IMPACT 2020
LAS VEGAS NEVADA USA

Deep Learning: An Overview

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Overview

- Motivation for why should you care
- Inspiration and history of artificial neural networks
- Feedforward neural networks
- Deep Networks in Computer Vision
- Deep Networks for Sequence Processing

Short bio

- Education in Electrical Engineering and Computer Science
- CTO at SYSNET International, Inc.
- Specializing in Health Information Technology

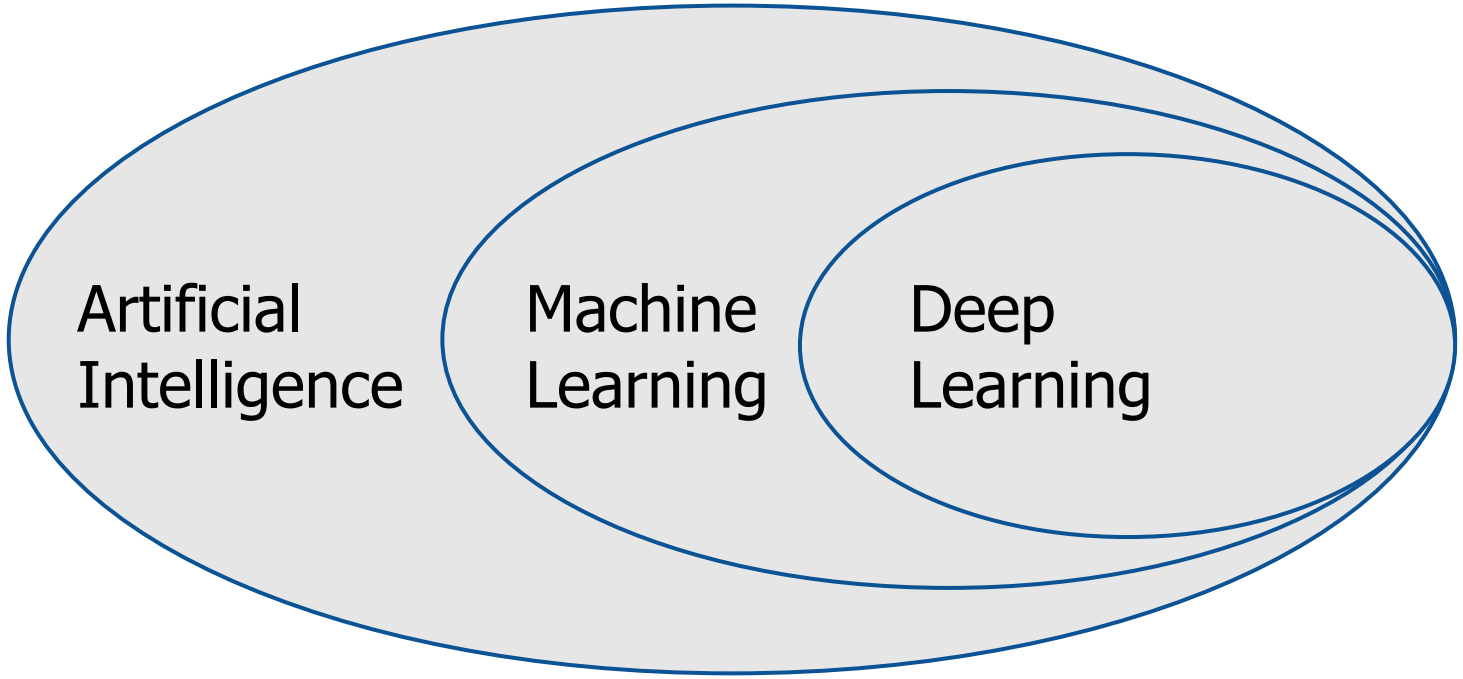
What is Artificial Intelligence

John McCarty coined the term in 1956

Merriam-Webster defines artificial intelligence this way:

- A branch of computer science dealing with the simulation of intelligent behavior in computers.
- The capability of a machine to imitate intelligent human behavior.

What is Deep Learning?



Deep Learning Applications

There are now countless applications of Deep Learning:

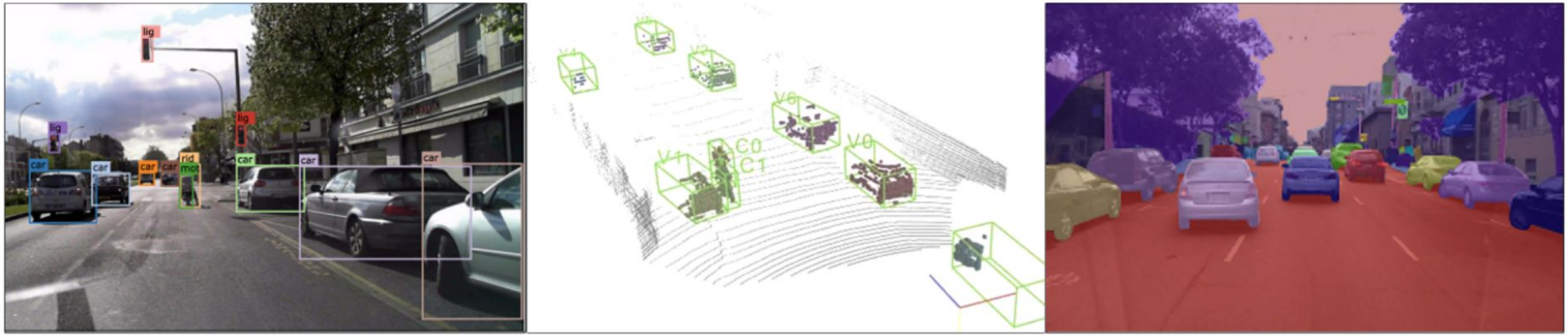
- Self-Driving Cars
- News Aggregation and News Fraud Detection
- Medical Diagnosis of images
- Natural Language Processing
- Financial Fraud Detection

Self-Driving Cars

- Uses various sensors to navigate to destination

Self Driving Cars (cont.)

Sensor data need to be interpreted and appropriate actions must be taken



Sorin Grigorescu, et al, "A Survey of Deep Learning Techniques for Autonomous Driving", https://arxiv.org/abs/1910.07738

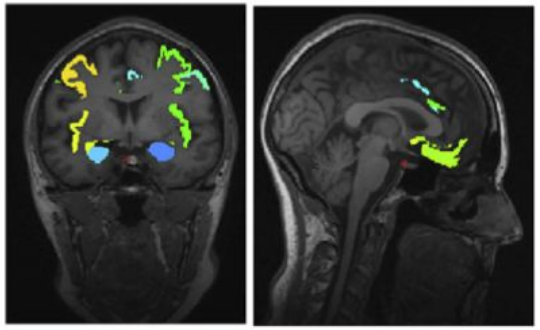
News Aggregation

- Analyse news sources, group them into categories and assess their veracity

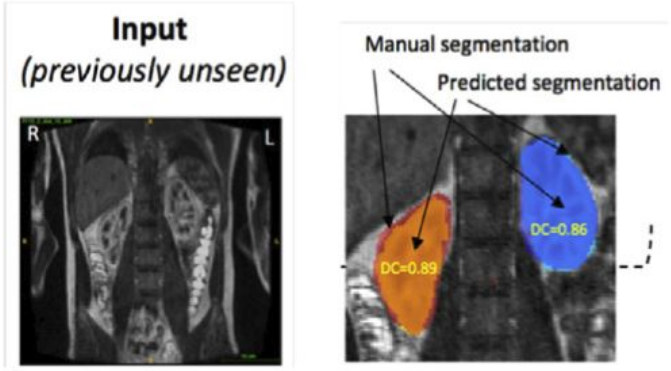
Medical Image Diagnosis

Machine learning can assist in many aspects of medical imaging from acquisition, to interpretation, and to diagnosis.

