A Brief Introduction to Convolutional Neural Network

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Agenda

1. Purposes
2. Background
3. Concepts
4. Neural Network Design
5. Implementation
6. Use Case
7. Practice
8. Summary

Purposes

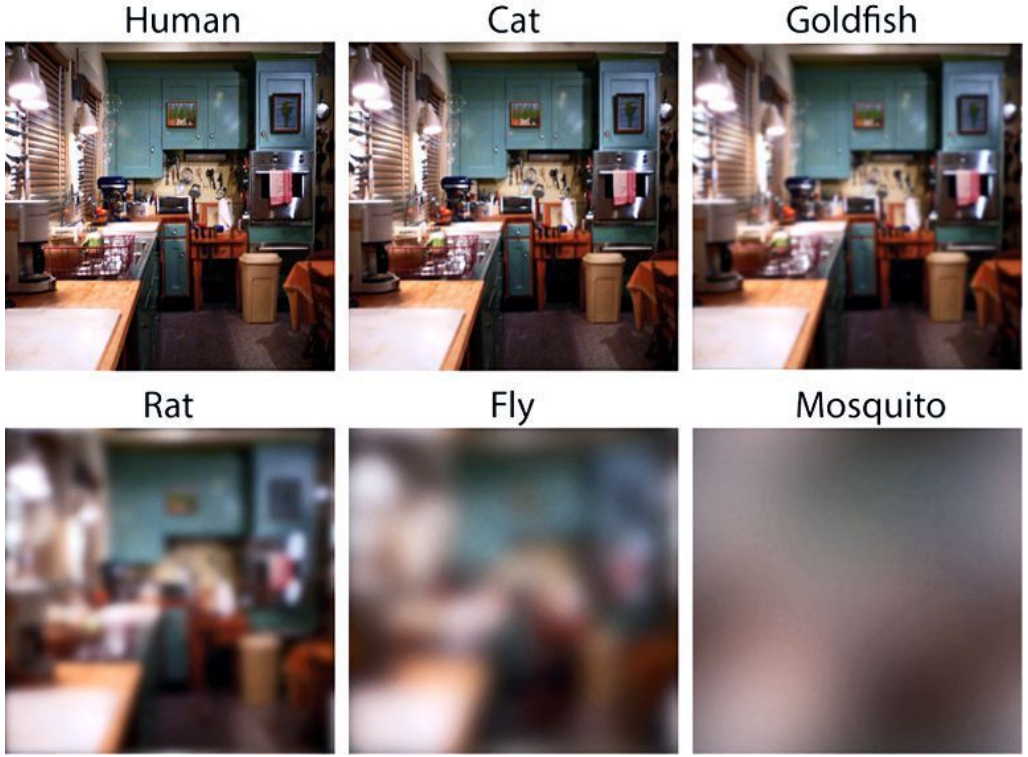
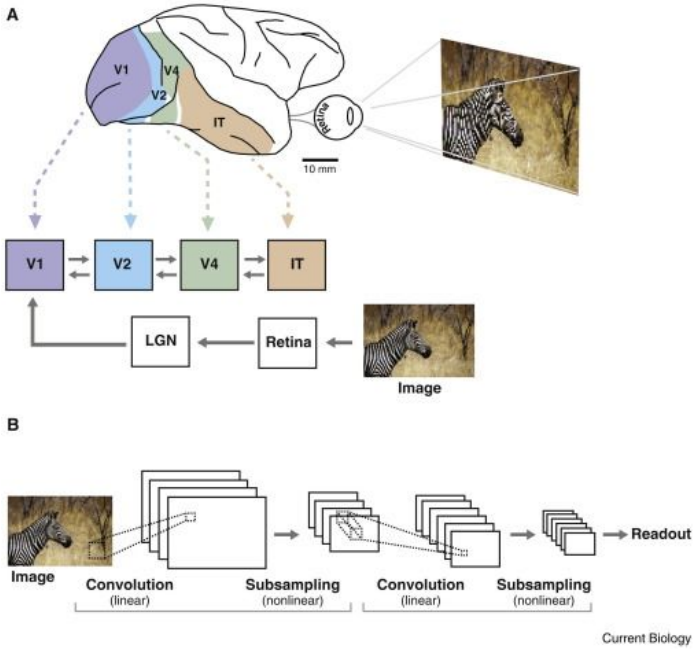


