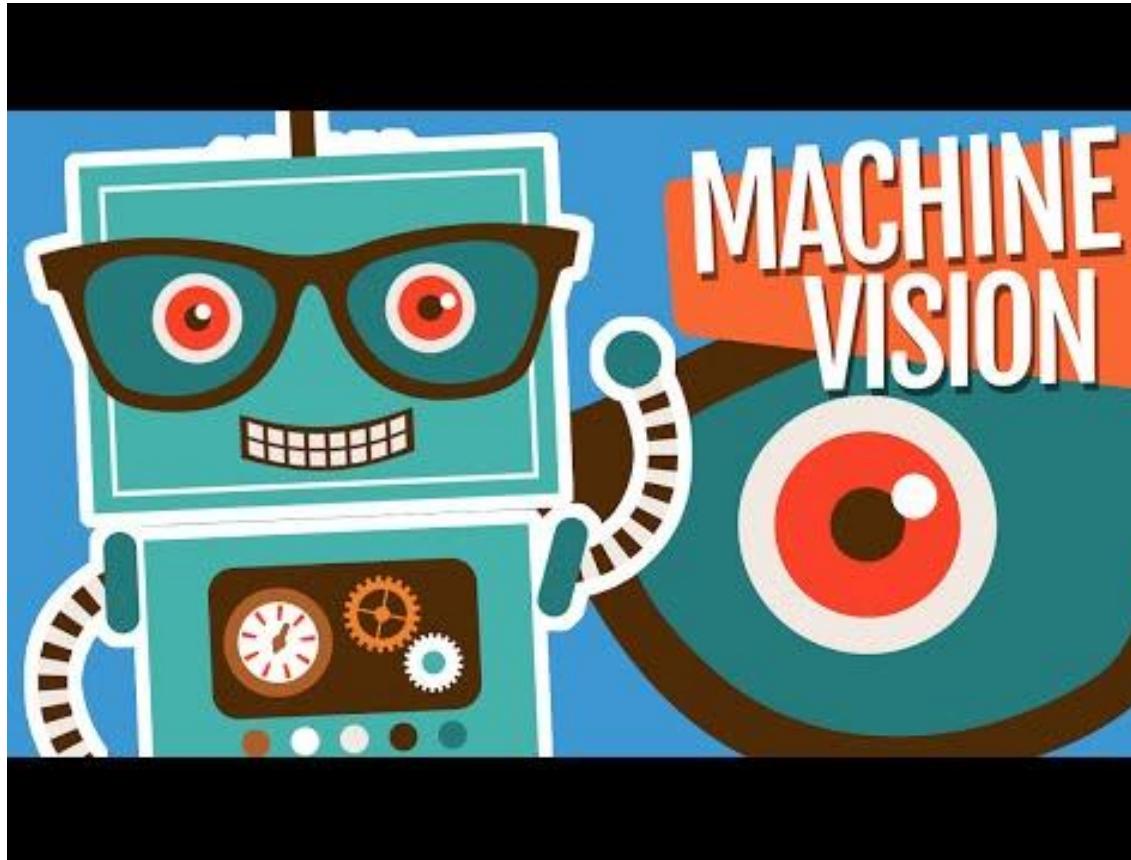
Convolutional Neural Network (CNN)

SaltiNet

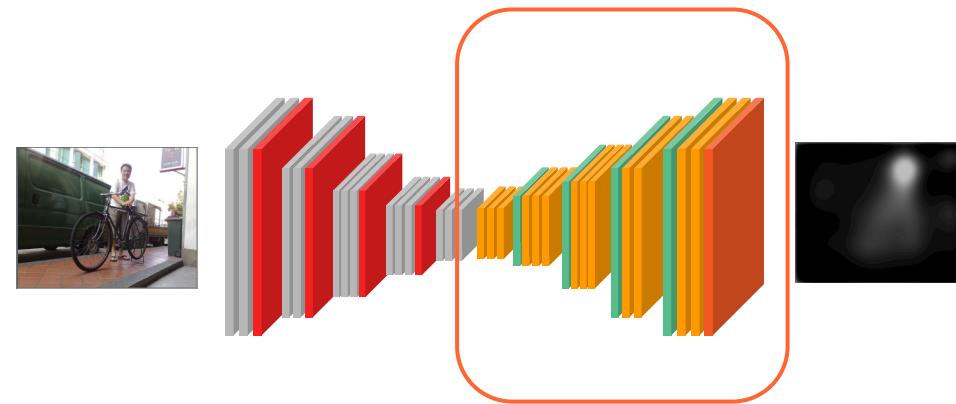


Marc Assens, Kevin McGuinness, Noel E. O'Connor, Xavier Giró-i-Nieto, "[SaltiNet: Scan-path Prediction on 360 Degree Images using Saliency Volumes](#)". ICCVW 2017. (**winner Salient360 2017**)

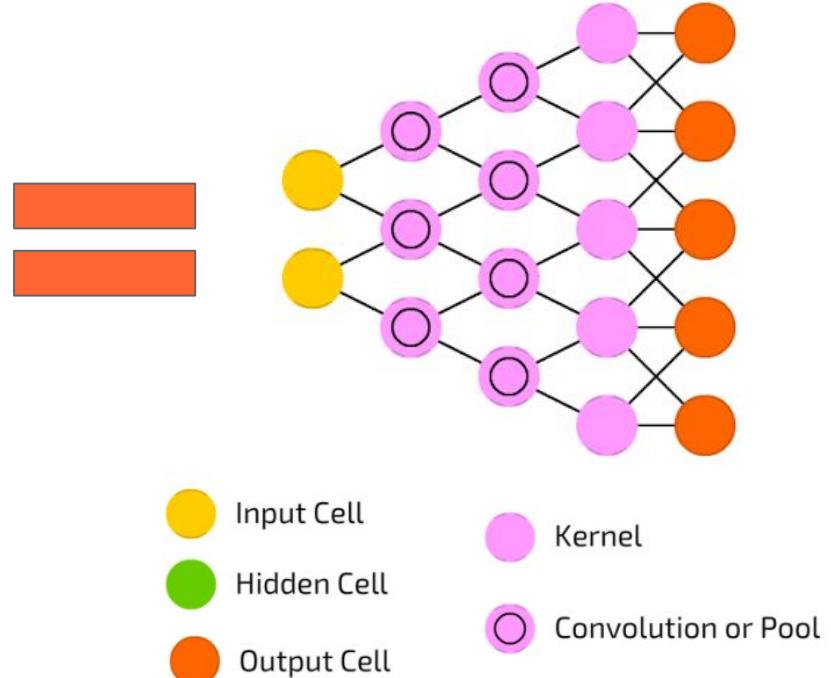
Convolutional Neural Network (CNN)



Deconvolutional Neural Network (Deconv)

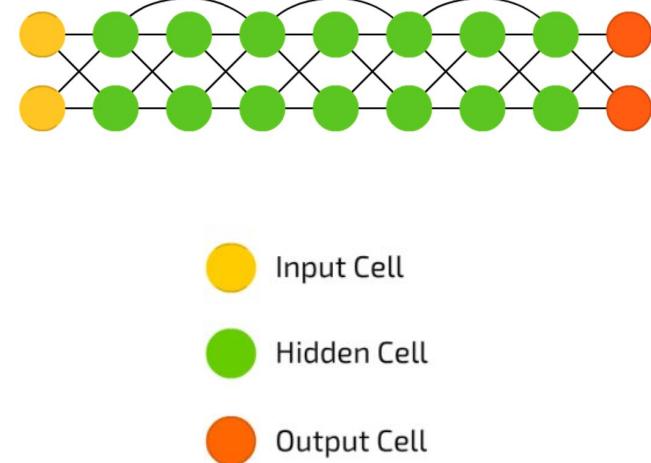
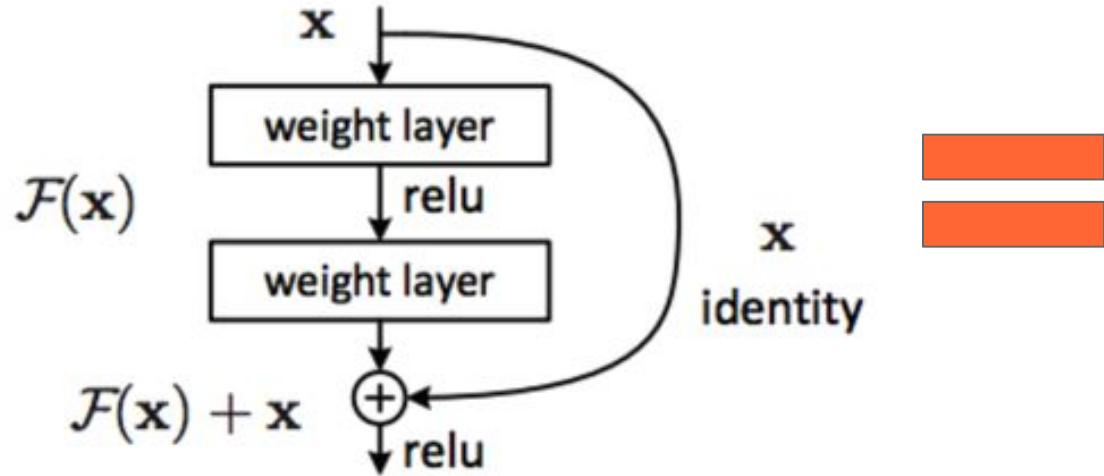