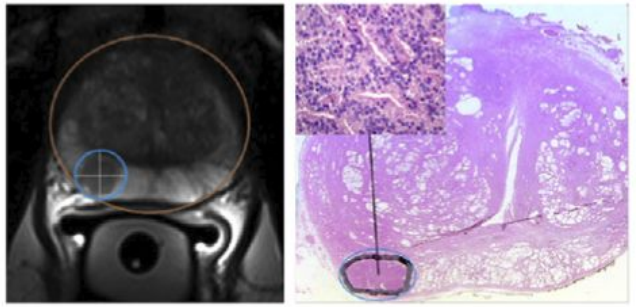
BRAIN



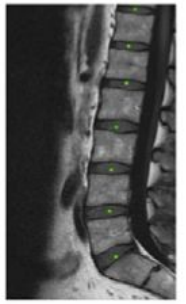
KIDNEY



PROSTATE

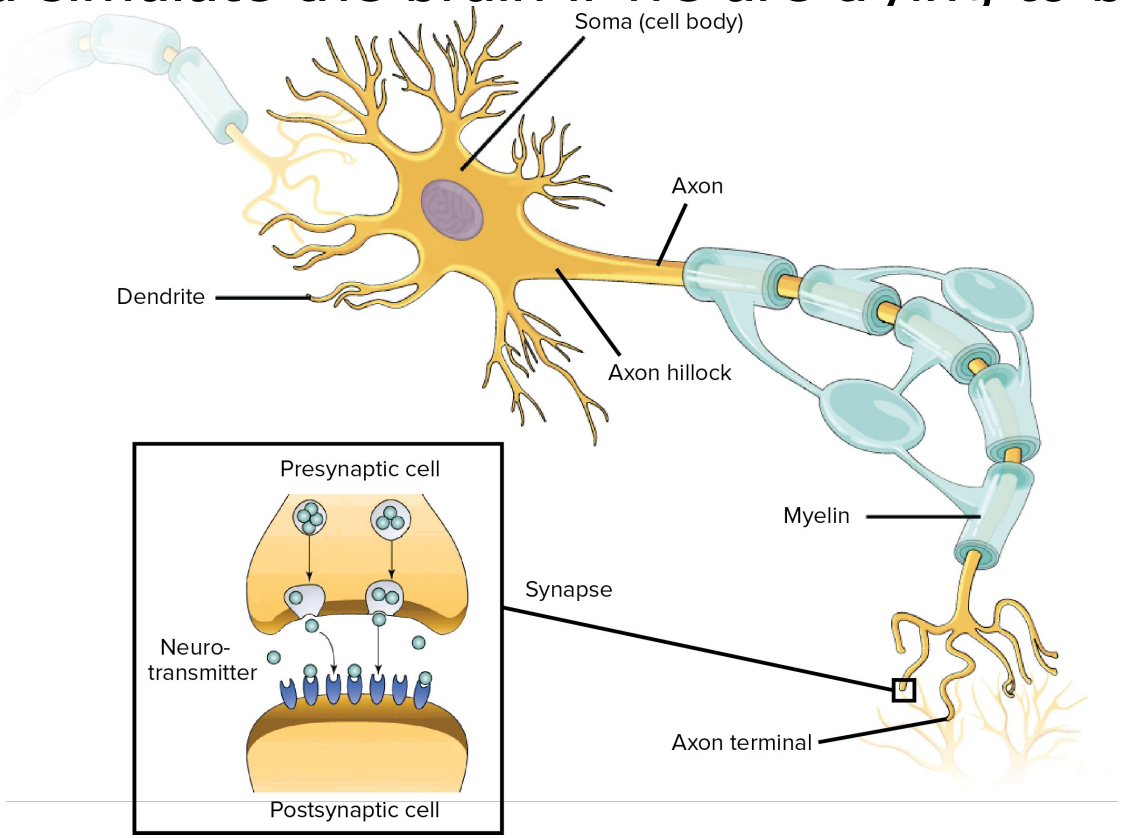


SPINE



Inspired by the Brain

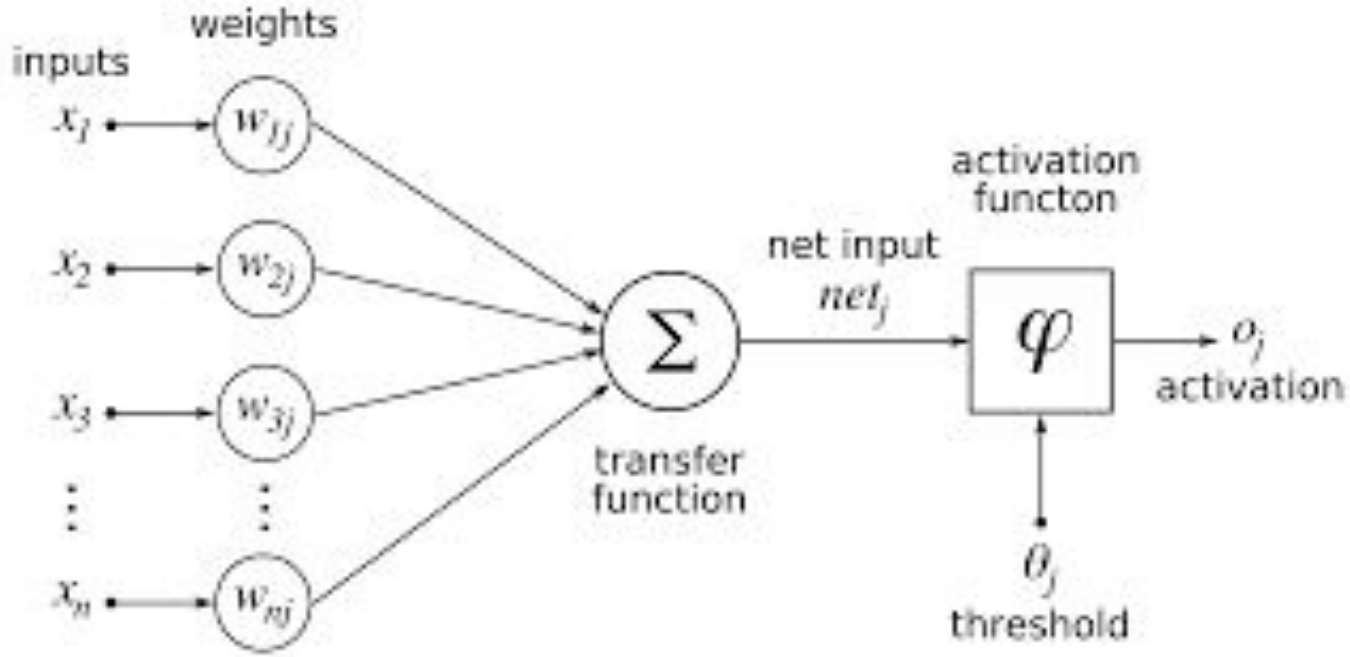
Why not try and simulate the brain if we are trying to build intelligence



https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/overview-of-neuron-structure-and-function

