Introduction to Machine Learning

Module 2A: Introduction to Convolutional Neural Networks

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Recap of yesterday

- Overparameterized ANNs are efficient universal approximators, but ANNs can memorize our data

GPT-3: Q. What do you call a droid that takes the long way around?
A.R2 detour.

Source:
https://pics.me.me/me-wondering-why-my-ai-is-classifying-my-cat-as-72552652.png

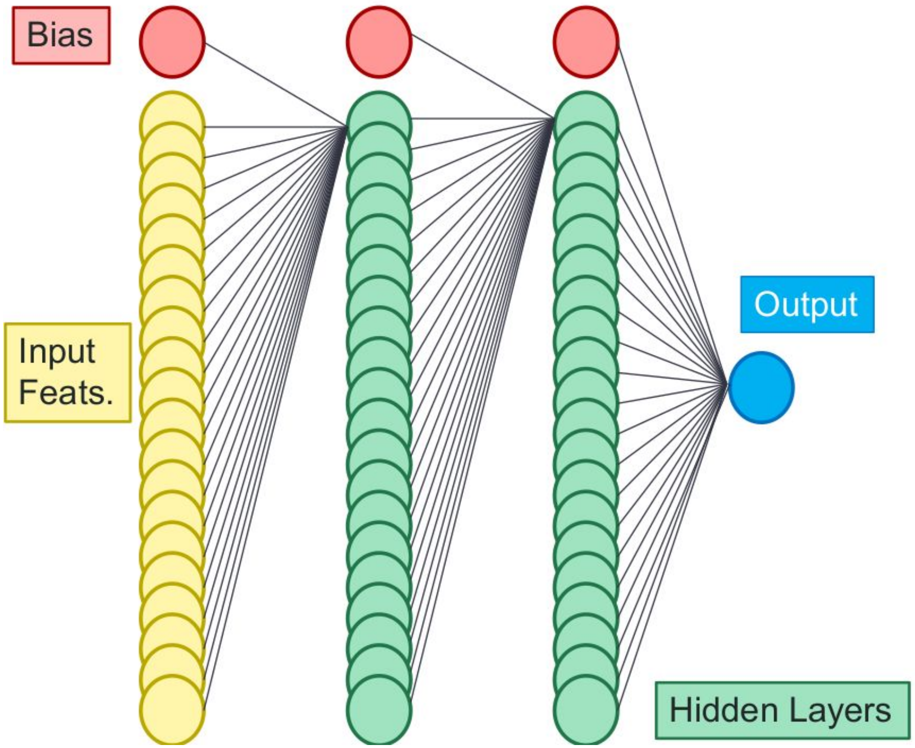
Recap of yesterday

- Regularization can help ANNs to better generalize
- It encourages simpler models by reducing effective number of parameters in a model.
- Some common regularization methods: L1, L2, data augmentation, dropout, early stopping, gradient descent.

How about making smarter architectures like a human brain?

Smarter Architectures

An MLP can have MANY parameters



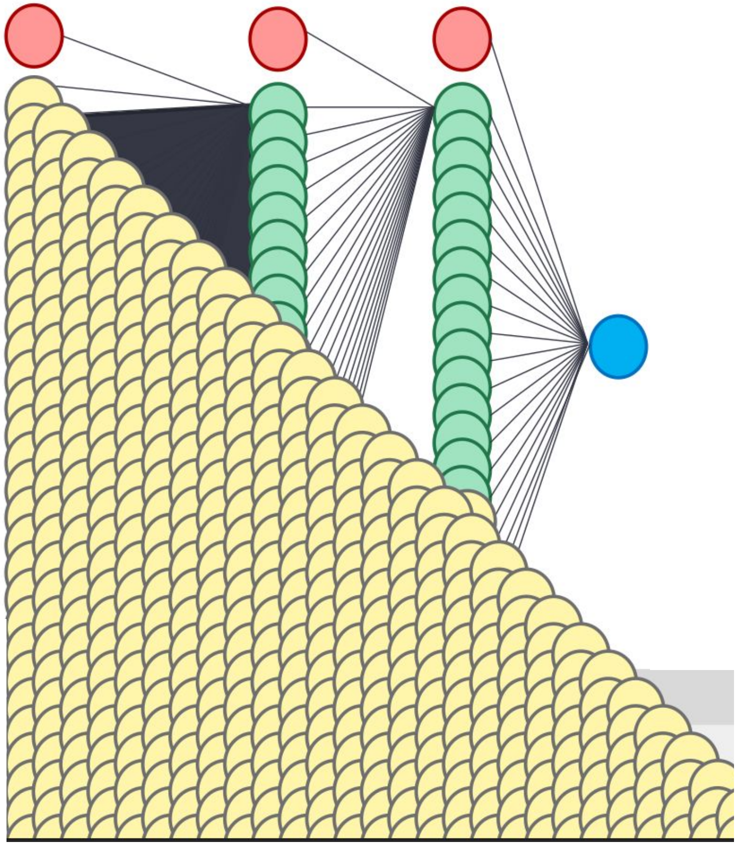
Data: 20 input features, single binary label