Deconvolutional Network (DN)



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

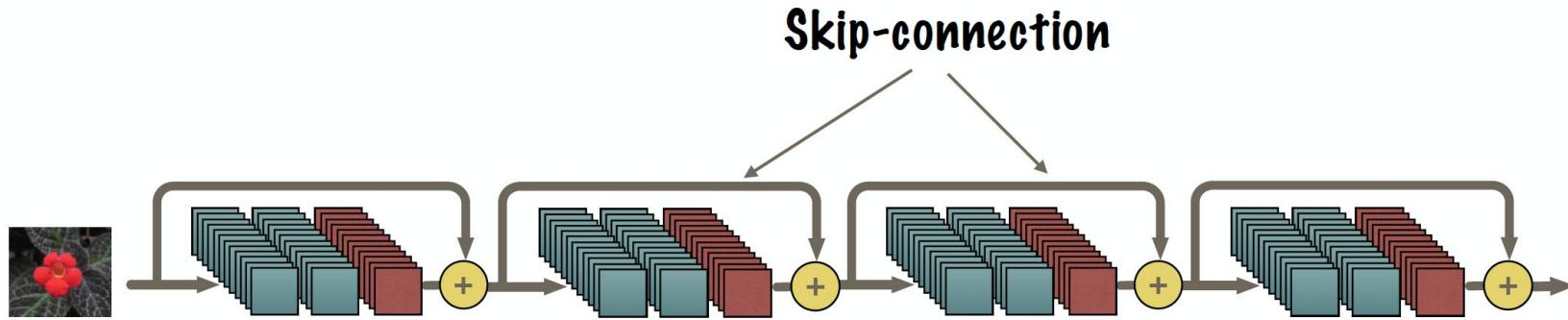
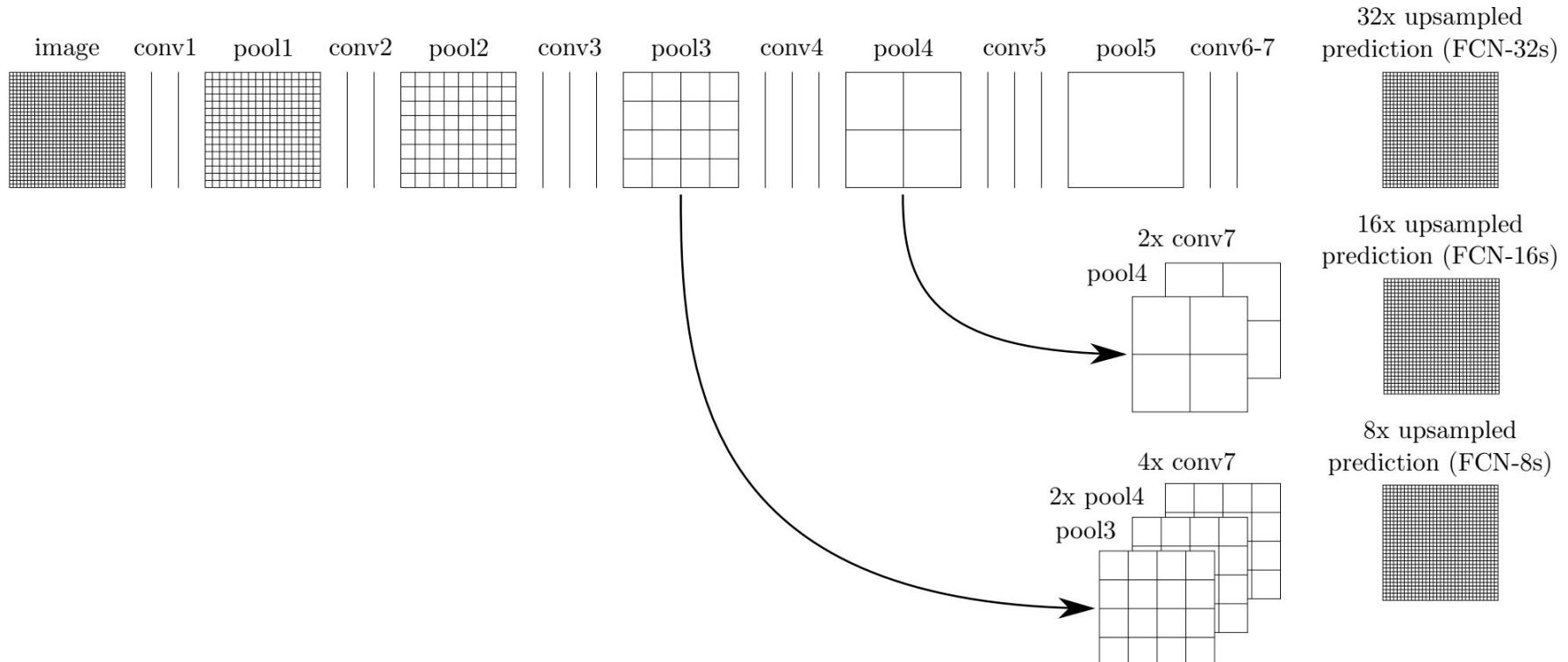


Figure: Kilian Weinberger

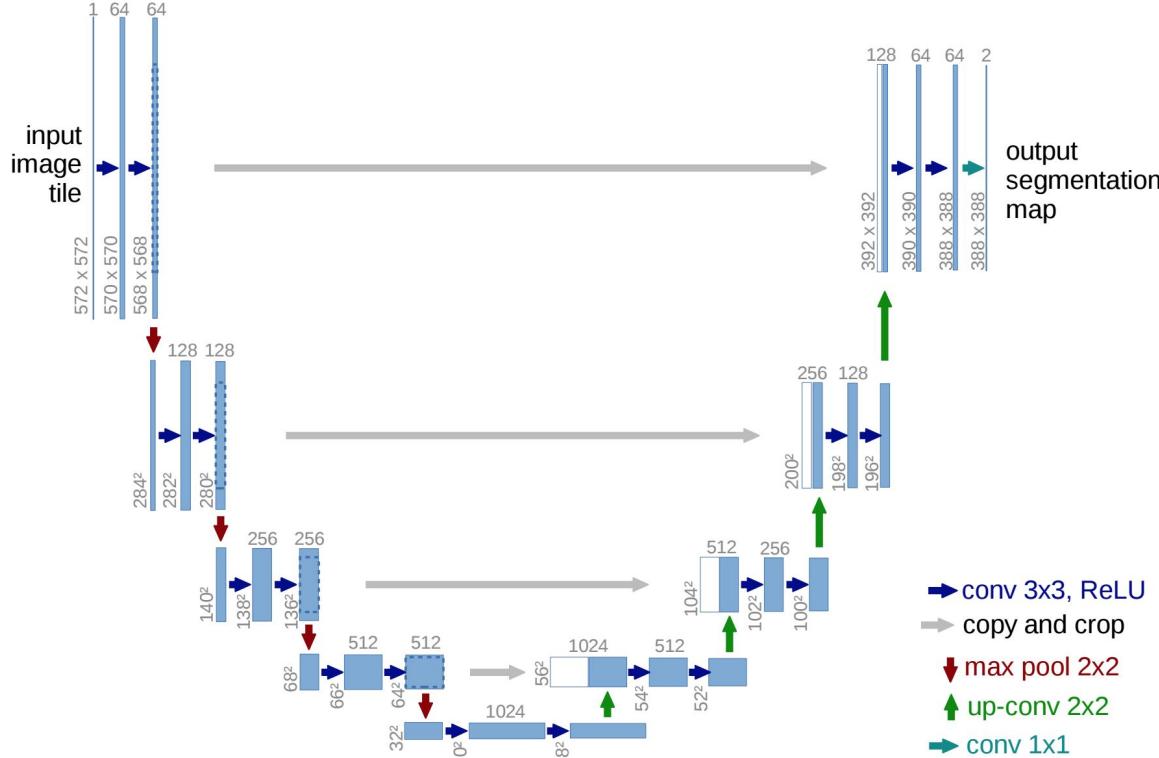
Deep Residual Learning / Skip connections