Artificial Neuron

Simplified version of a biological neuron



$$y_k = \varphi\left(\sum_{j=0}^{m} w_{kj} x_j\right)$$

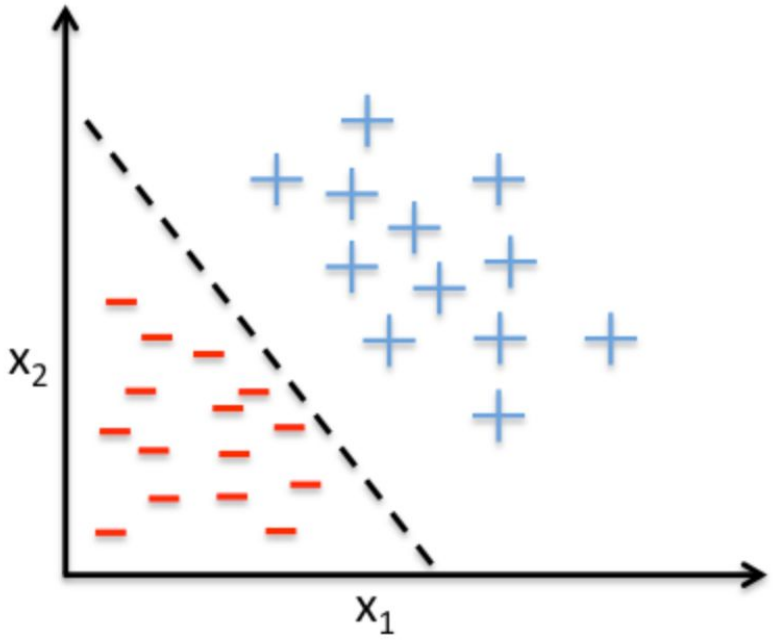
Sigmoid function

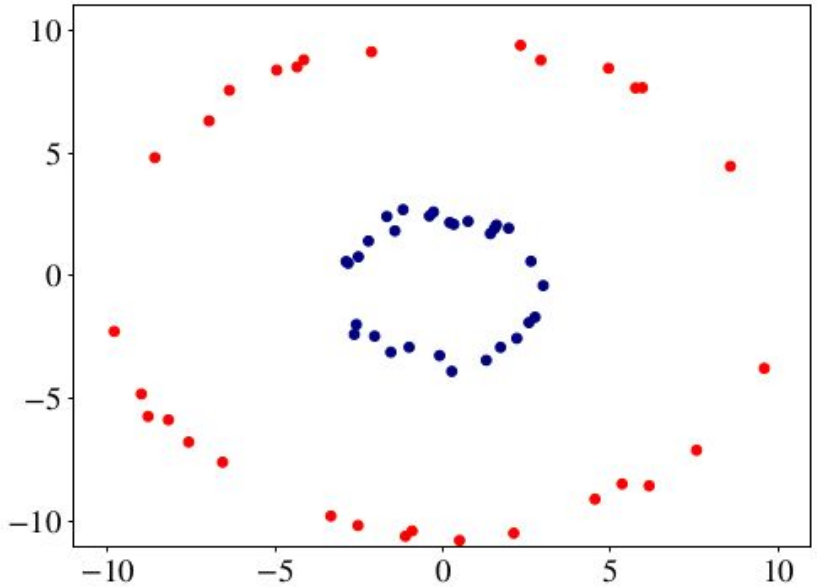
$$S(x) = \frac{1}{1+e^{-x}} = \frac{e^x}{e^x+1}.$$

https://en.wikipedia.org/wiki/Artificial_neuron

Linear Separability

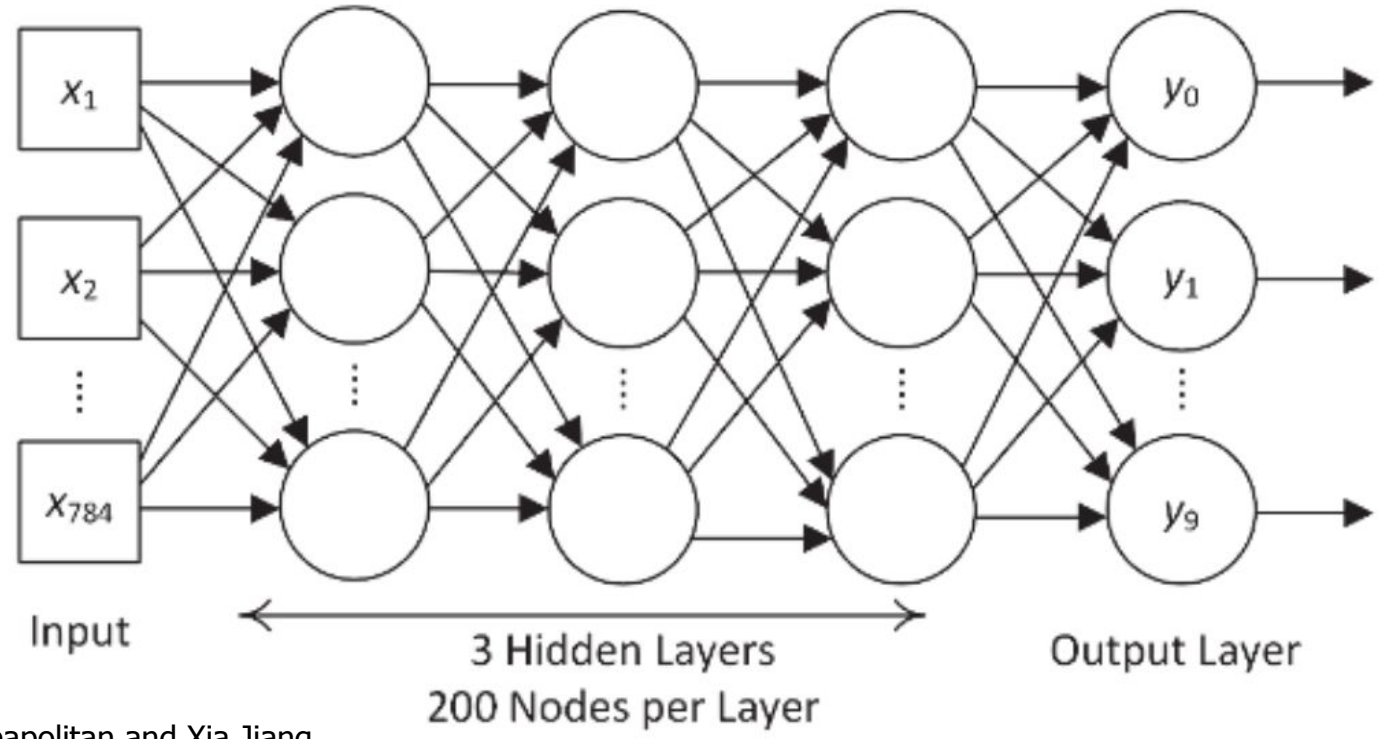
Single layer neural networks can only provide linear separation