Figure from https://www.smithsonianmag.com/

Background

Convolutional Neural Network (CNN) is one of the most successful biology inspired AI (Goodfellow et al., 2016). CNN is guided by the design of human vision system and other disciplines.



From: Cox, D. D., & Dean, T. (2014). Neural networks and neuroscience-inspired computer vision. *Current Biology*, *24*(18), R921-R929.

Concepts

1. Convolution operation
2. Sparse interaction
3. Parameter sharing
4. Pooling

Convolution operation

This is an operation to average on several measurements to reduce noisy in the data, preferring recent data.

$$s(t) = \int x(a)\, w(t-a)\, da$$

Where x is the feature and w is the kernel to averaging on the features, a is the age of the data and t is time (or other locational measure).

Sparse connection

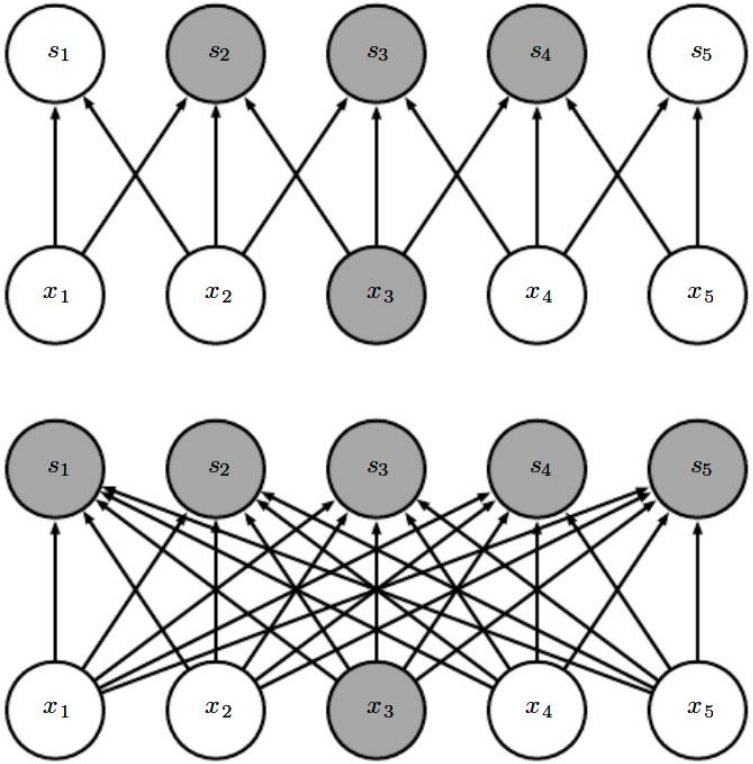


Figure from Goodfellow et al. 2016

Sparse connection

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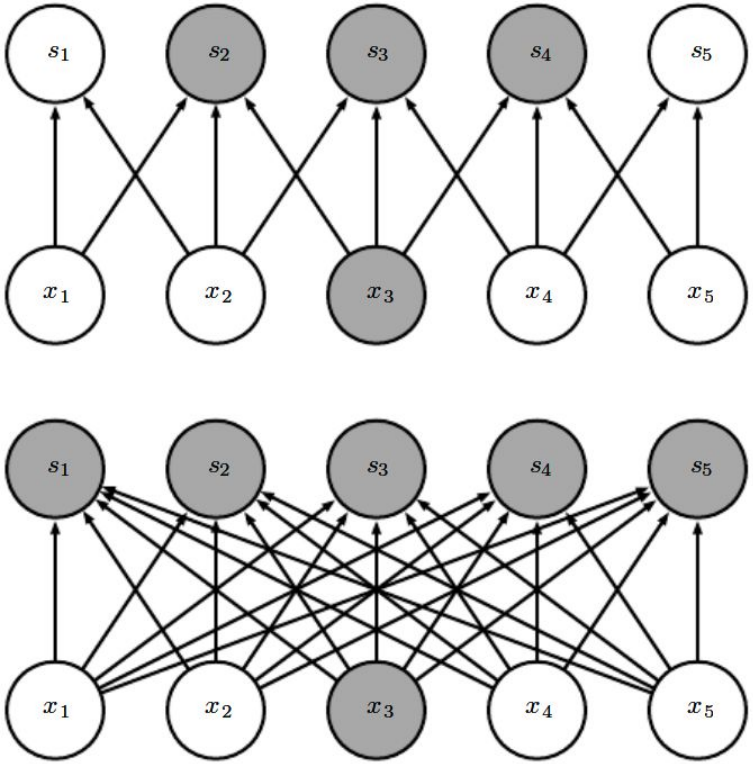

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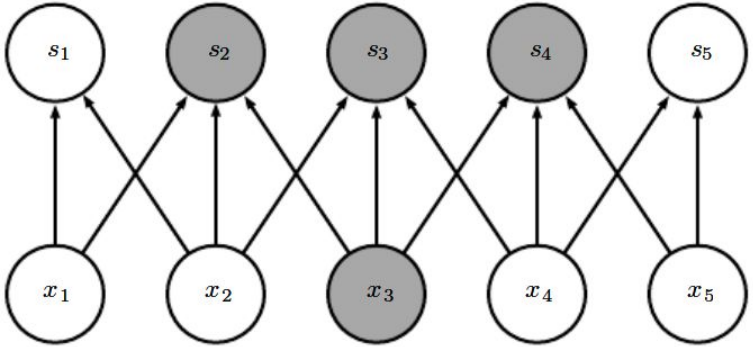


Full connection:

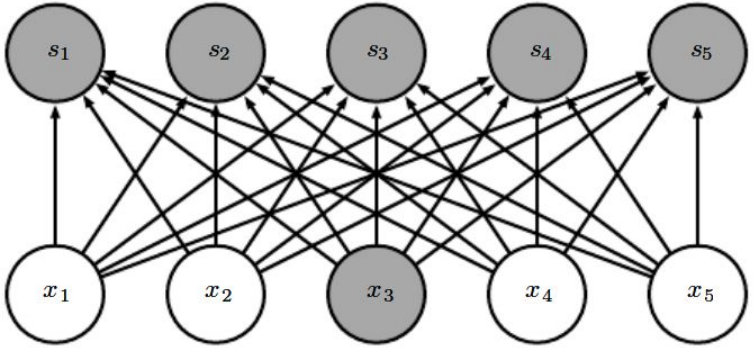
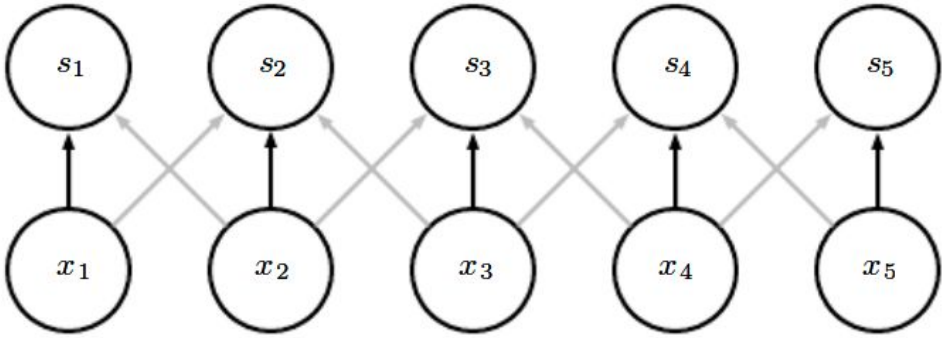