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

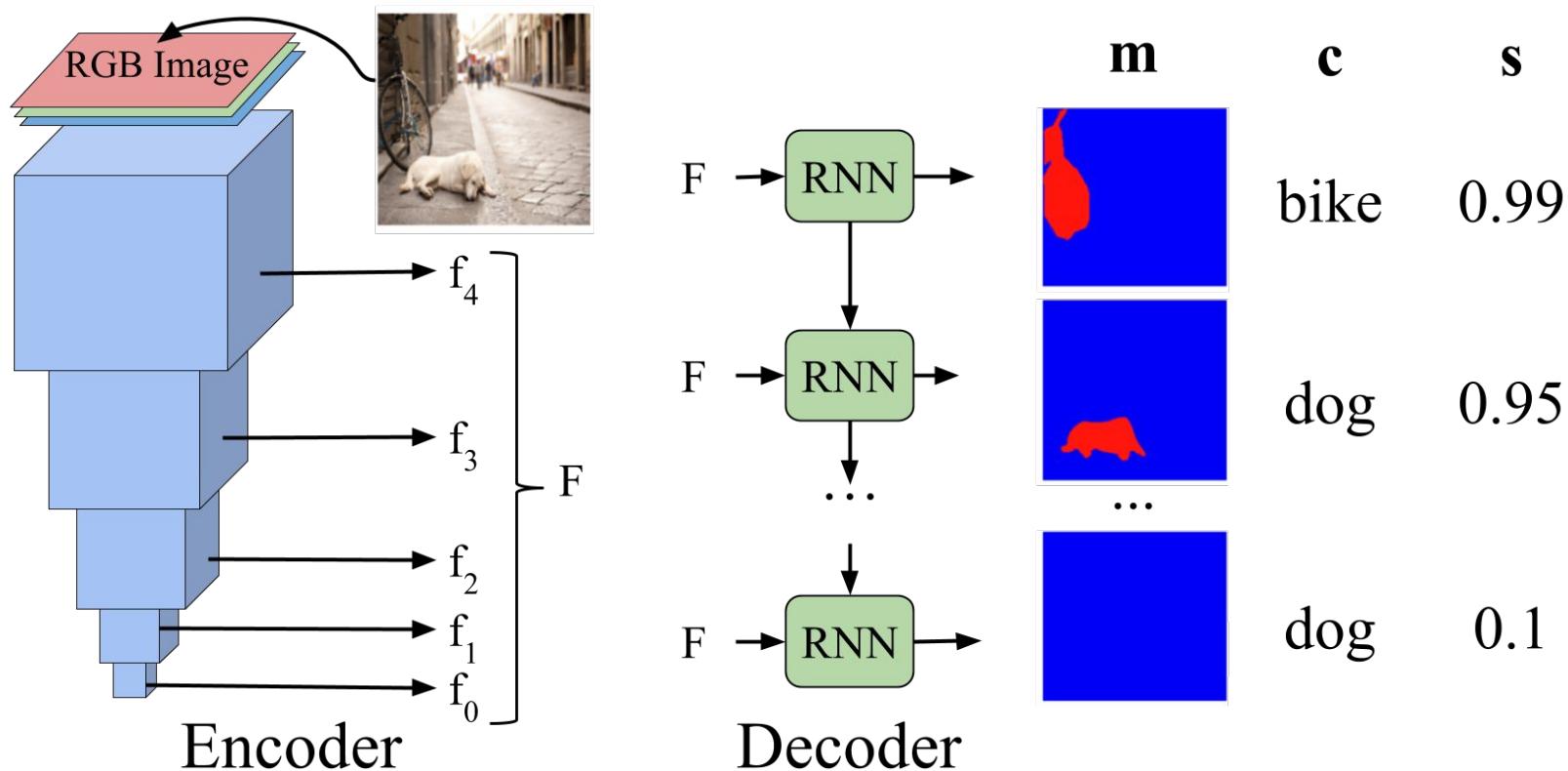
Deep Residual Learning / Skip connections

U-Net



Ronneberger, Olaf, Philipp Fischer, and Thomas Brox. "[U-net: Convolutional networks for biomedical image segmentation.](#)" MICCAI 2015

CNN + RNN + Skip connections

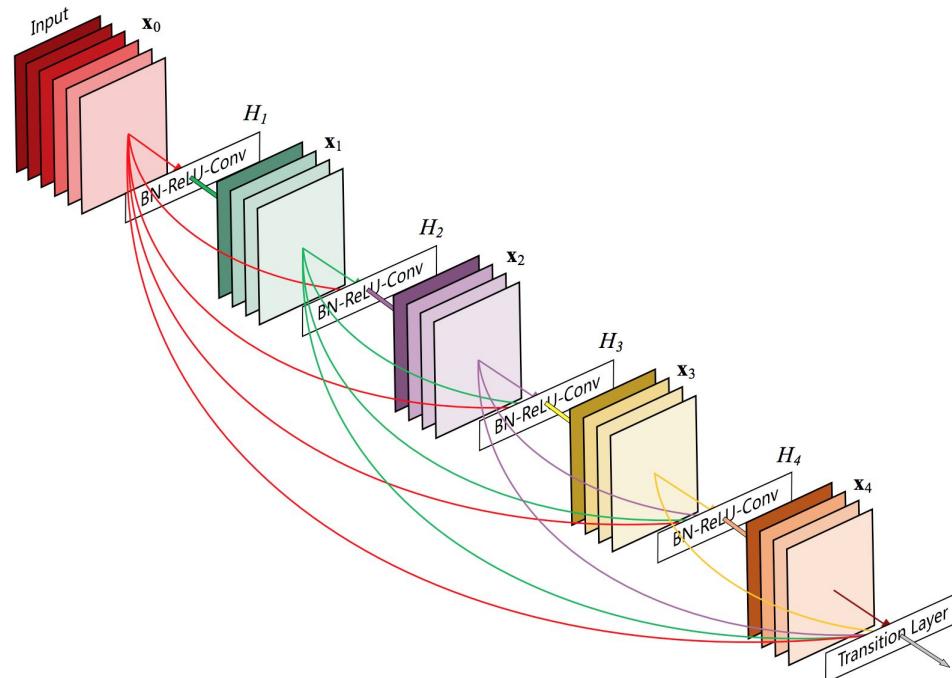


Dense connections

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

DenseNet

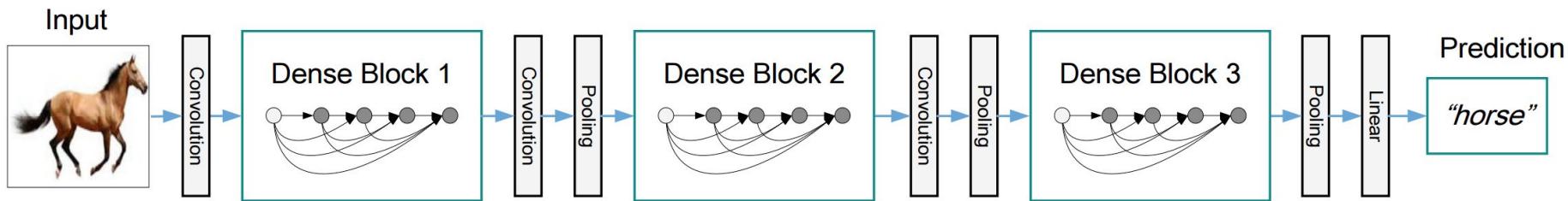
Dense Block of 5-layers
with a growth rate of $k=4$



Huang, Gao, Zhuang Liu, Kilian Q. Weinberger, and Laurens van der Maaten. "[Densely connected convolutional networks.](#)" CVPR 2017. [\[code\]](#)

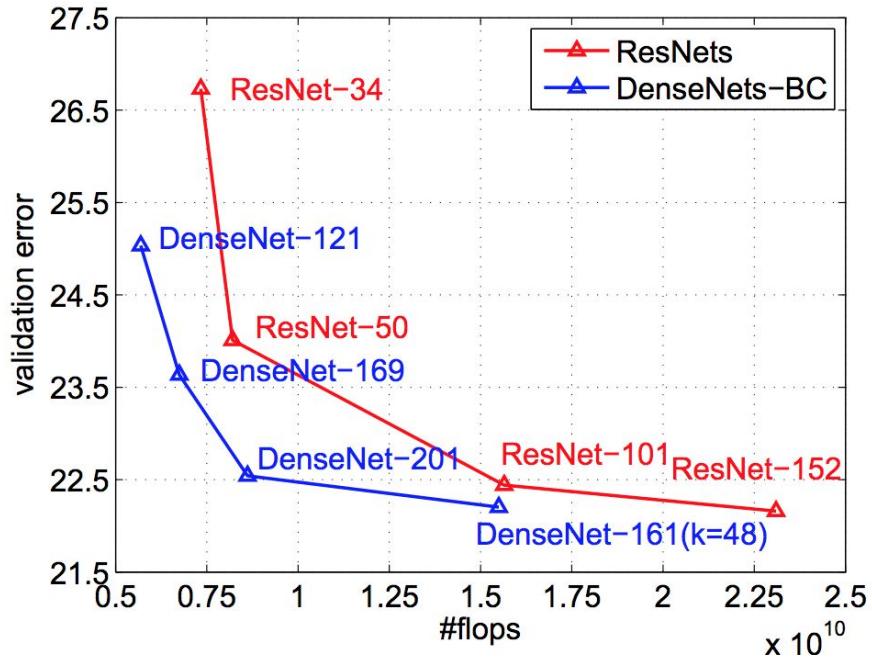
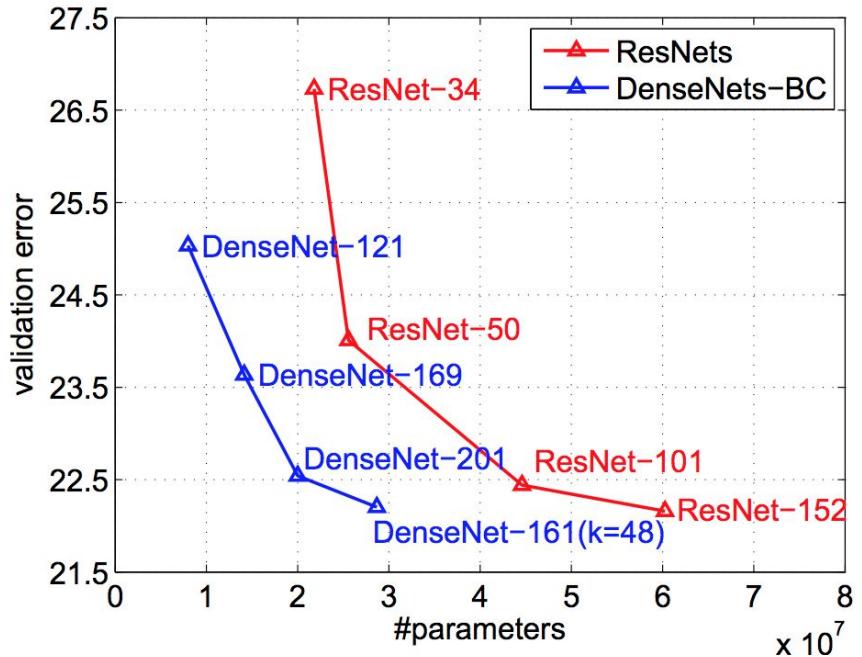
Dense connections