- 1 input layer with 20 nodes,
- 2 fully connected layers, 20 nodes each
- 1 final prediction node

How many weights is that?
(20+1)*20+(20+1)*20+(20+1)*1=861 params

Smarter Architectures

An MLP can have MANY parameters



Data: 1 input layer with 256*256 nodes,
2 fully connected layers, 20 nodes each
1 final prediction node
How many weights is that?
(256*256+1)*20+(20+1)*20+(20+1)*1
= ~1.3M params

Smarter Architectures

ConvNets <3

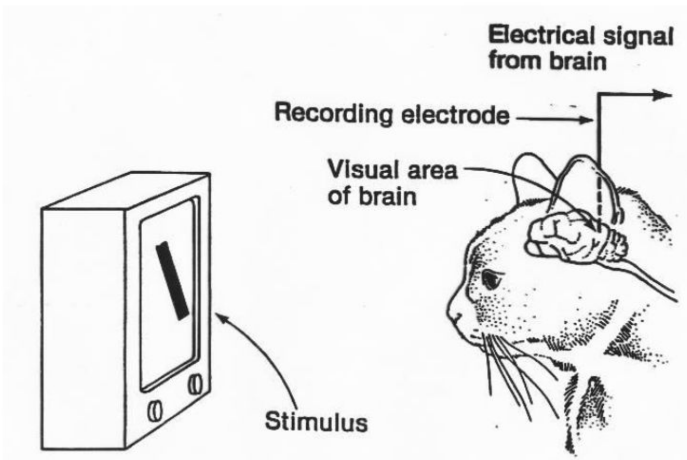
- Convolutional neural networks share parameters across the space -> reduces total number of parameters

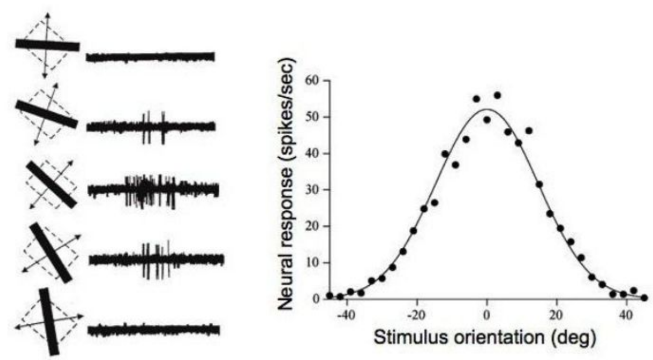
Visual Processing in the Brain

- Brain is an efficient machine -> How it solves vision?