Figure from Goodfellow et al. 2016

Parameter sharing

With Parameter sharing:



Without Parameter sharing:

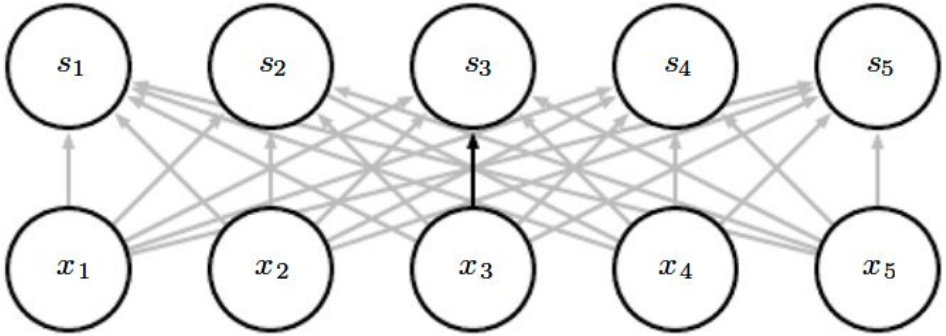


Figure from Goodfellow et al. 2016

Pooling

This step is to summarize the output from previous layers with statistical analysis. By this way, the output from this step to be invariant to the small shifts in the input from previous layers.