DenseNet



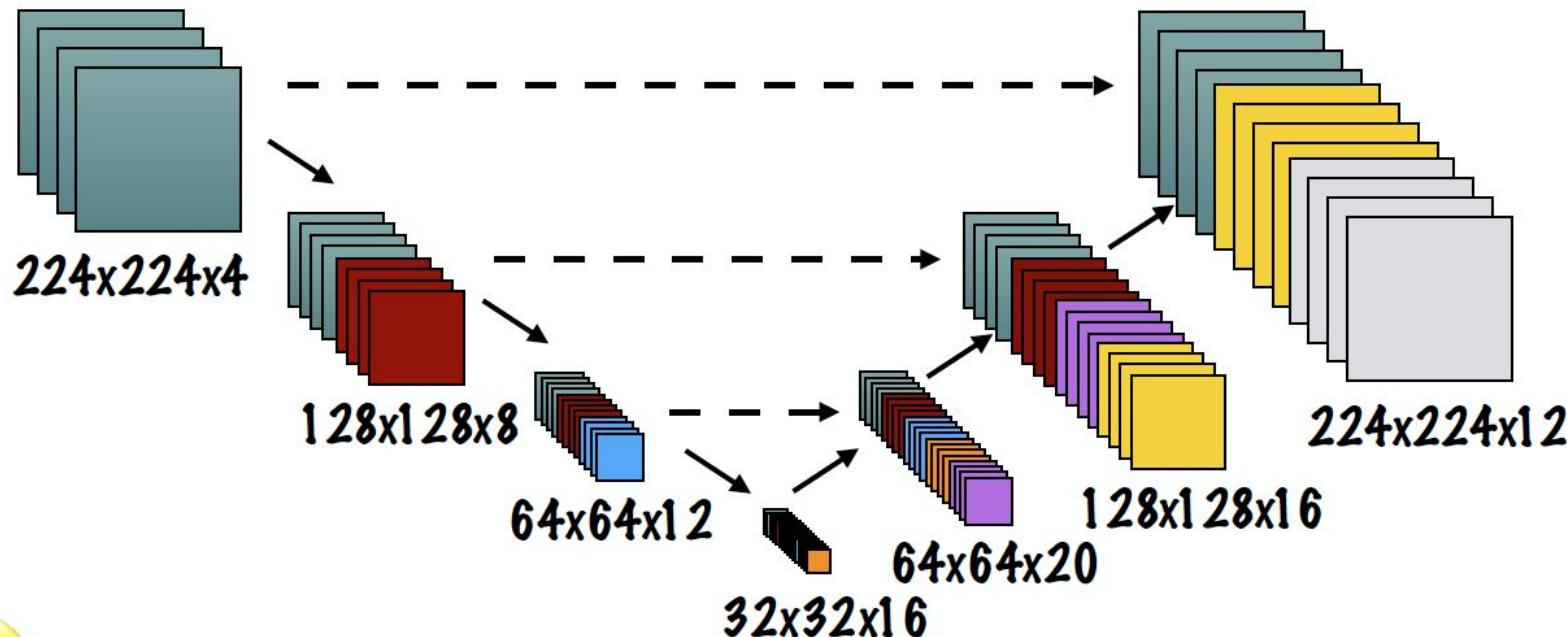
Huang, Gao, Zhuang Liu, Kilian Q. Weinberger, and Laurens van der Maaten. "[Densely connected convolutional networks.](#)" CVPR 2017. [\[code\]](#)

Dense connections

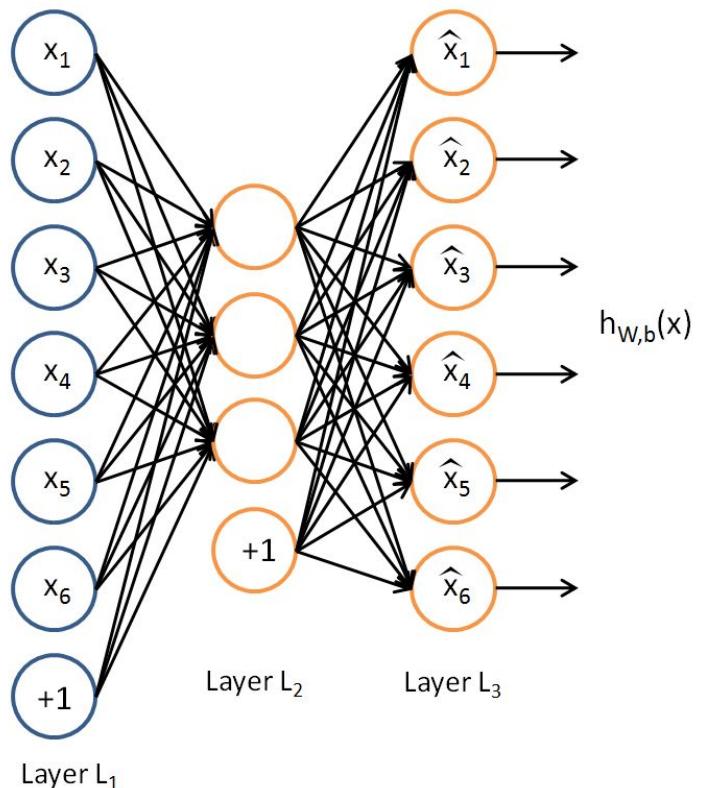


Huang, Gao, Zhuang Liu, Kilian Q. Weinberger, and Laurens van der Maaten. "[Densely connected convolutional networks.](#)" CVPR 2017 [\[code\]](#)

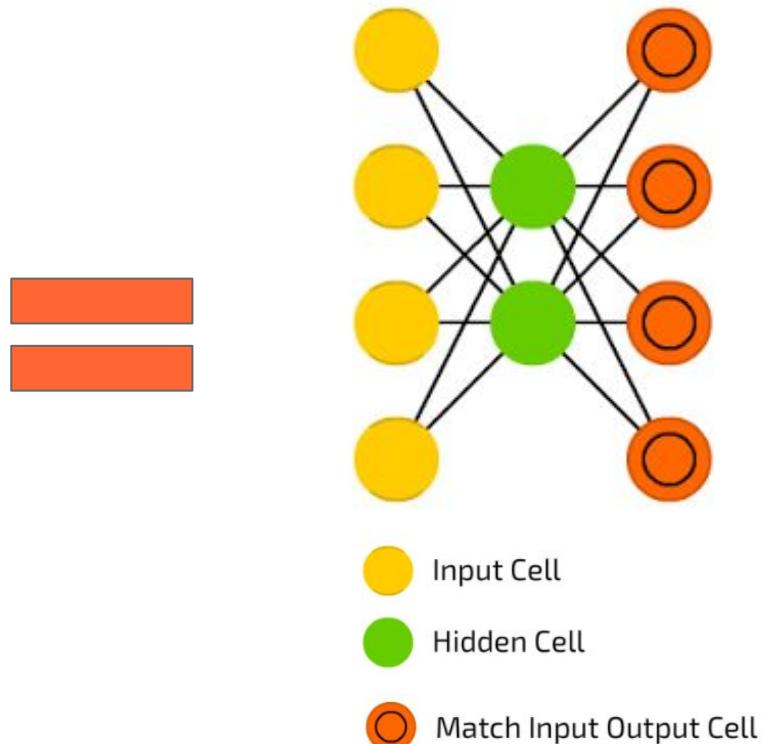
Dense connections



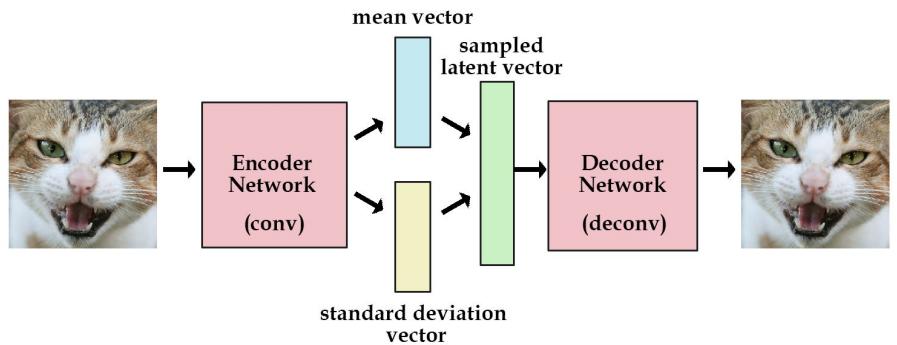
Autoencoder (AE)