Visual Processing in the Brain

- **Feature selectivity:** Hubel & Wiesel, 1968

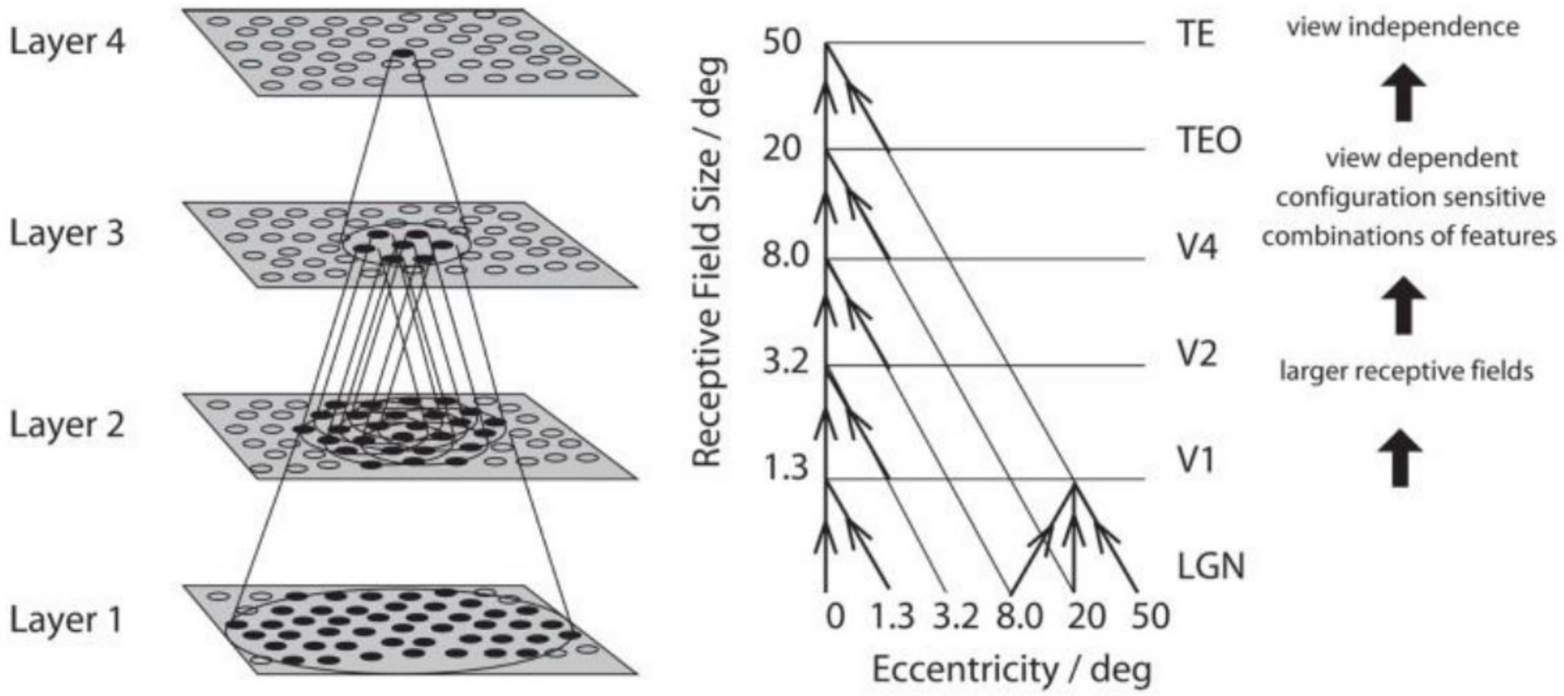




Hubel & Wiesel, 1968

Visual Processing in the Brain

- **Hierarchy of processing**



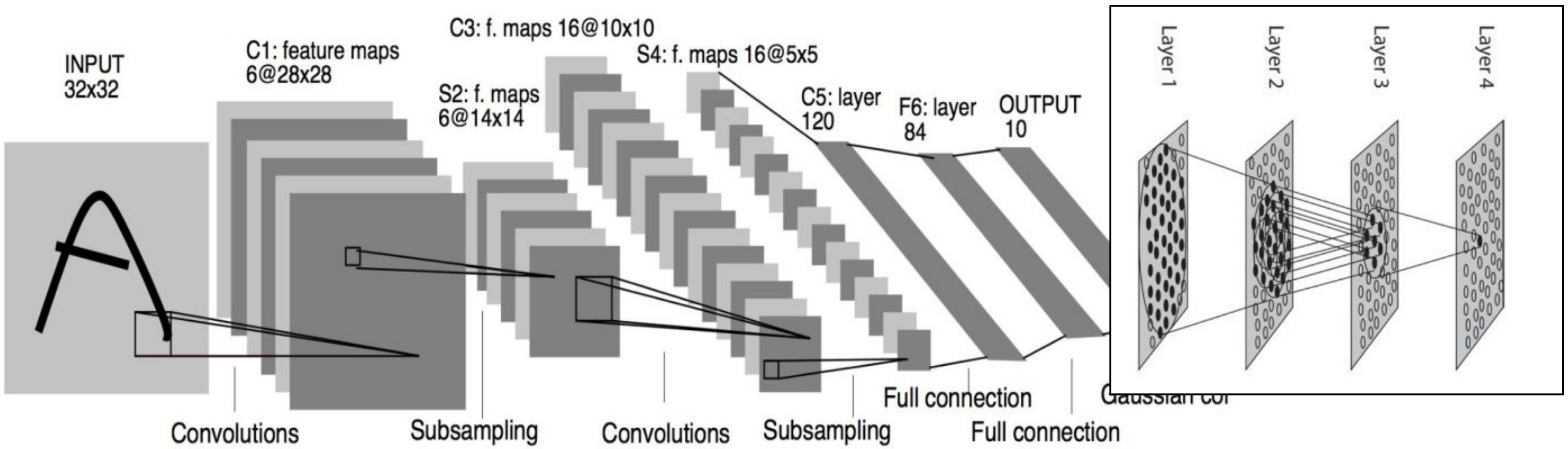
Rolls, 2012

Visual Processing in the Brain

- **Invariance**

History of CNNs

LeNet (1998) - Yann LeCun @Bell Labs



Recipe: convolution + subsampling (pooling) + hierarchy

History of CNNs

CNNs are everywhere!