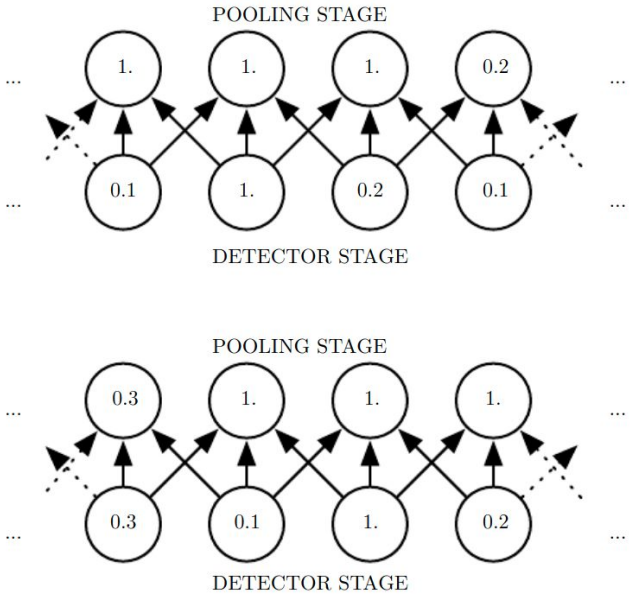


Figure from Goodfellow et al. 2016

Neural Network Design

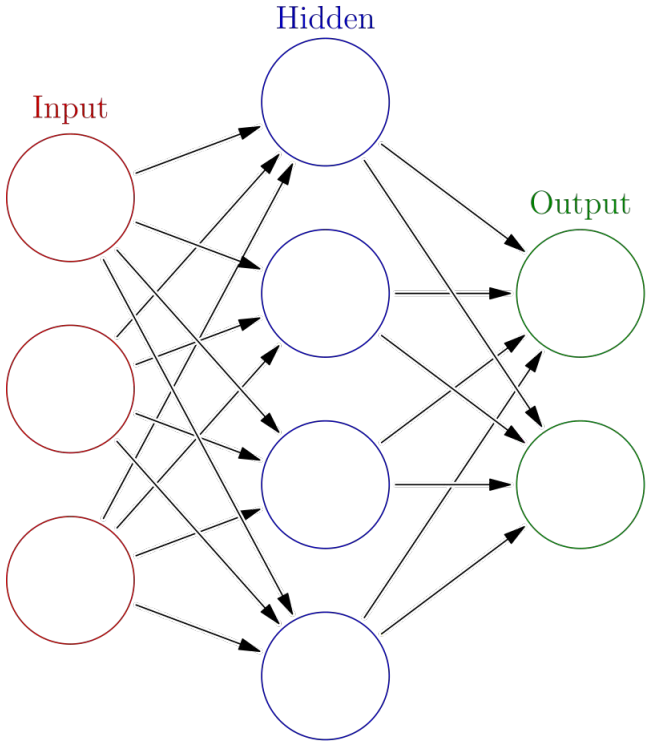
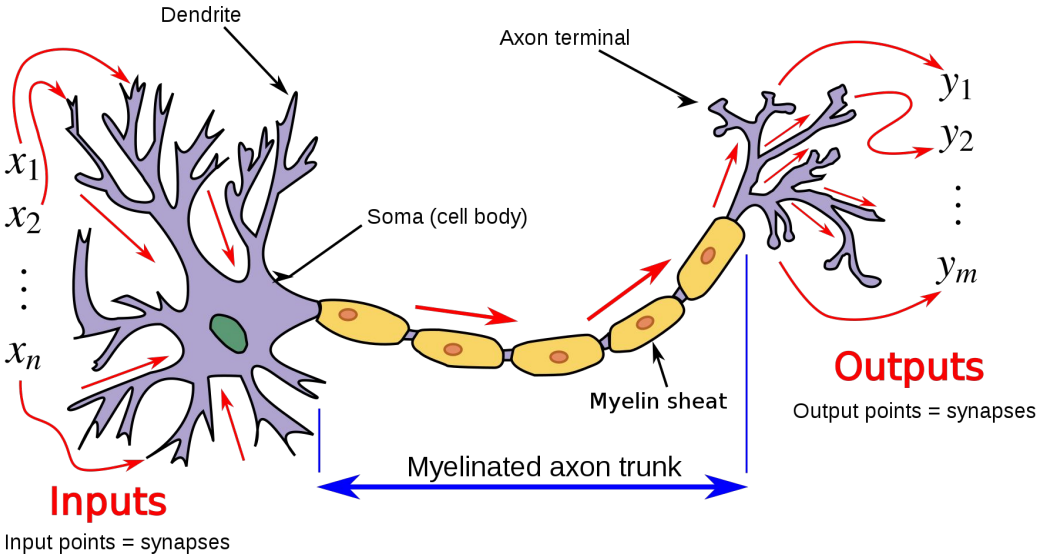
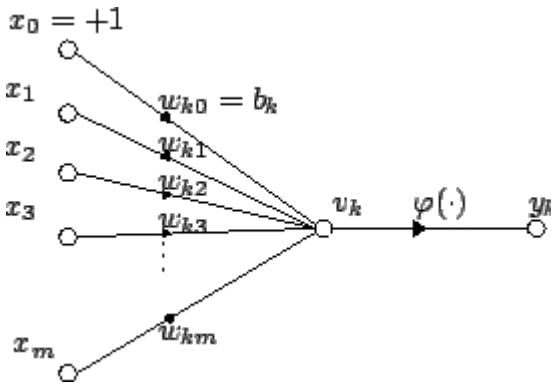