Feedforward Neural Networks

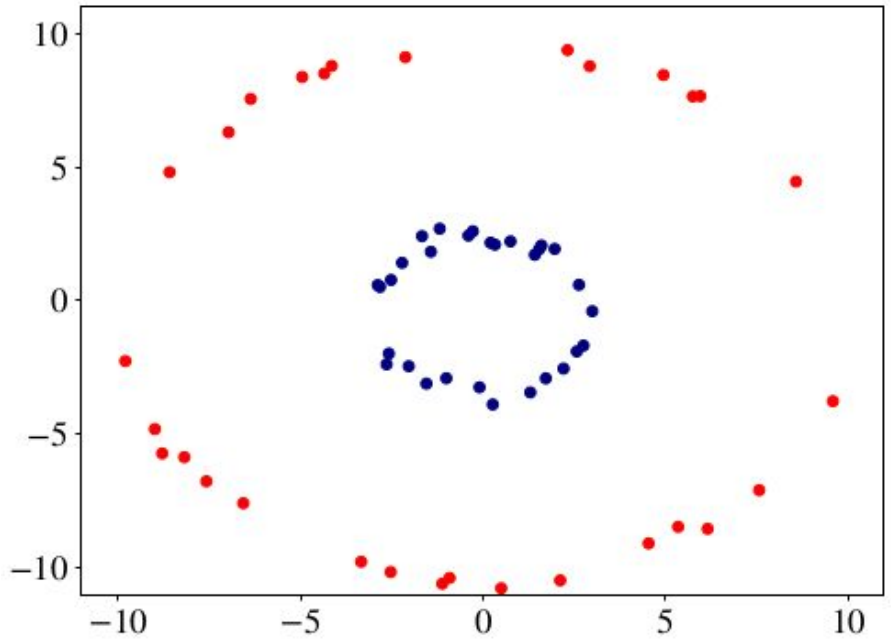
We can increase the capacity of the network by increasing the number of layers

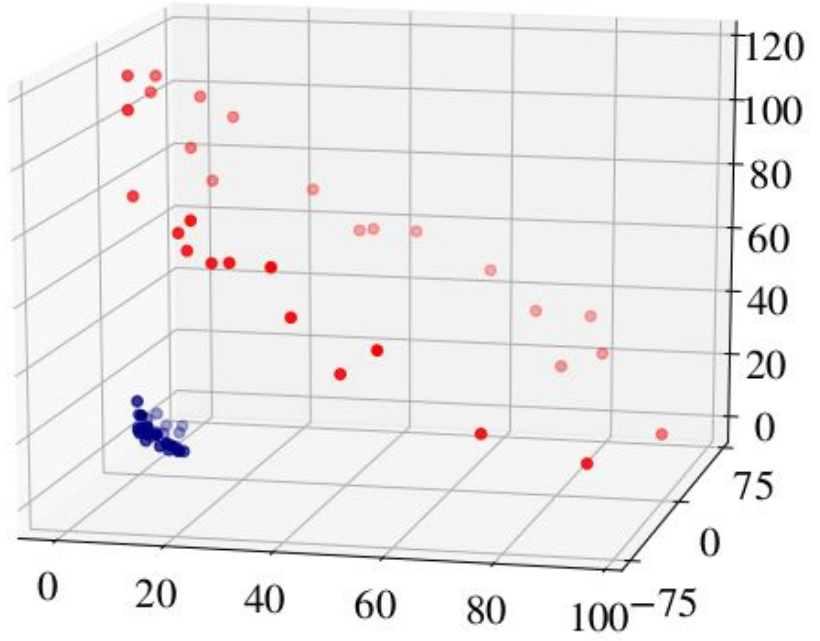


"Artificial Intelligence" by Richard Neapolitan and Xia Jiang

Transformation of Input Space

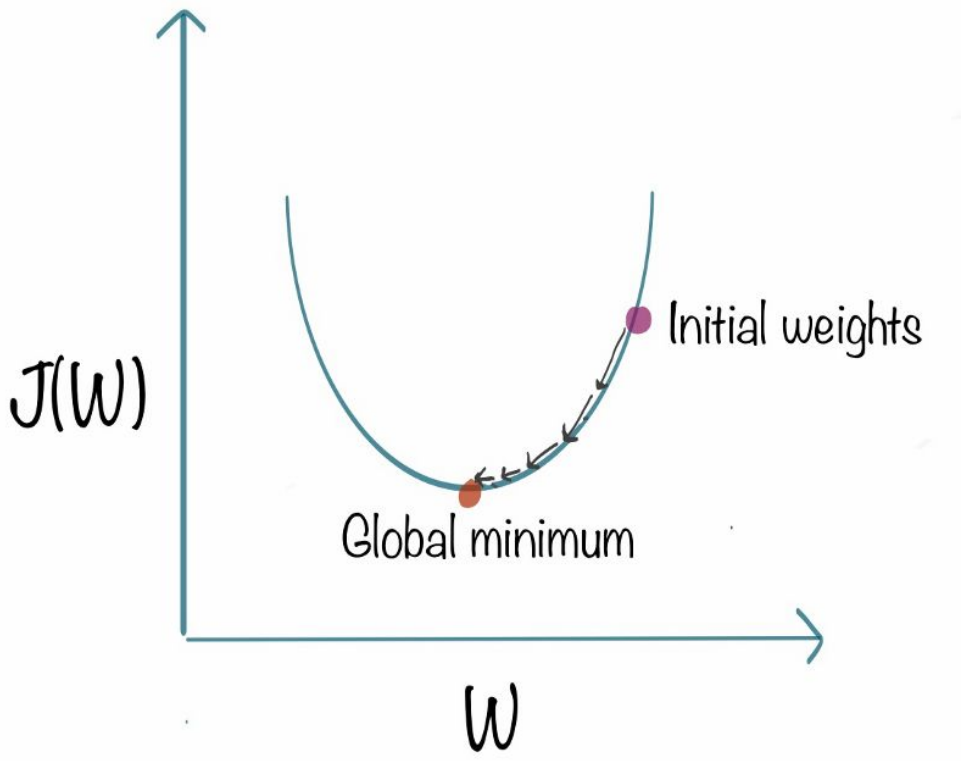
The hidden layers allow you to transform the input space into a higher dimensional space where linear separation is possible





How do we train multi-layered networks?

Gradient Descent Algorithm with backpropagation (chain rule)