History of CNNs

CNNs are everywhere!

"man in black shirt is playing guitar."

"construction worker in orange safety vest is working on road."

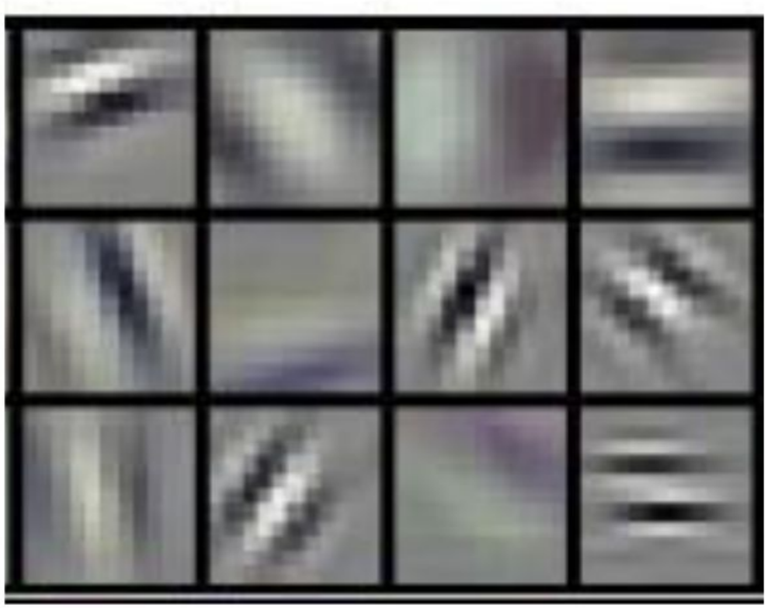
"two young girls are playing with lego toy."

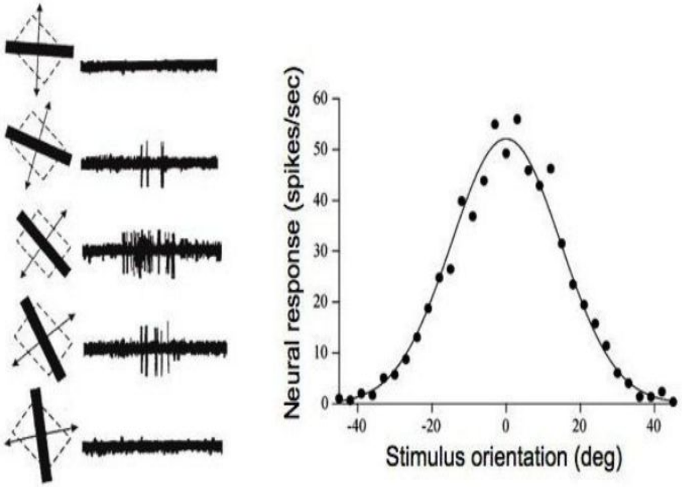
History of CNNs

CNNs are everywhere!