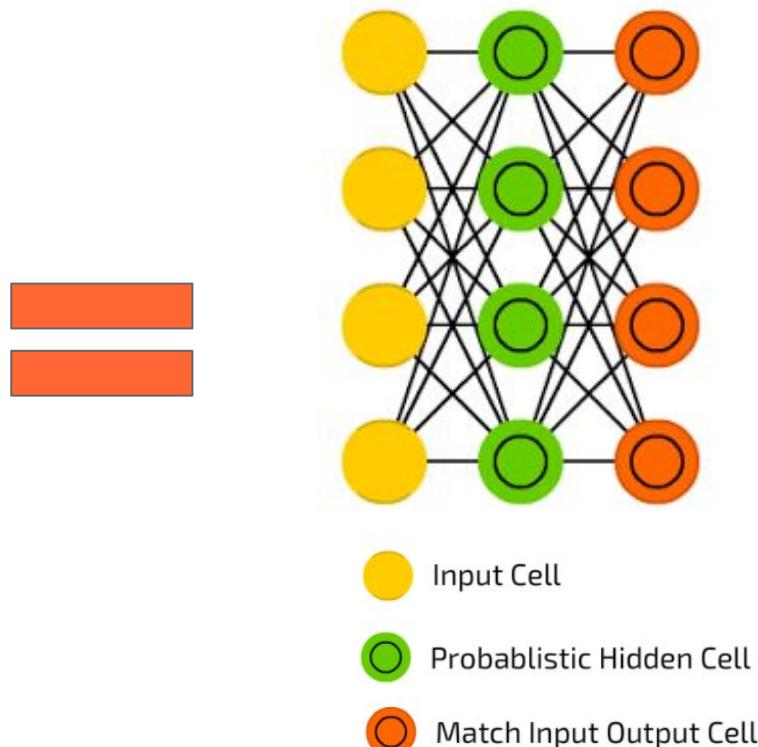
Auto Encoder (AE)



Variational Autoencoder (VAE)

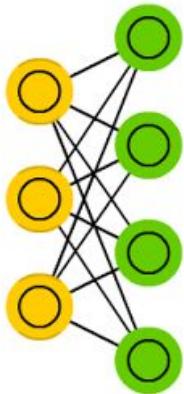


Variational AE (VAE)



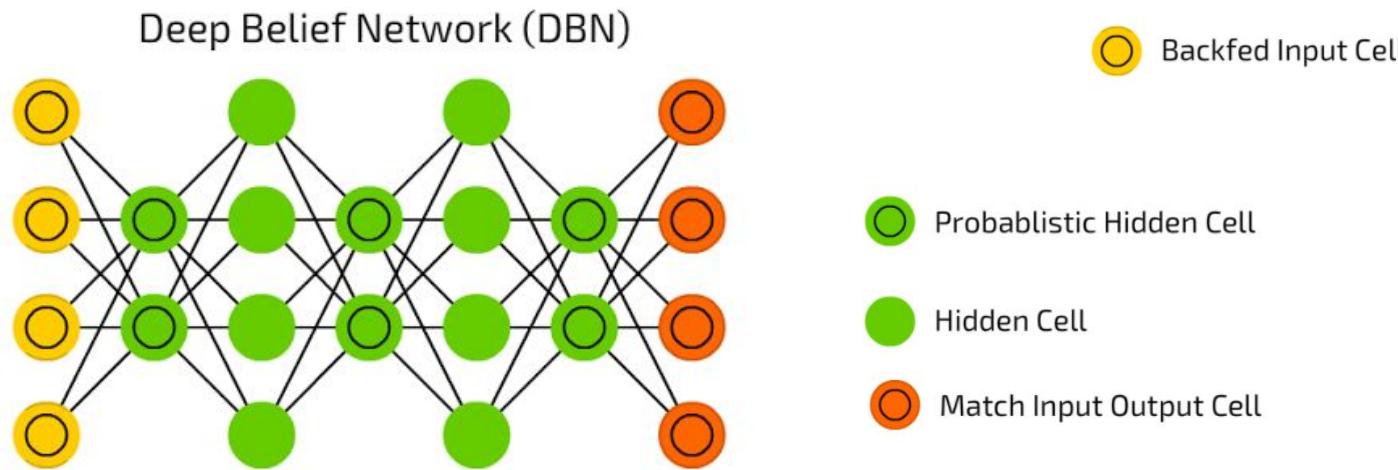
Restricted Boltzmann Machine (RBM)

Restricted BM (RBM)

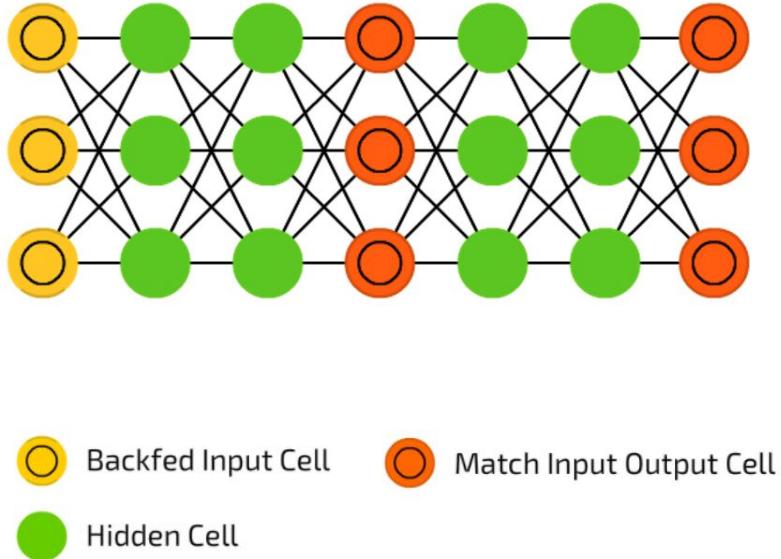
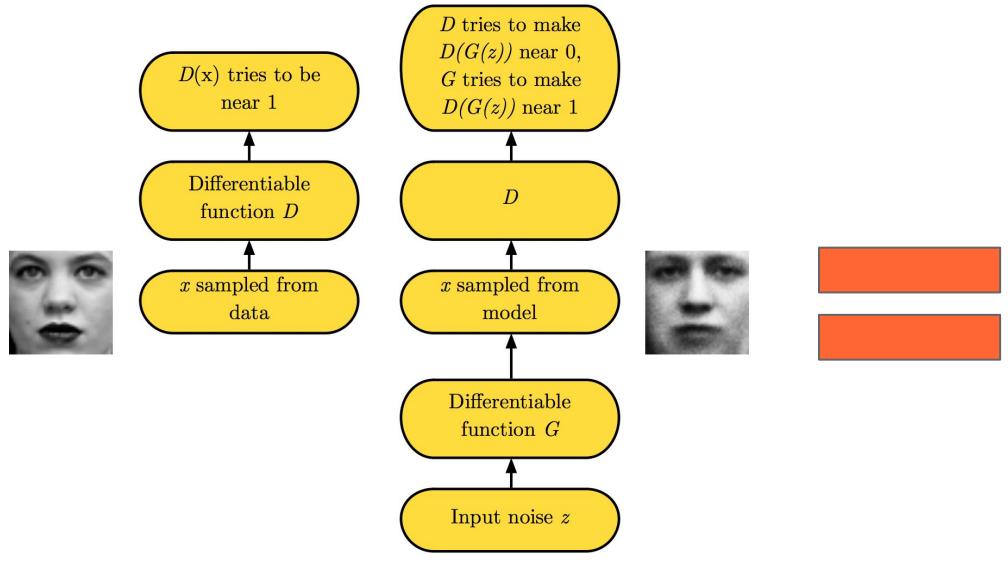


- Backfed Input Cell
- Probabilistic Hidden Cell
- Hidden Cell
- Match Input Output Cell

Deep Belief Networks (DBN)