$$\text{for } j = 1 \text{ to } j = N$$

$$w_j := w_j + \alpha \frac{\partial J(\vec{W})}{\partial w_j}$$

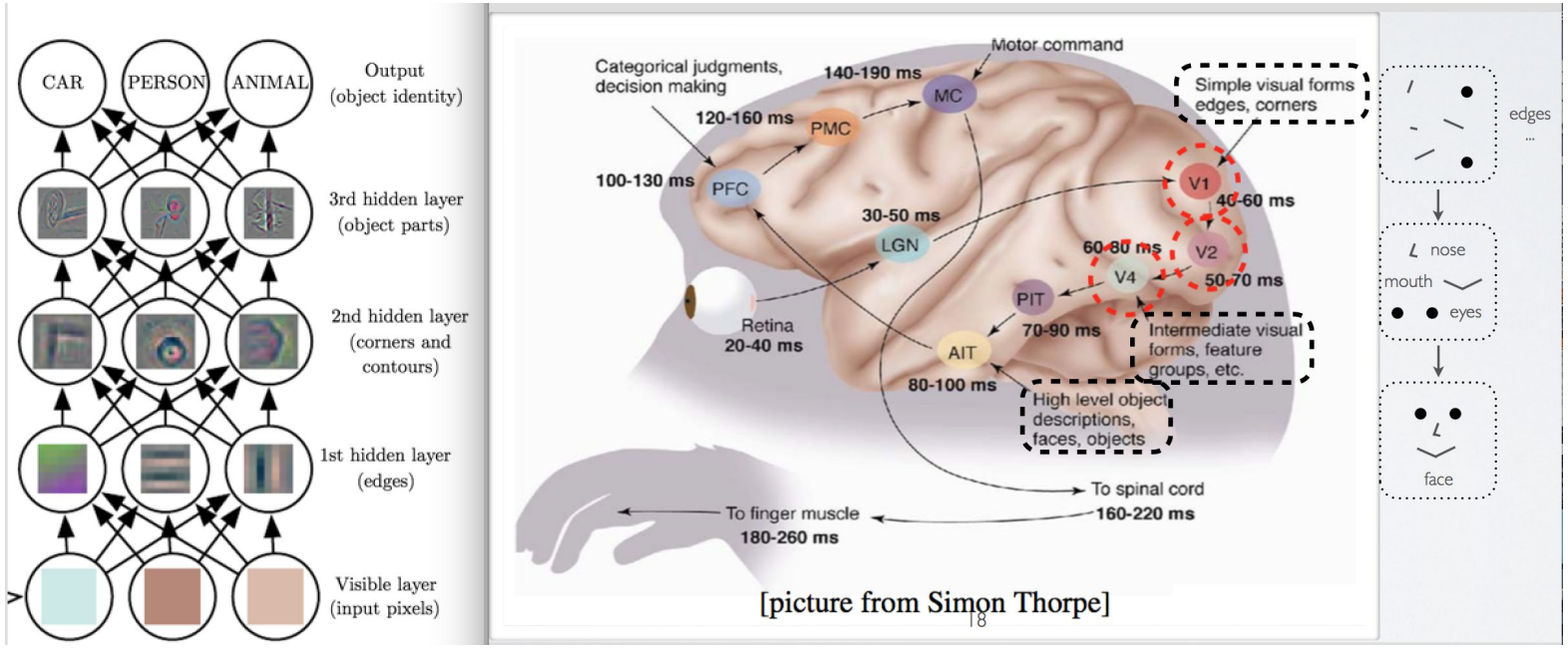
Deep Learning in Computer Vision

Aspects of Learning that are unique to Computer Vision

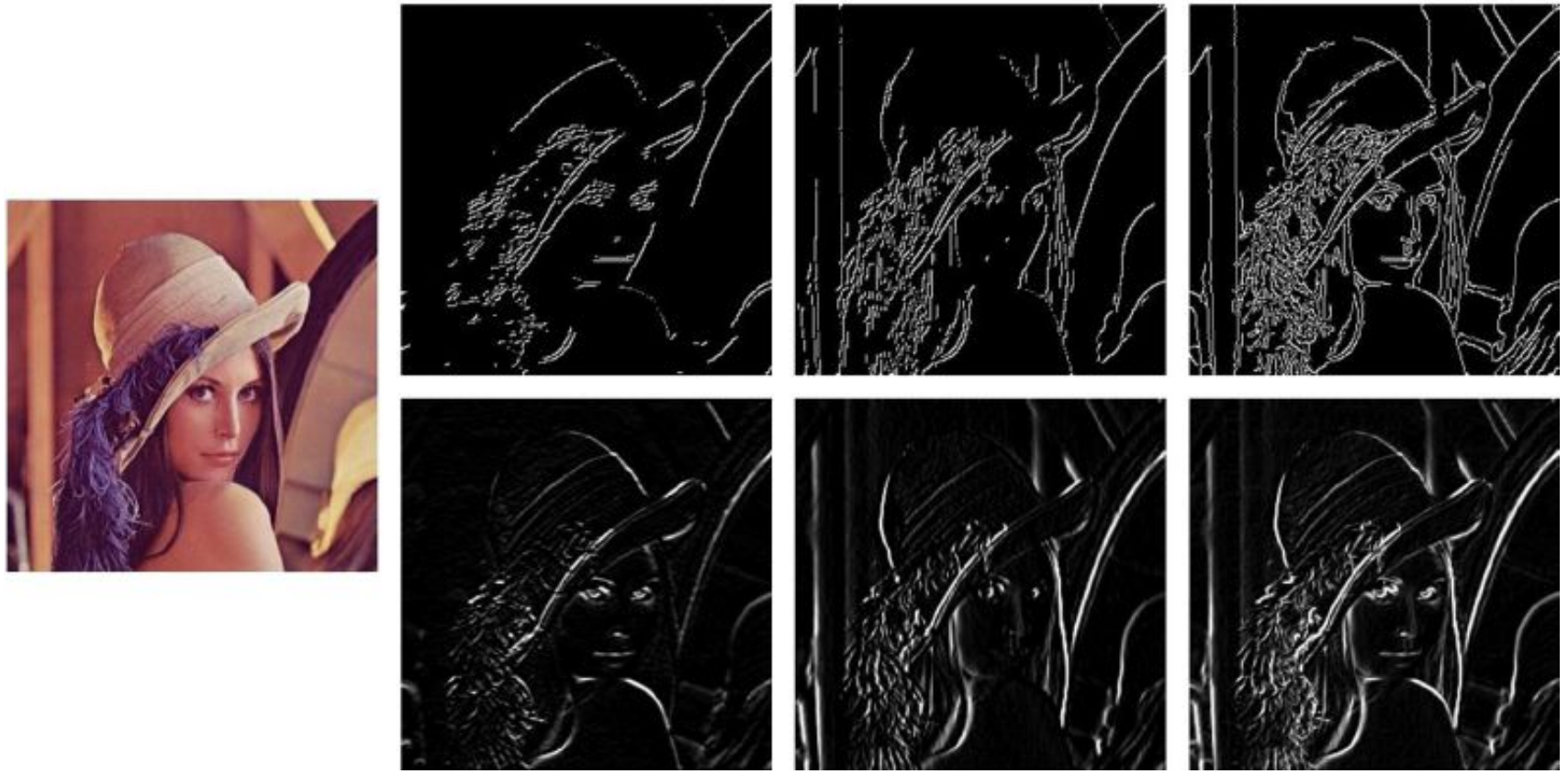
- Images can be large and require too many weights
- Basic features repeat throughout the image in different locations

Inspired by the brain again

Our brains process visual information in successive layers of increasing complexity