CNN Recipe

Recipe: **convolution** + subsampling (pooling) + hierarchy

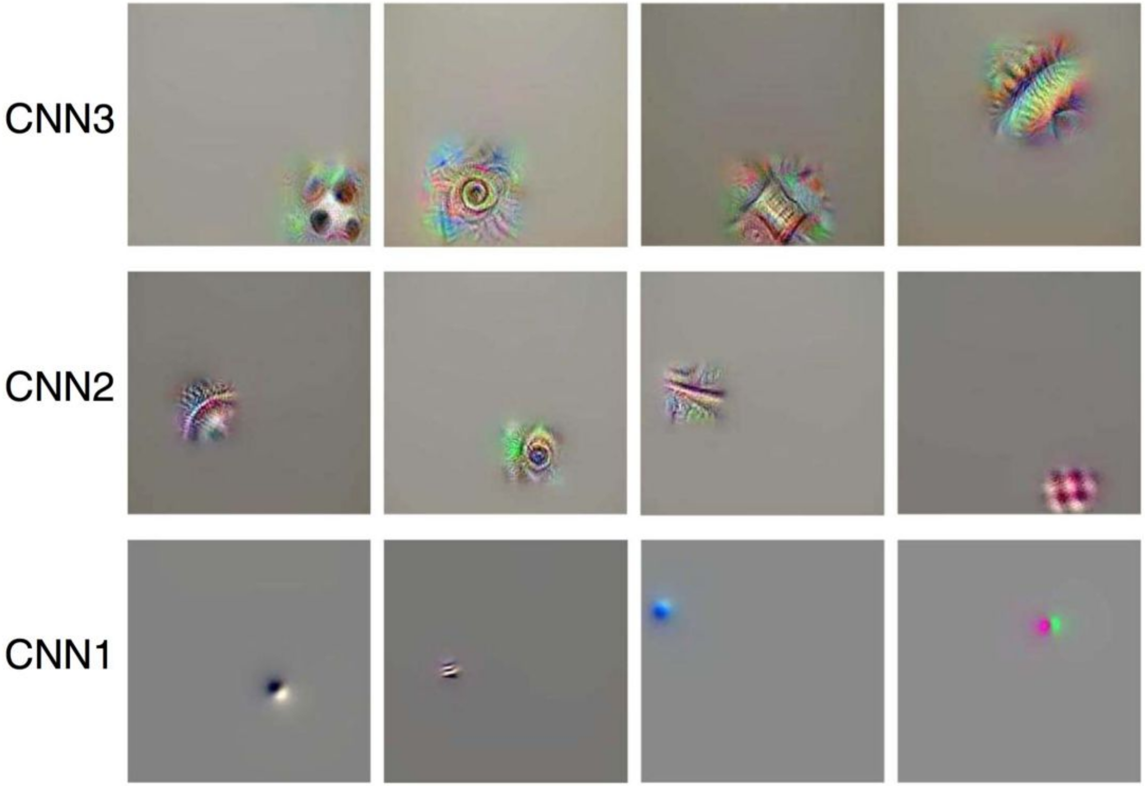




Hubel & Wiesel, 1968

CNN Recipe

Recipe: **convolution** + subsampling (pooling) + hierarchy



Horikawa & Kamitani (2017)