Adversarial Networks

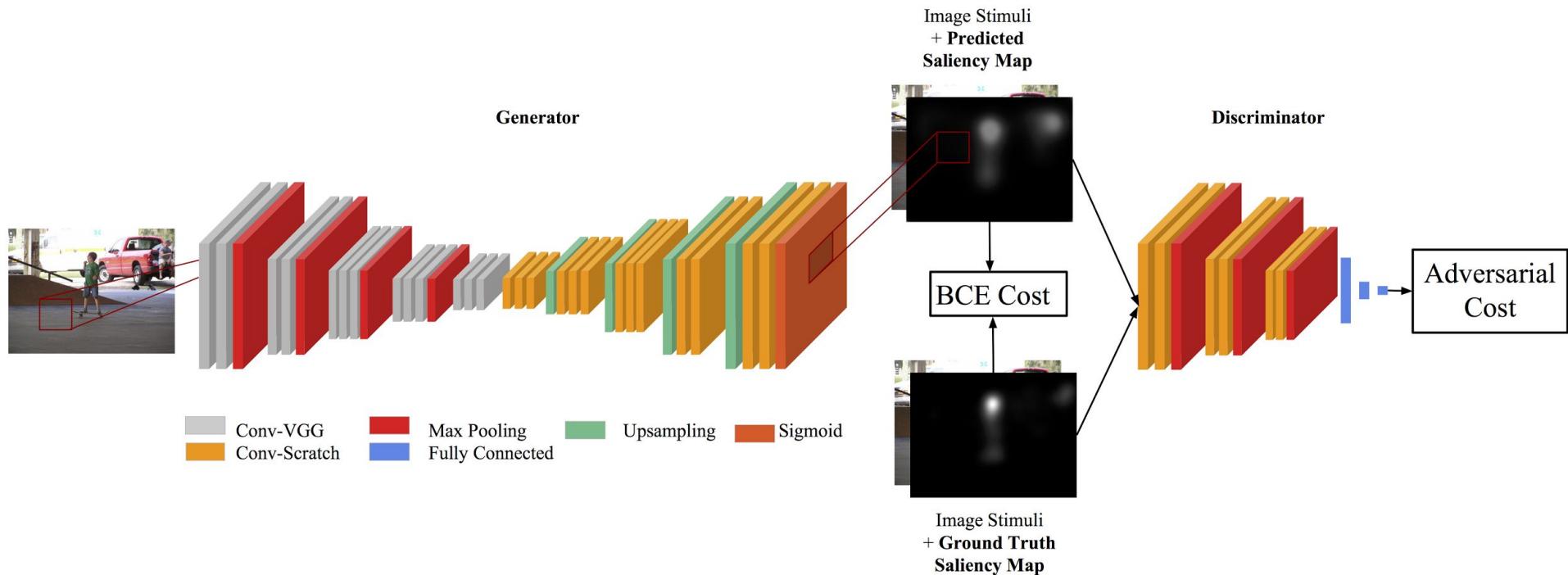


Goodfellow, Ian, Jean Pouget-Abadie, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair, Aaron Courville, and Yoshua Bengio. ["Generative adversarial nets."](#) NIPS 2014

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

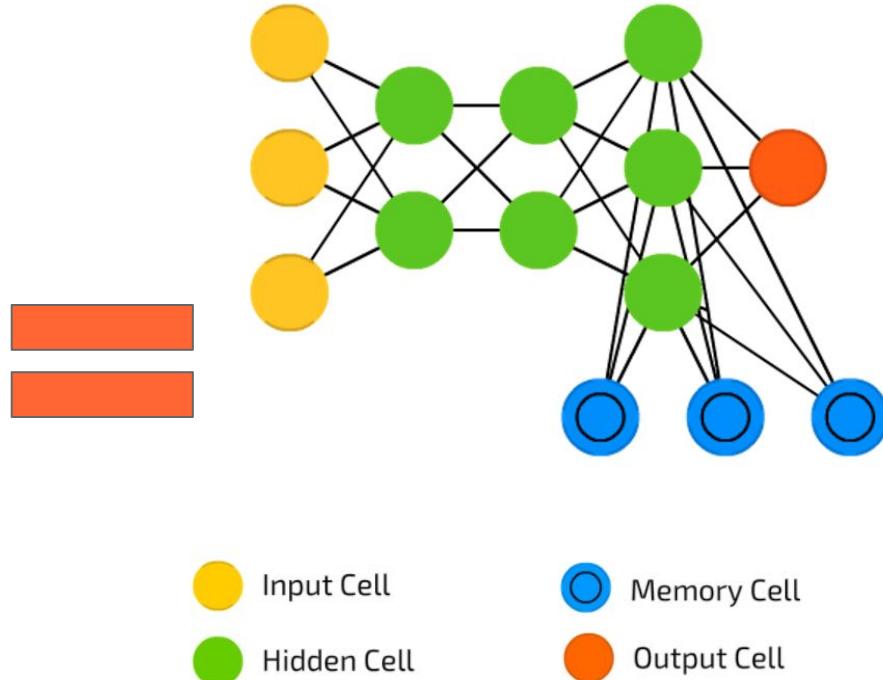
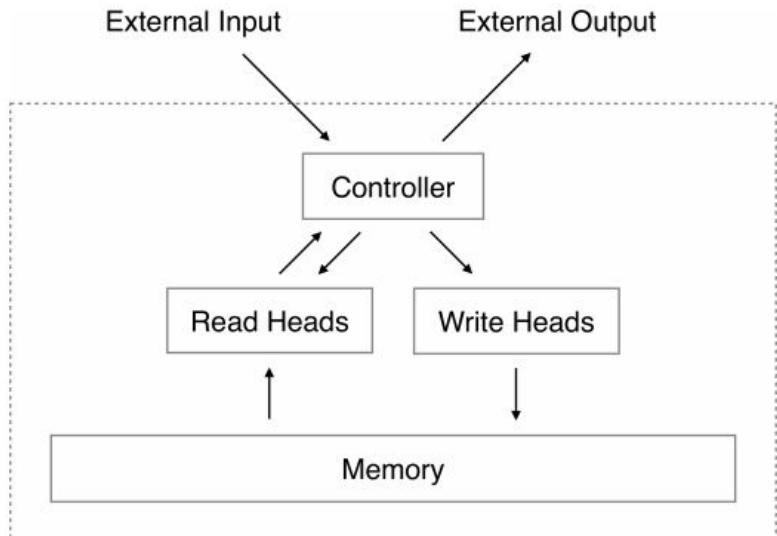
Adversarial Networks

Introduce an additional term to the loss to improve performance.



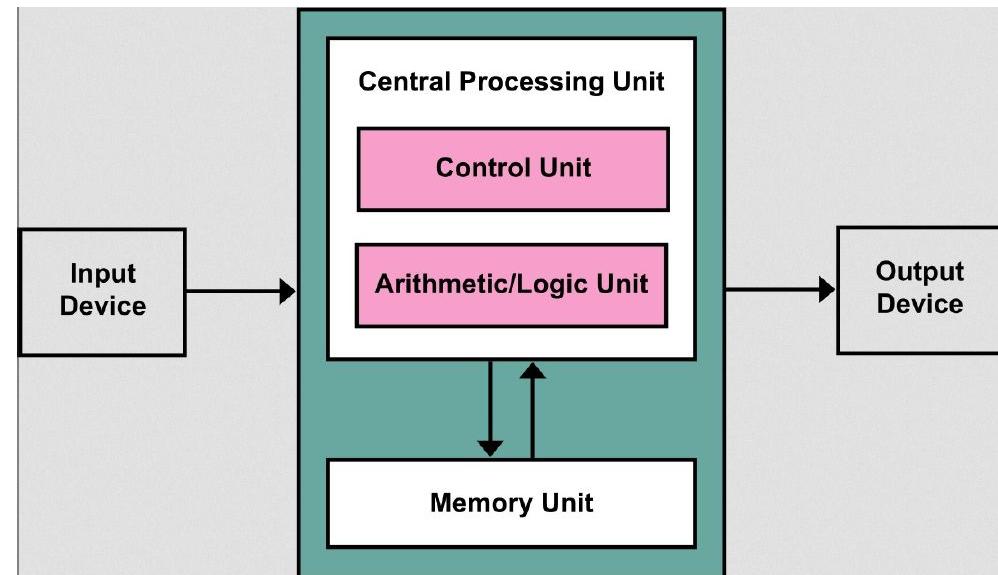
Junting Pan, Cristian Canton, Kevin McGuinness, Noel E. O'Connor, Jordi Torres, Elisa Sayrol and Xavier Giro-i-Nieto. "[SalGAN: Visual Saliency Prediction with Generative Adversarial Networks.](#)" CVPRW 2017.