Figure from: https://en.wikipedia.org/wiki/Artificial_neural_network

Neural Network Design





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Neural Network Design

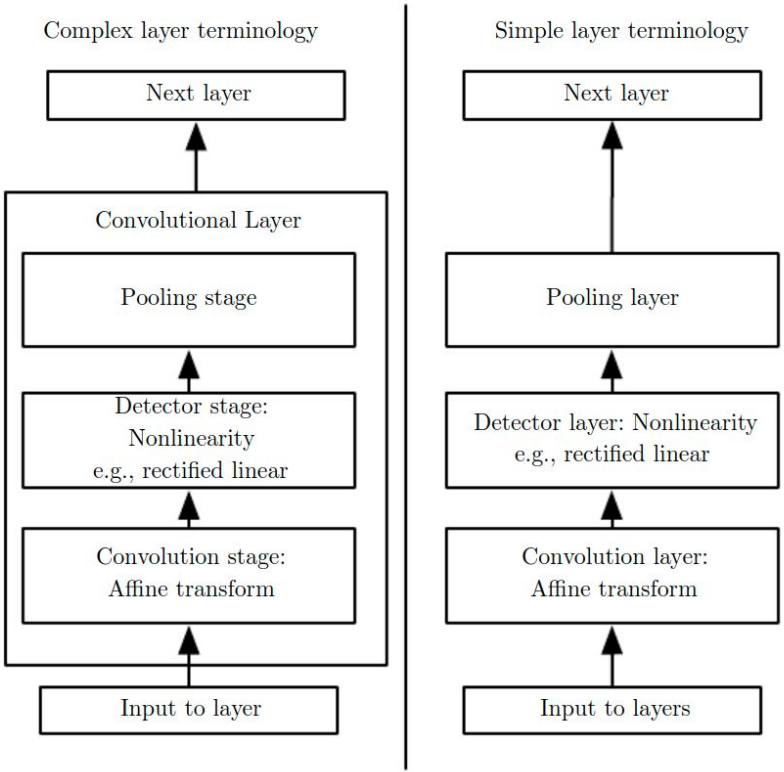
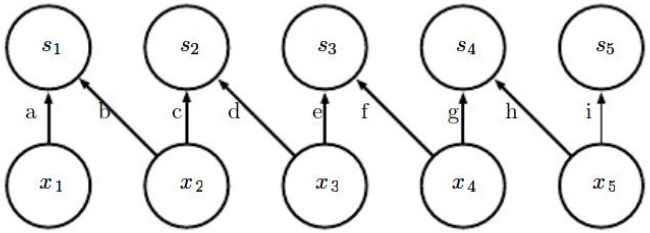


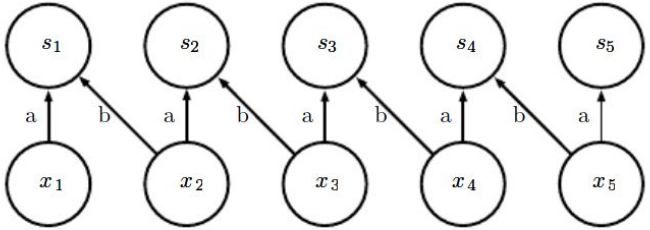
Figure from Goodfellow et al. 2016

Neural Network Design: different connections

Local connection:



Convolution:



Full connection:

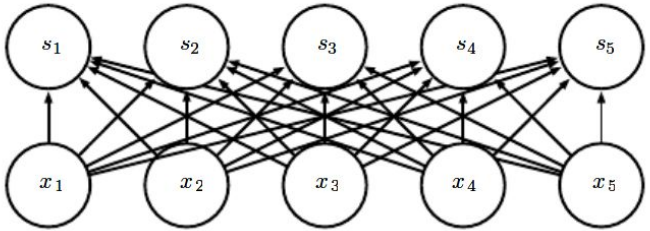


Figure from Goodfellow et al. 2016

Neural Network Design: different convolution

locally connected

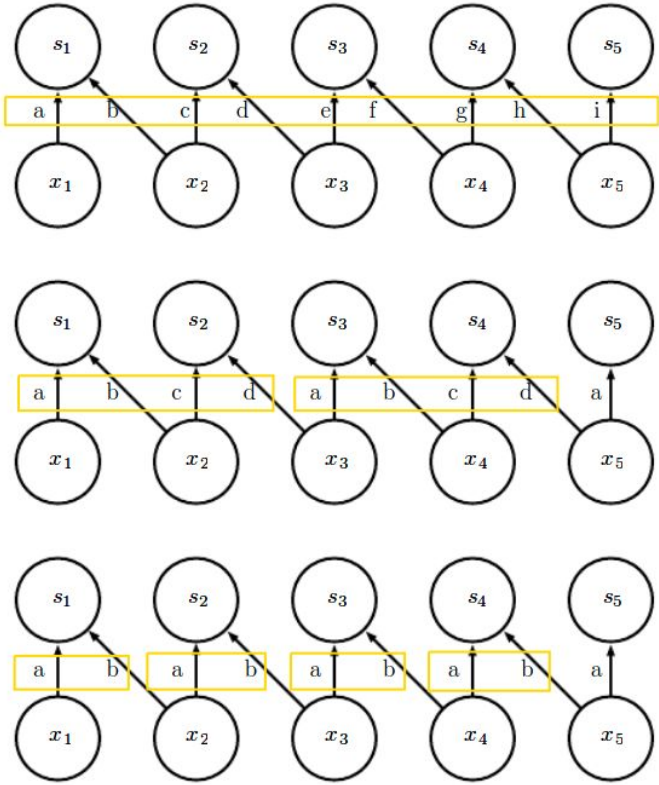


Figure from Goodfellow et al. 2016

Neural Network Design: different convolution

locally connected

tiled convolution

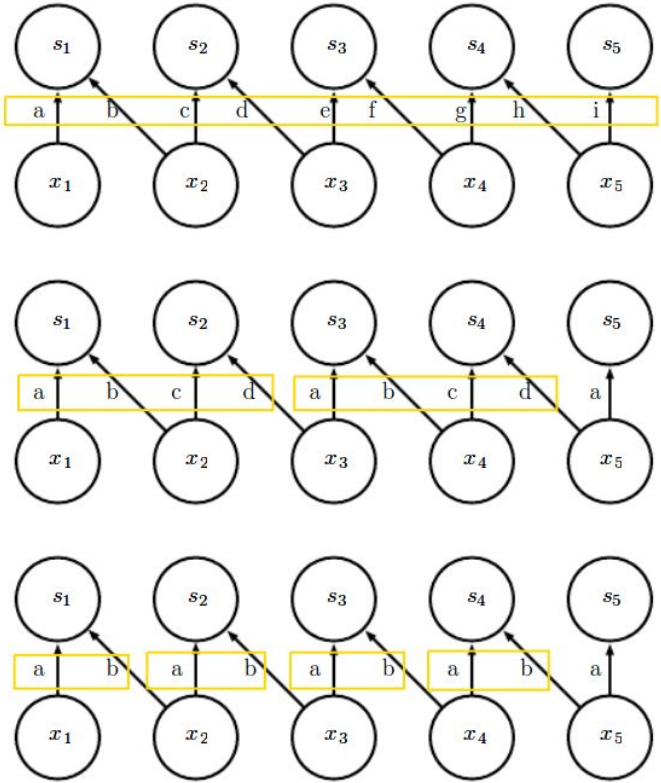


Figure from Goodfellow et al. 2016

Neural Network Design: different convolution

locally connected

tiled convolution

standard convolution

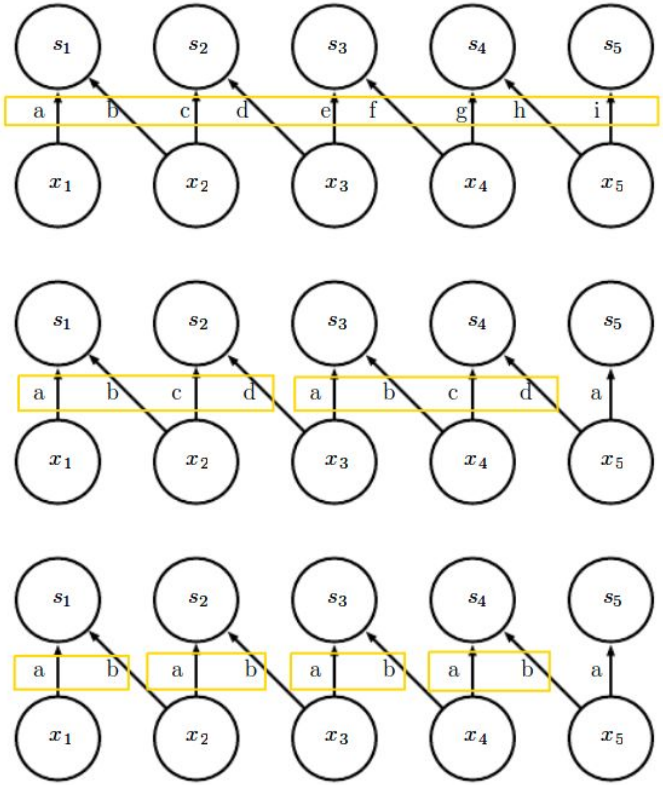


Figure from Goodfellow et al. 2016

Implementation

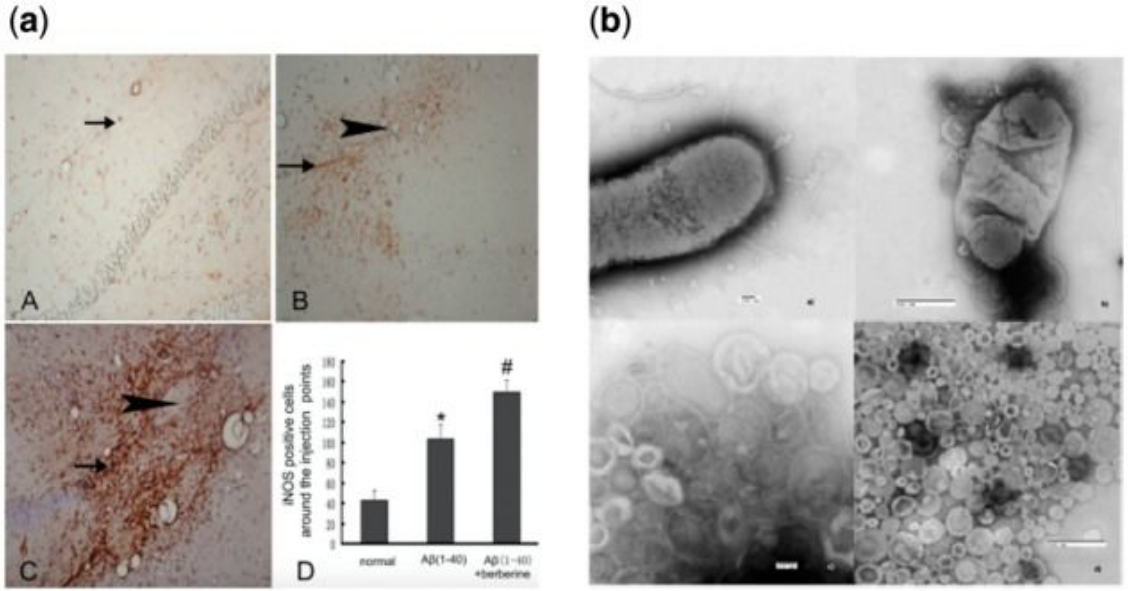
Here, I will not introduce how CNN are implemented by computer programs. Instead, I will briefly introduce two packages: Tensorflow and Pytorch.

Both Tensorflow and Pytorch can work with python. But they are designed in different ways: graph definition, parallelism and etc.

	Graph definition	Parallelism
Tensorflow	Static	Manual modification
Pytorch	Dynamic	Automated wrap function

Use Case

CNN perform well at object recognition and image classification. For science, we need to learn from figures in publications. One example, we can do compound figure classification for publications.



Practice

We can try to classify scientific figures to categories. Prof. West and his team (Lee, P. S. et al. 2017) has done this for science. But it would be interesting if you can try this problem with your own hand and advance our knowledge.

Summary

CNN is inspired by the human vision system, but they are not exactly same. The development of CNN is ongoing, and new architectures of CNN are published regularly.