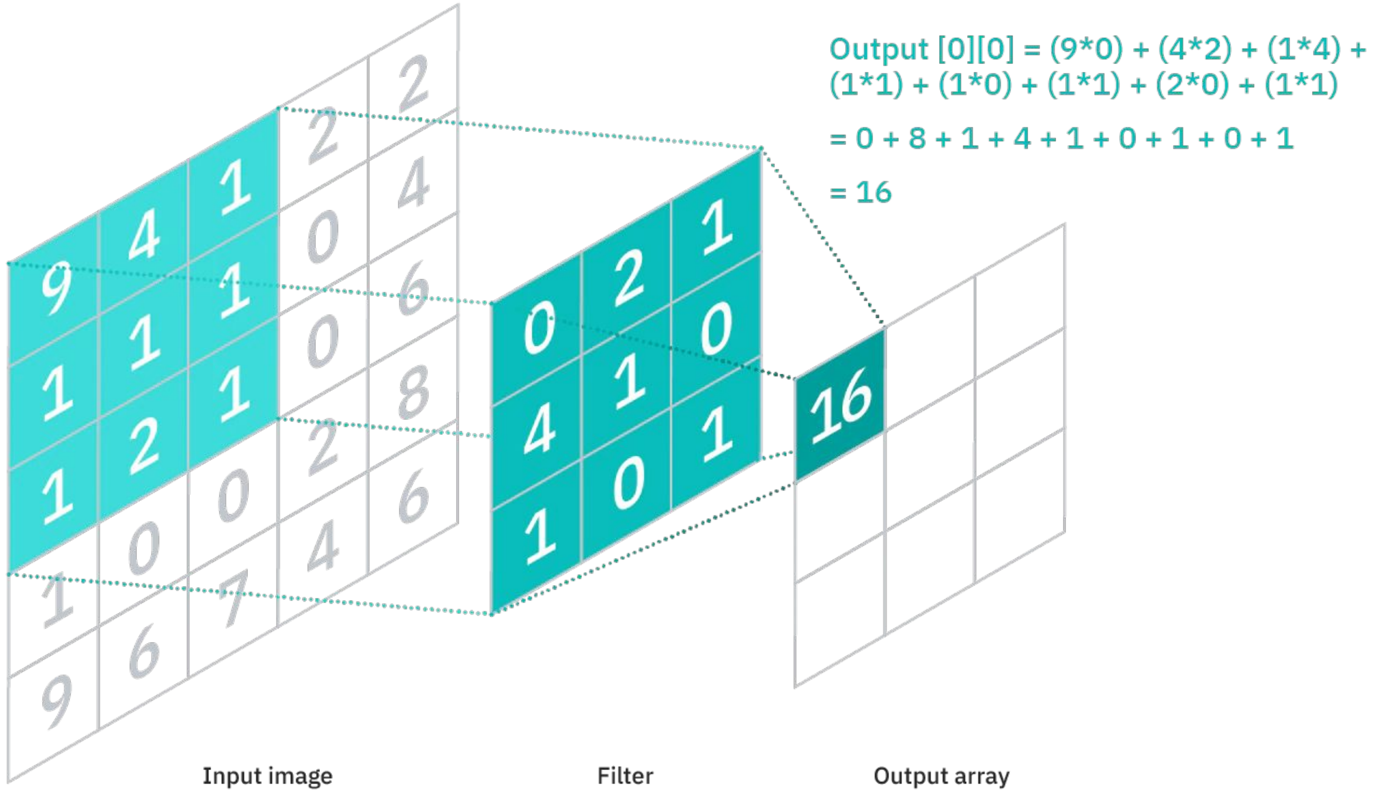
CNN Recipe

Recipe: **convolution** + subsampling (pooling) + hierarchy

Horikawa & Kamitani (2017)

CNN Recipe

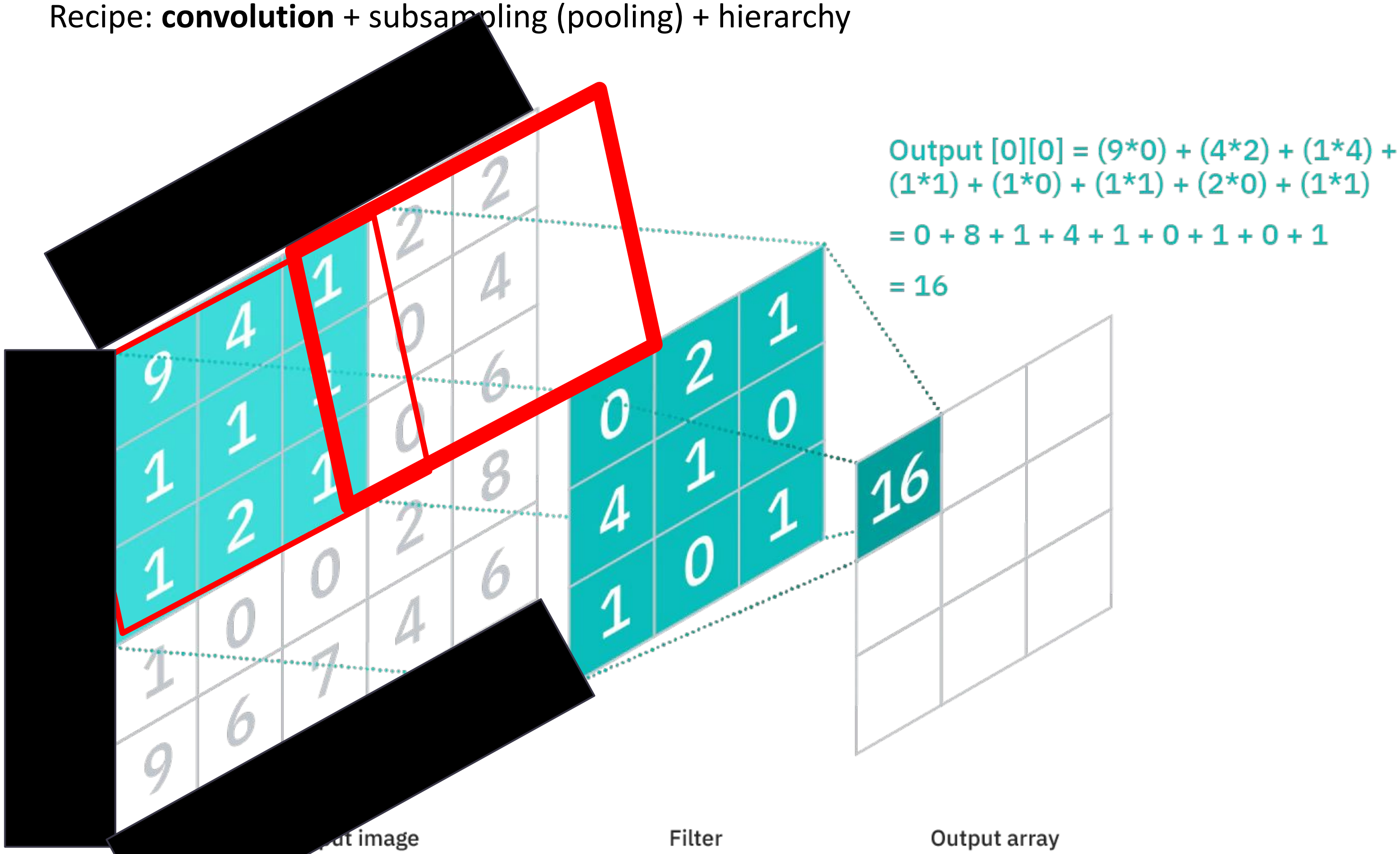
Recipe: **convolution** + subsampling (pooling) + hierarchy