Differentiable Neural Computers (DNC)

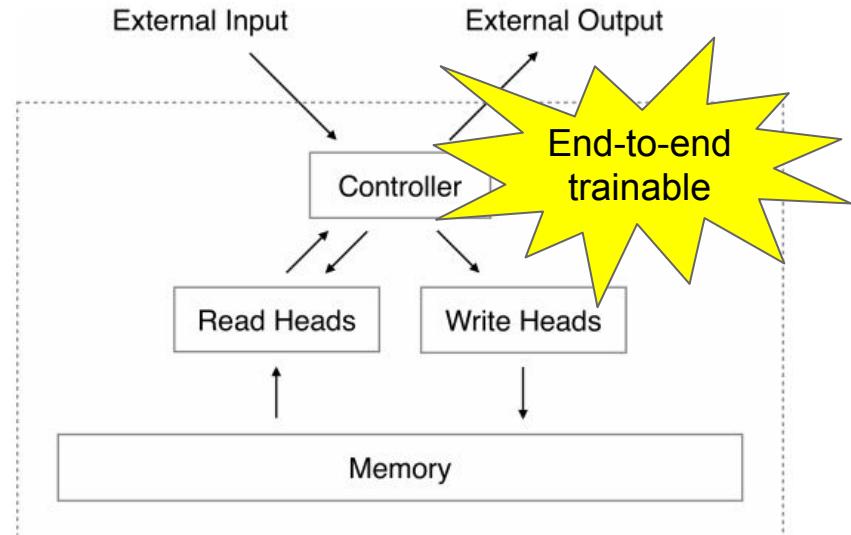


Graves, Alex, Greg Wayne, and Ivo Danihelka. "[Neural turing machines.](#)" *arXiv preprint arXiv:1410.5401* (2014). [\[slides\]](#) [\[code\]](#)

Differentiable Neural Computers (DNC)



von Neumann architecture (1952)

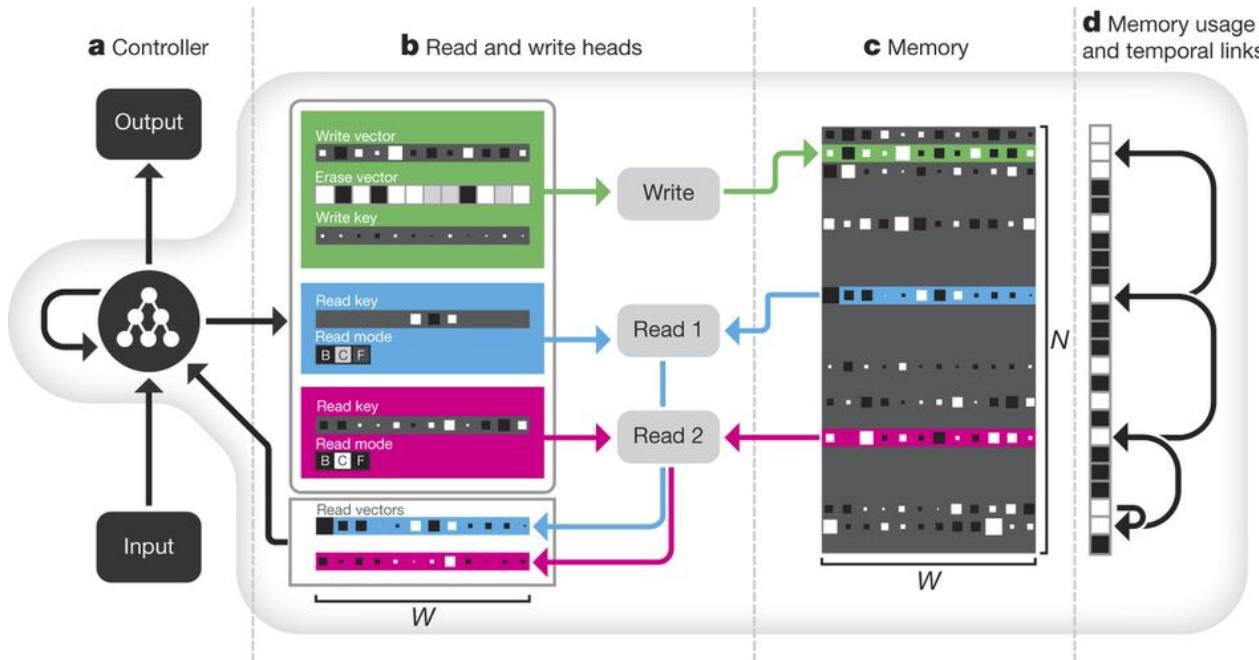


Neural Turing Machine (2014)

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

Differentiable Neural Computers (DNC)

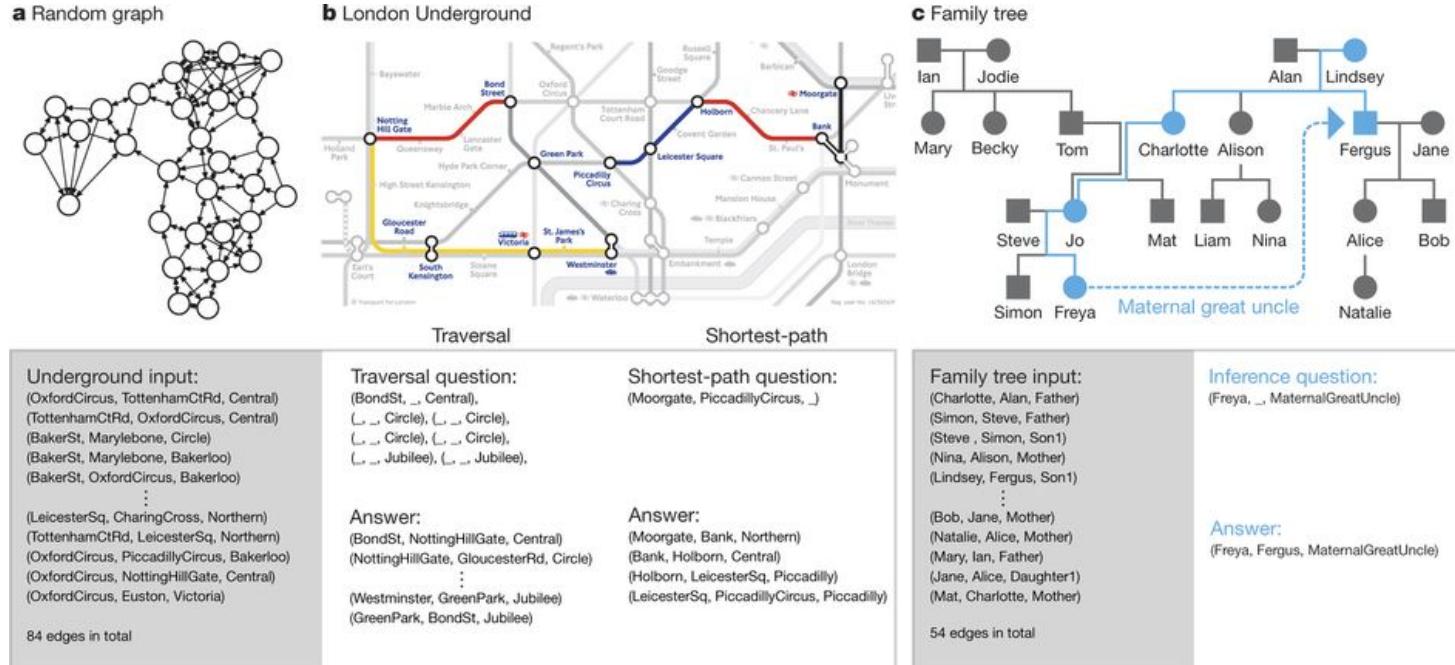
Add a trainable external memory to a neural network.



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. [\[Post by DeepMind\]](#)

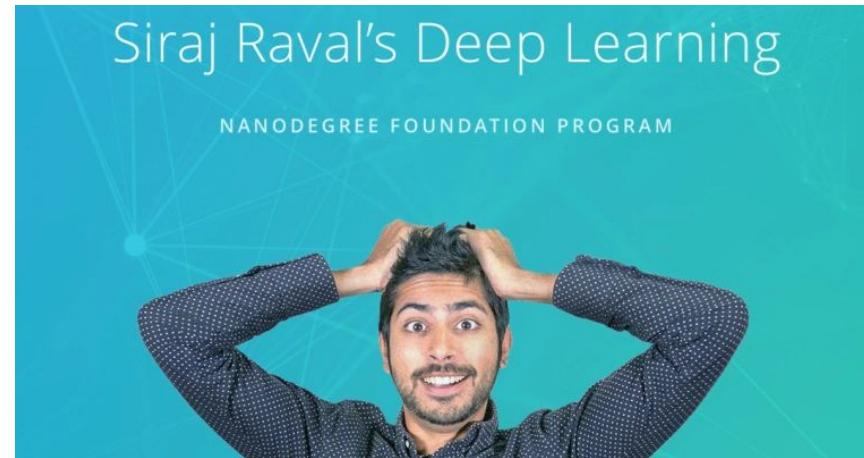
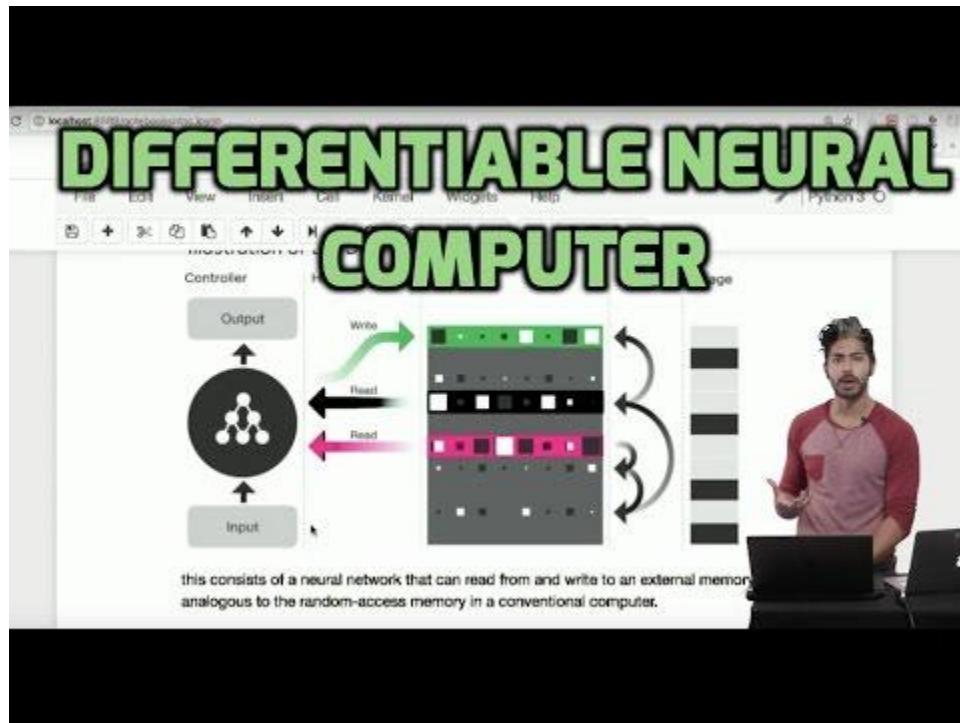
Differentiable Neural Computers (DNC)