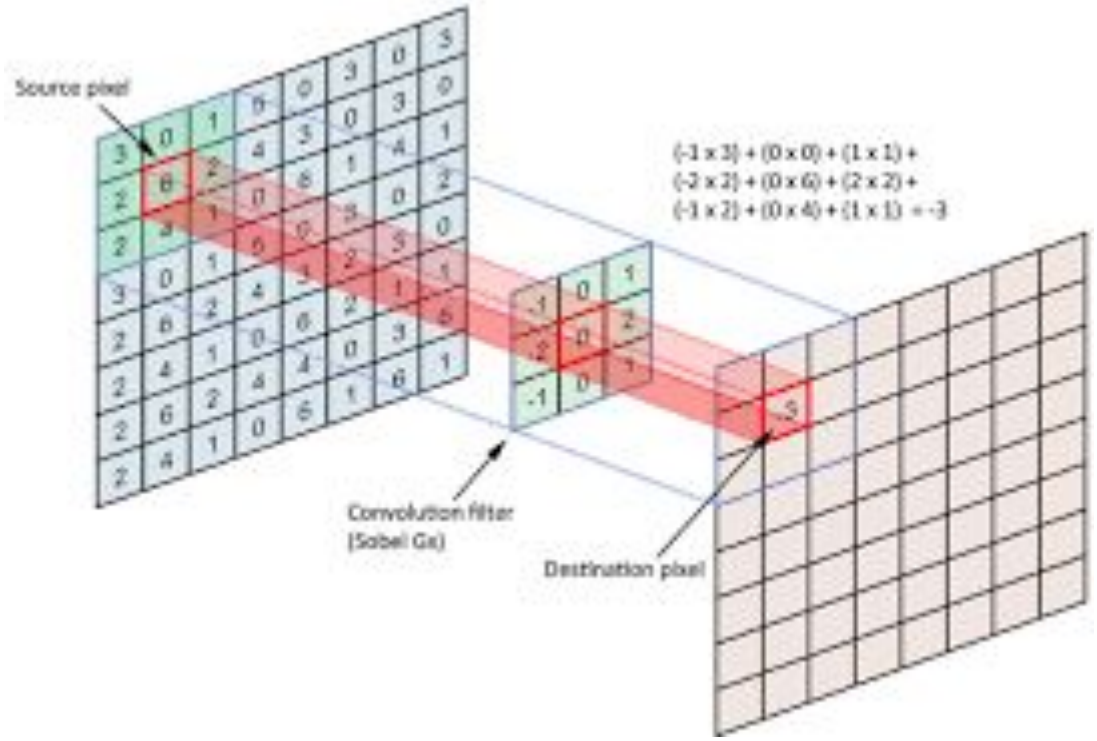


Features of an image

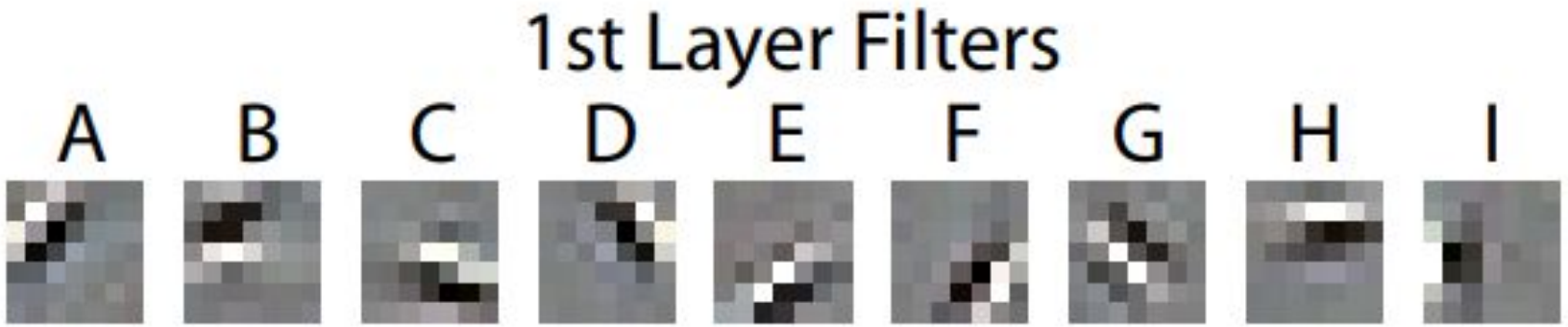


Convolutional Neural Networks

Define filters to apply across the image to evaluate presence at a given location