Source:https://www.ibm.com/cloud/learn/convolutional-neur
al-networks

CNN Recipe

Recipe: **convolution** + subsampling (pooling) + hierarchy



Source:https://www.ibm.[redacted]/cloud/learn/convolutional-neural-networks

CNN Recipe

Recipe: **convolution** + subsampling (pooling) + hierarchy

Definitional Note

If you have a background in signal processing or math, you may have already heard of convolution. However, the definitions in other domains and the one we use here are slightly different. The more common definition involves flipping the kernel horizontally and vertically before sliding.

For our purposes, no flipping is needed. Flipping does not affect CNN's learning performance. If you are familiar with conventions involving flipping, just assume the kernel is pre-flipped.

CNN Recipe

Recipe: **convolution** + subsampling (pooling) + hierarchy

Let’s go to section-1 in tutorial-1 to practice it!

CNN Recipe

Recipe: ~~convolution~~ + **subsampling (pooling)** + hierarchy

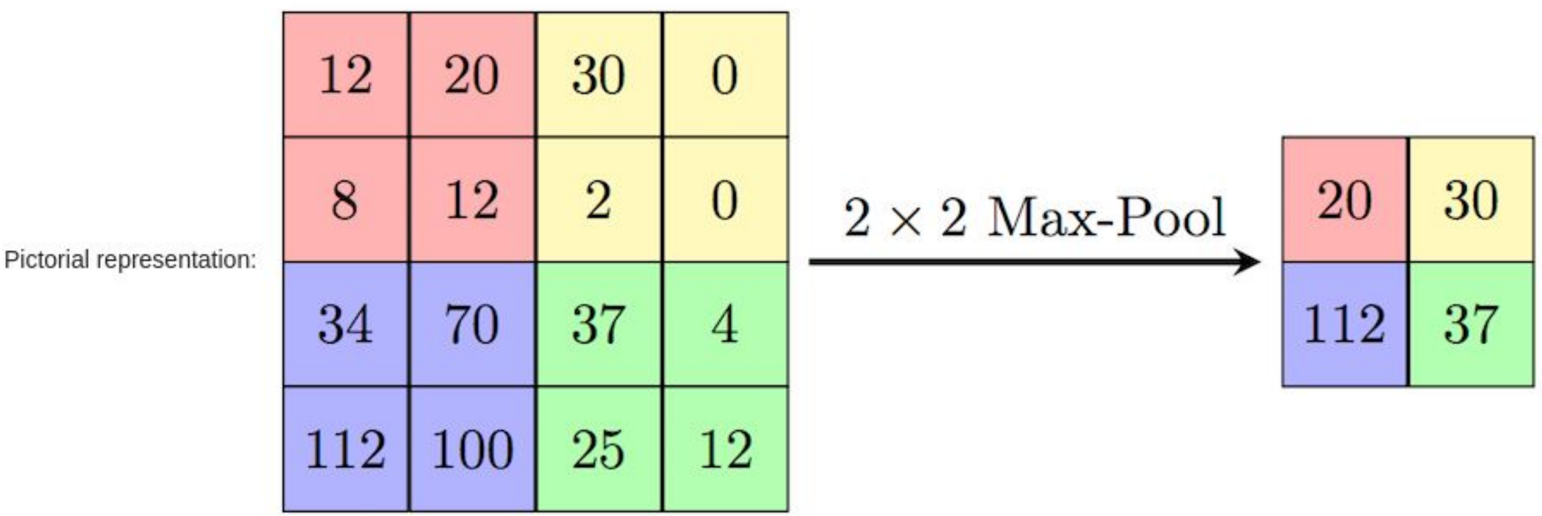
Recall: filters give us global invariance