DNC can solve tasks reading information from a trained memory.

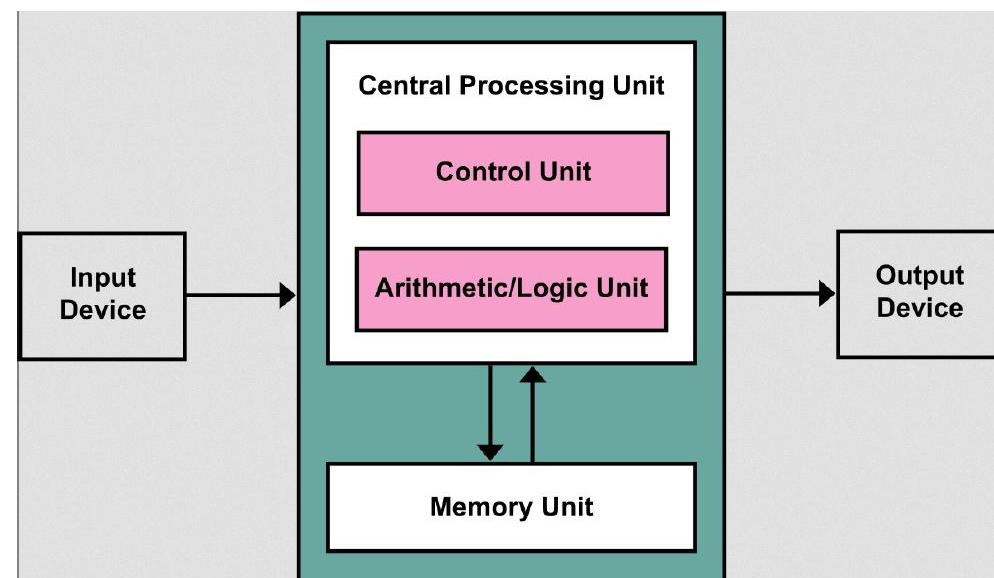


Graves, Alex, Greg Wayne, Malcolm Reynolds, Tim Harley, Ivo Danihelka, Agnieszka Grabska-Barwińska, Sergio Gómez Colmenarejo et al. ["Hybrid computing using a neural network with dynamic external memory."](#)
Nature 538, no. 7626 (2016): 471-476. [Post by DeepMind]

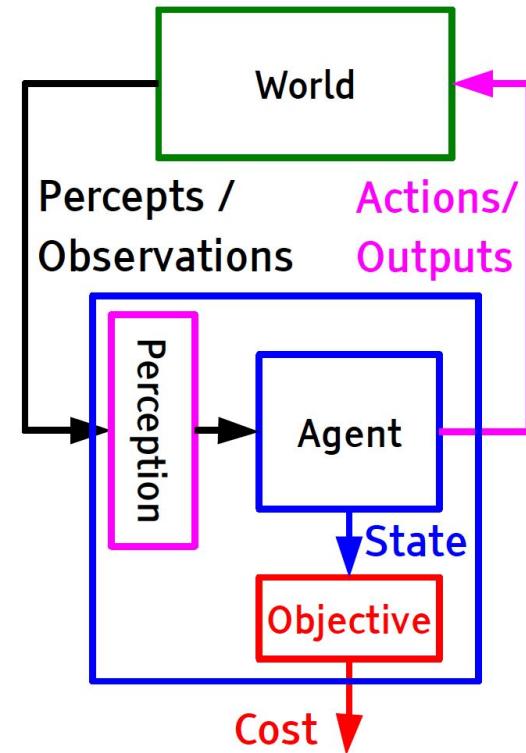
Differentiable Neural Computers (DNC)



More architectures to come...

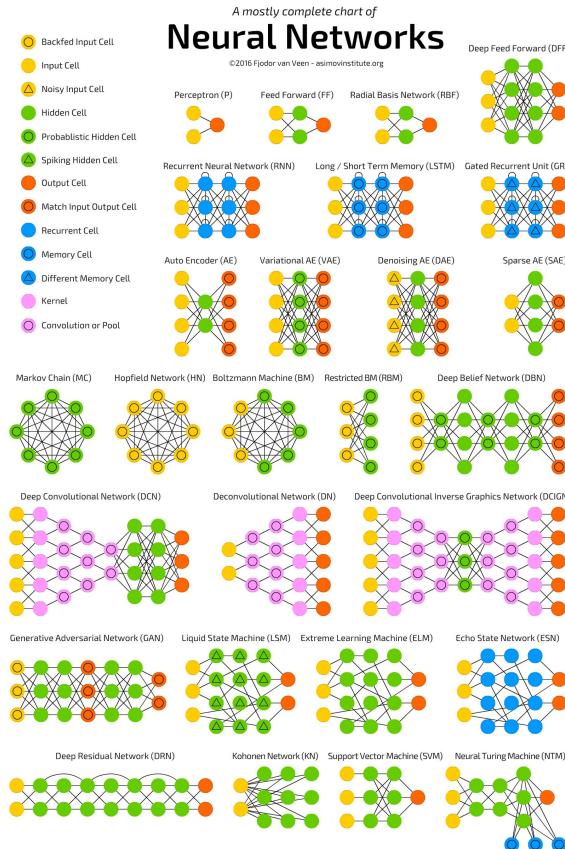


von Neumann architecture (1952)



Yann LeCun, [“A Path to AI”](#),
Beneficial AI 2017.

The Full Story



The Prequel

An informative chart to build

Neural Network Cells

©2016 Fjodor van Veen - asimovinstitute.org

0.6 ----- 0.6

0.25
0.5
-1.0
-2.0
0.7
0.2

Fixed Weight
(fixed at 1)

Weights



=
2.0 -1.0
0.1 0.2

Recurrent Weights
(grouped by colour)



input sum sigmoid output
bias

Feed Forward Cell
(basic cell)

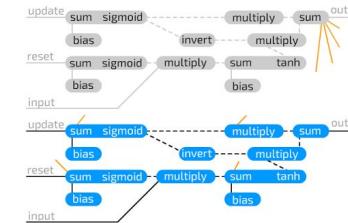


input sum relu output
bias

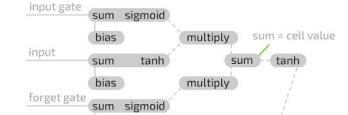
Recurrent Cell
(previous iteration)



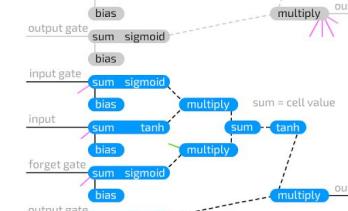
Recurrent Cell



GRU Cell
(previous iteration)



LSTM Cell
(previous iteration)



LSTM Cell



Fjodor Van Veen, ["Neural Network Zoo Prequel: Cells and Layers"](#) (2017)

Questions ?

Undergradese

What undergrads ask vs. what they're REALLY asking

"Is it going to be an open book exam?"

Translation: "I don't have to actually memorize anything, do I?"

"Hmm, what do you mean by that?"

Translation: "What's the answer so we can all go home."

"Are you going to have office hours today?"

Translation: "Can I do my homework in your office?"

"Can i get an extension?"

Translation: "Can you re-arrange your life around mine?"

"Is this going to be on the test?"

Translation: "Tell us what's going to be on the test."

"Is grading going to be curved?"

Translation: "Can I do a mediocre job and still get an A?"