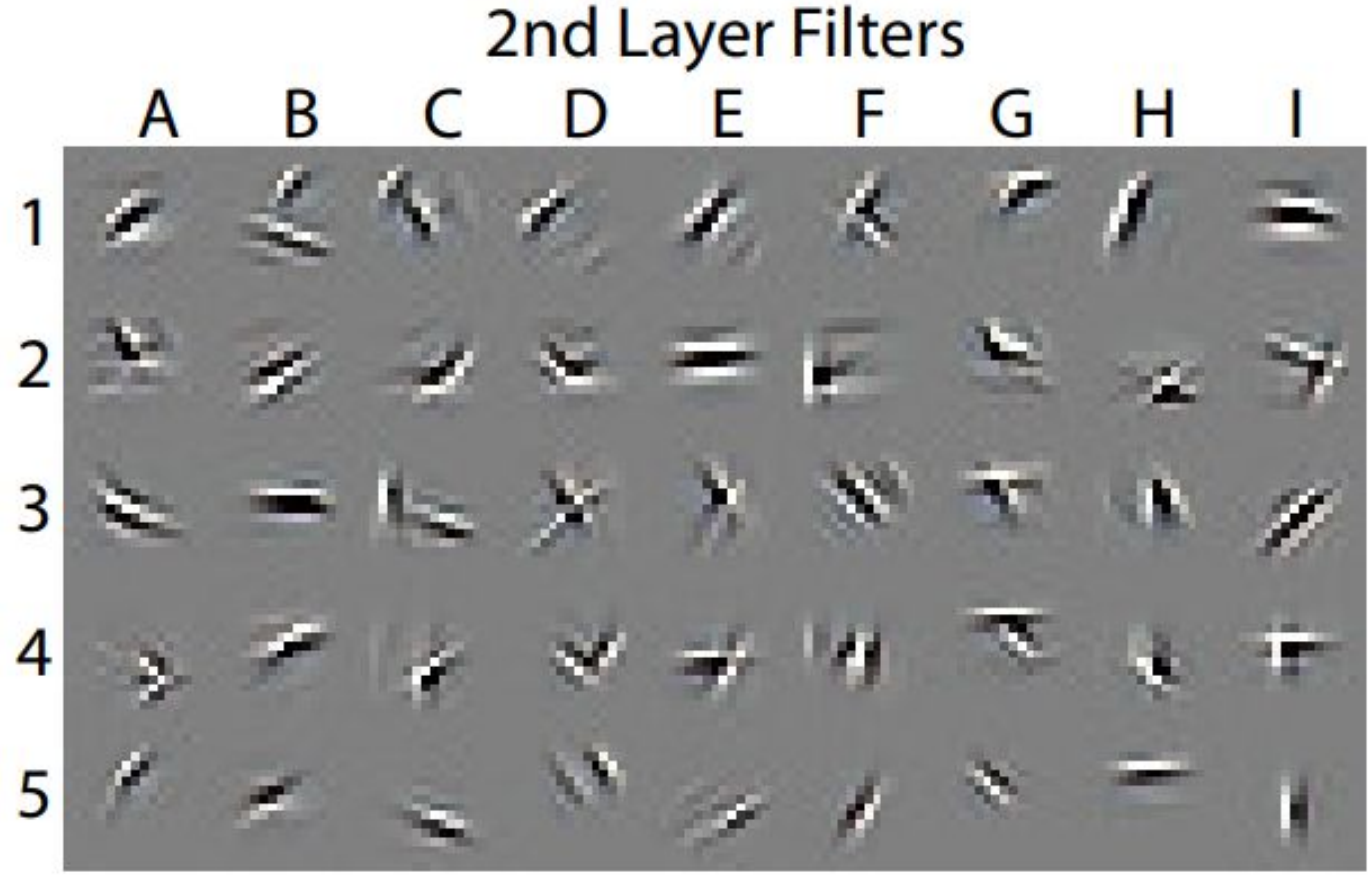


1st Layer Filters



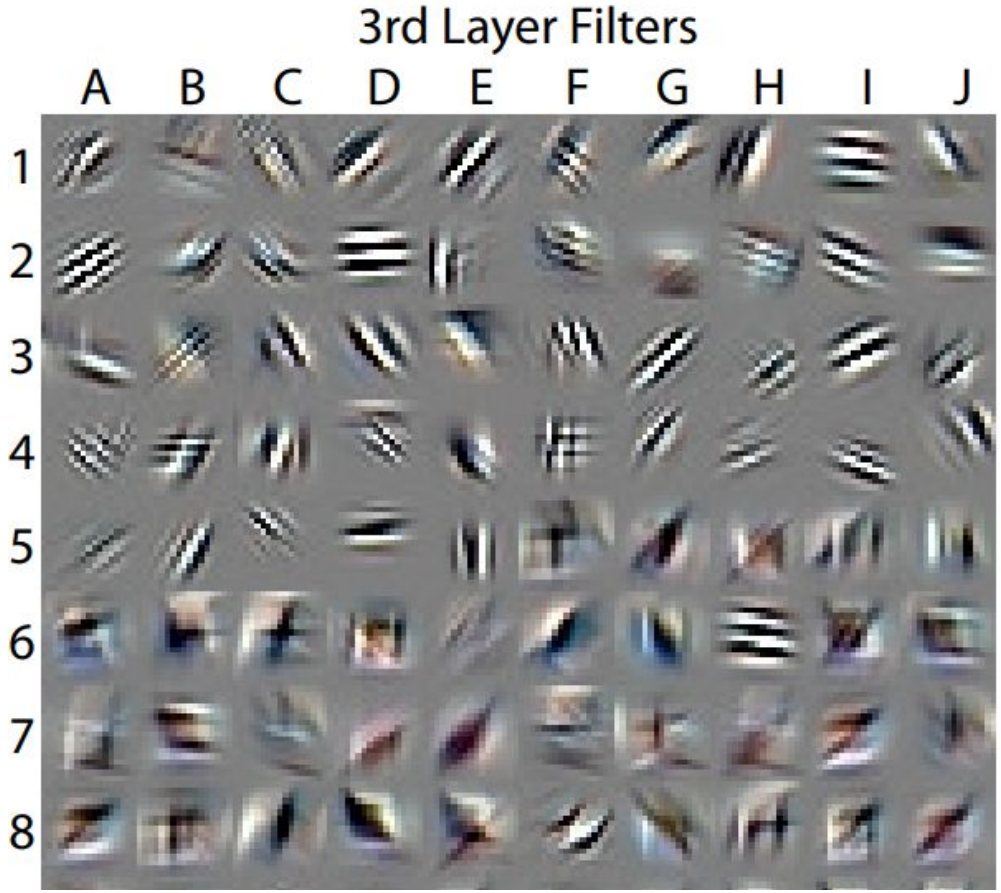
Deconvolutional Networks Matthew D. Zeiler, Dilip Kirshnan, Graham W. Taylor, and Rob Fergus CVPR 2010 (June 13-18, 2010)

2nd Layer Filters



Deconvolutional Networks Matthew D. Zeiler, Dilip Kirshnan, Graham W. Taylor, and Rob Fergus CVPR 2010 (June 13-18, 2010)

3rd Layer Filters



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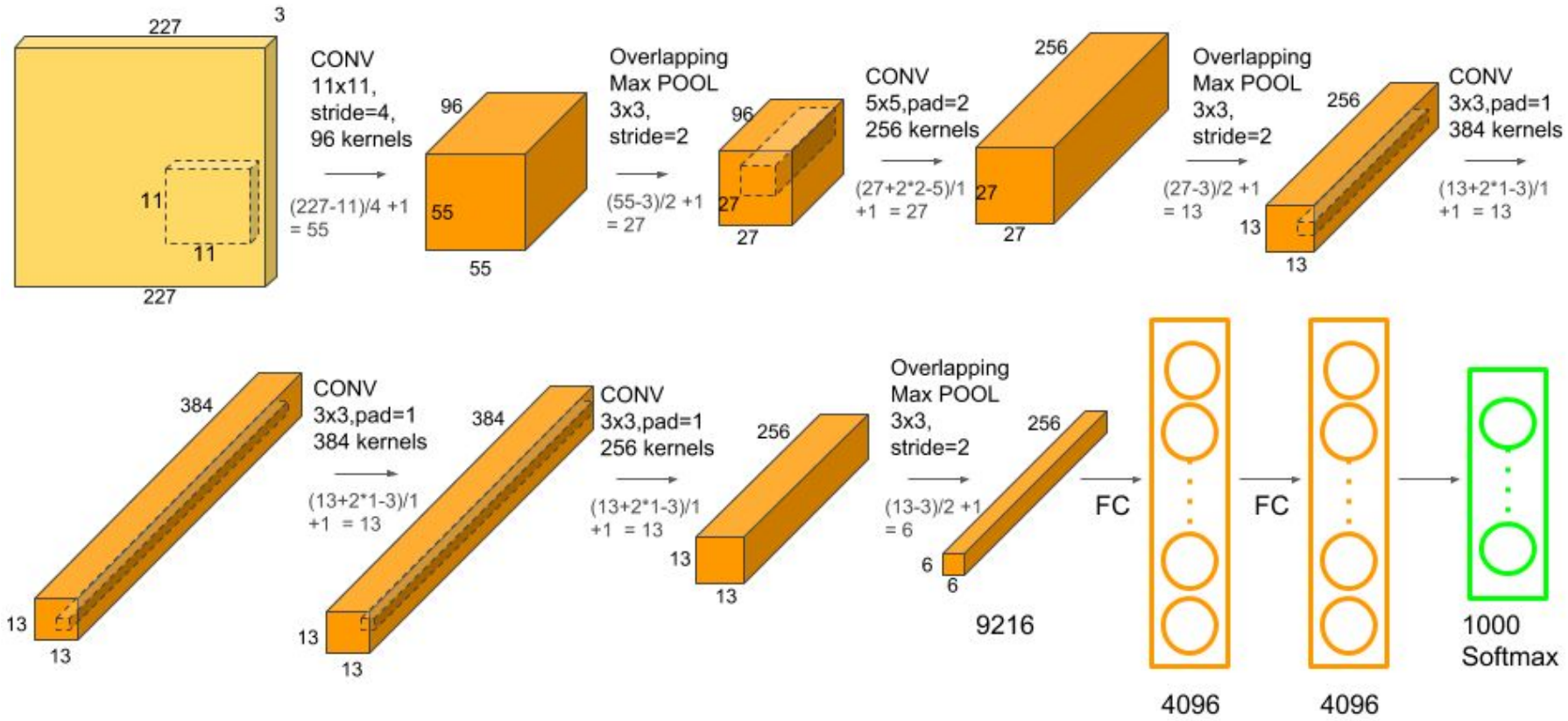
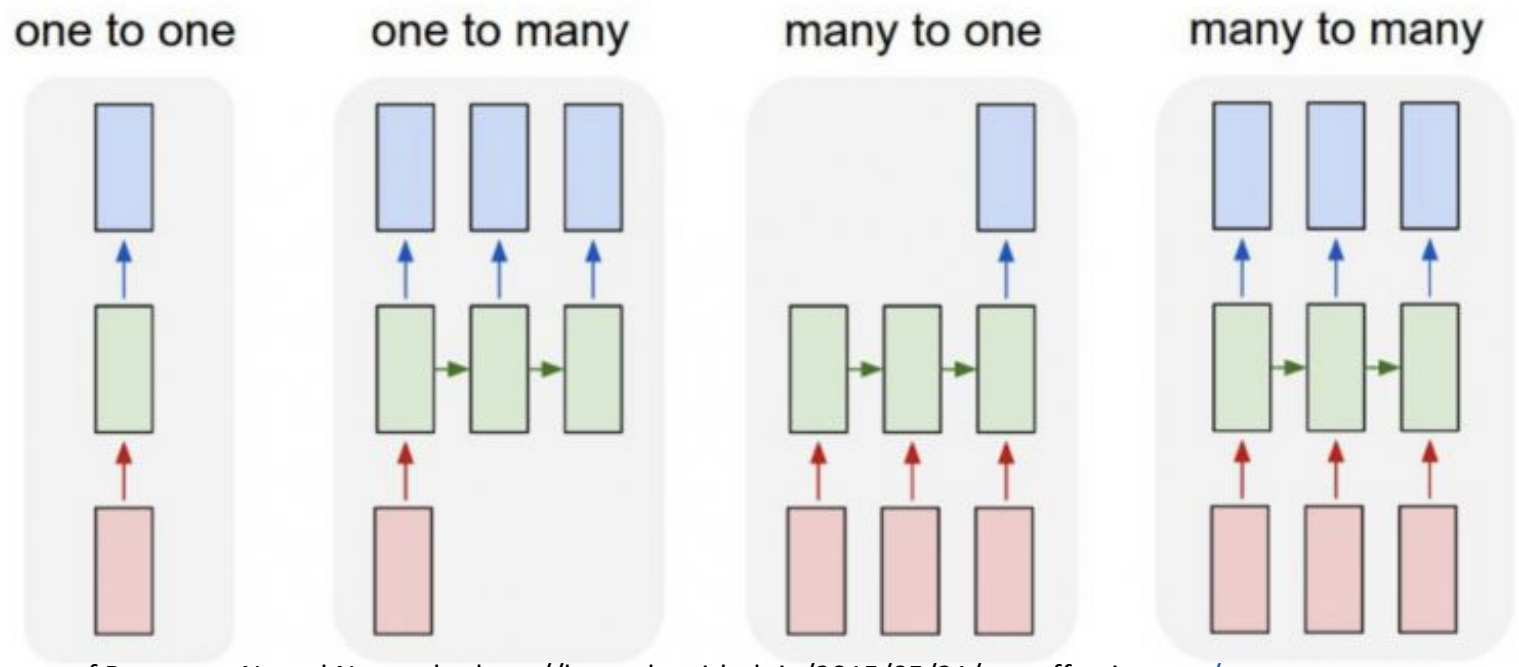
AlexNet Convolutional Neural Network



What about applications with State?

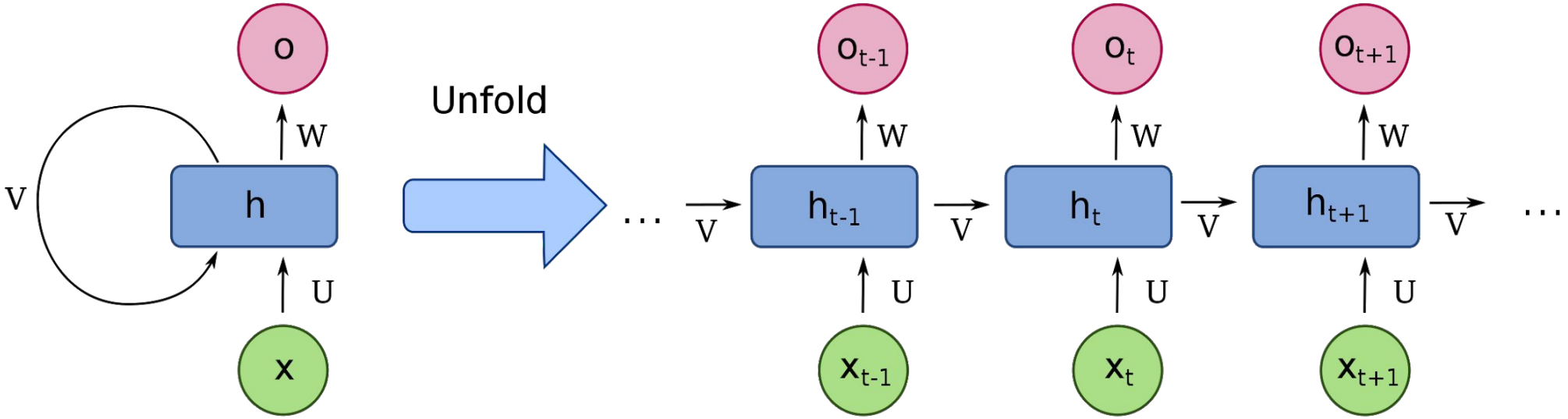
How about other problems that involve sequences?



The Unreasonable Effectiveness of Recurrent Neural Networks, http://karpathy.github.io/2015/05/21/rnn-effectiveness/

Recurrent Neural Networks

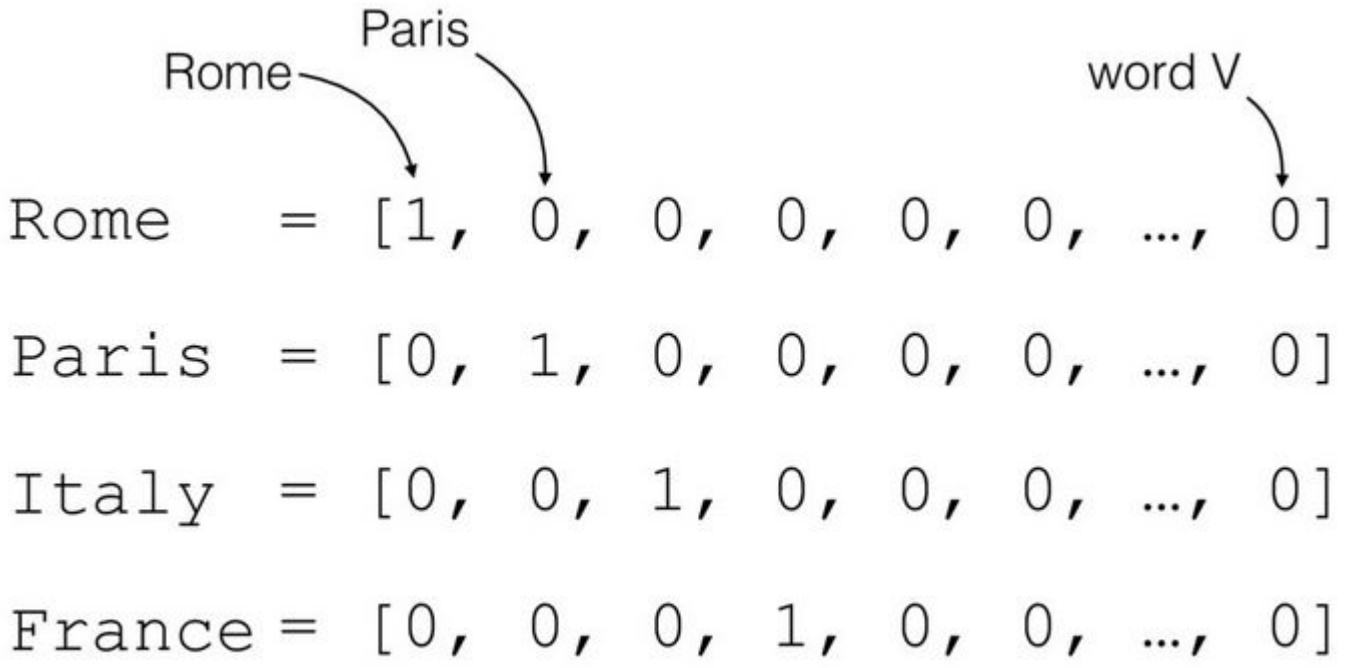
Output depends on current input but also current state



http://karpathy.github.io/2015/05/21/rnn-effectiveness/

Deep Learning for NLP

How do we represent sentences as numerical vectors?



Conclusion

Questions?