Pooling gives us local invariance

CNN Recipe

Recipe: ~~convolution~~ + **subsampling (pooling)** + hierarchy

Max-Pooling



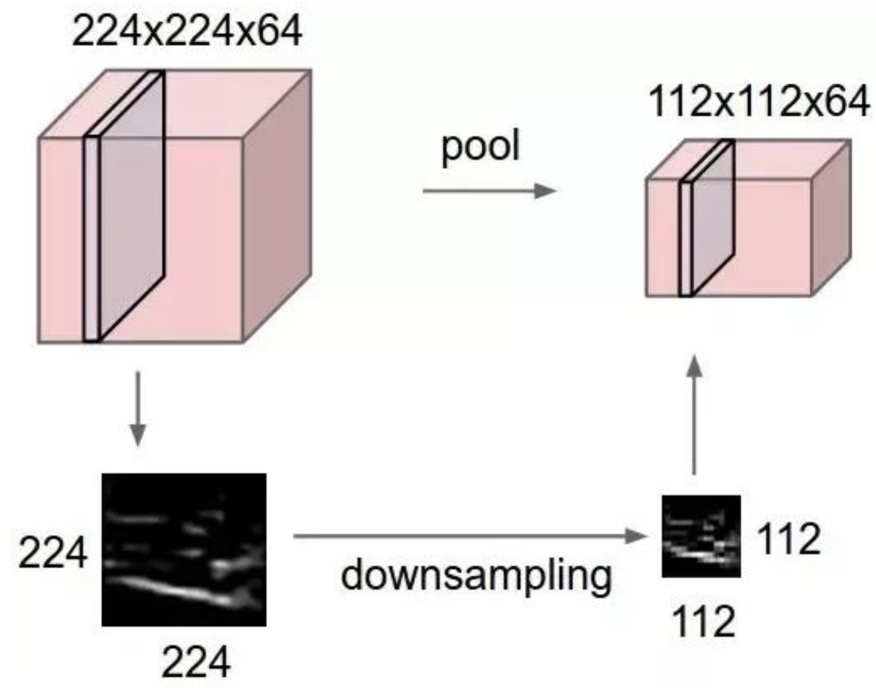
Source:
https://computersciencewiki.org/index.php/Max-pooling_/_Pooling

CNN Recipe

Recipe: ~~convolution~~ + **subsampling (pooling)** + hierarchy

Max-Pooling

Real-life example:

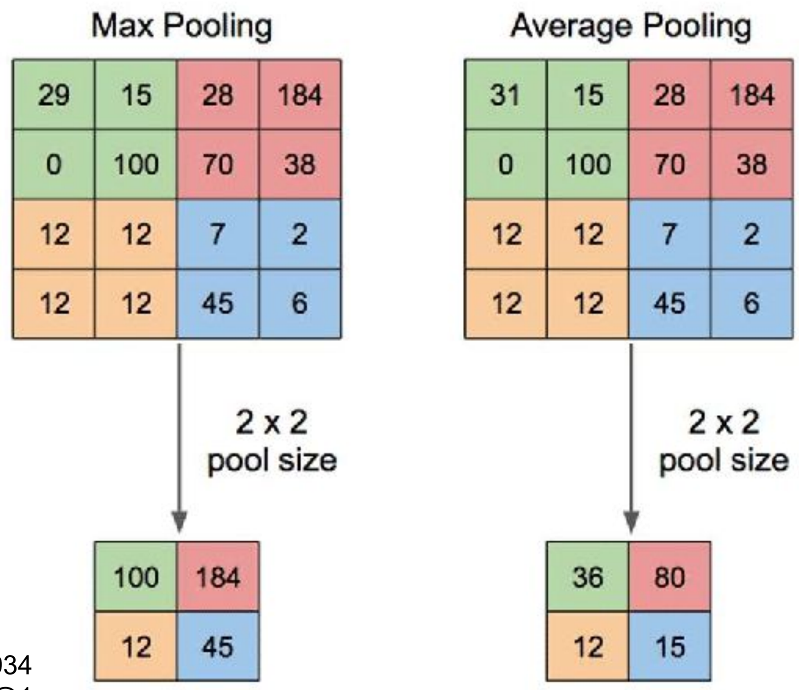


Source:
https://computersciencewiki.org/index.php/Max-pooling_/_Pooling

CNN Recipe

Recipe: ~~convolution~~ + **subsampling (pooling)** + hierarchy

Average-Pooling



Source: https://www.researchgate.net/publication/333593451/figure/download/fig2/AS:765890261966848@1559613876098/Illustration-of-Max-Pooling-and-Average-Pooling-Figure-2-above-shows-an-example-of-max.png

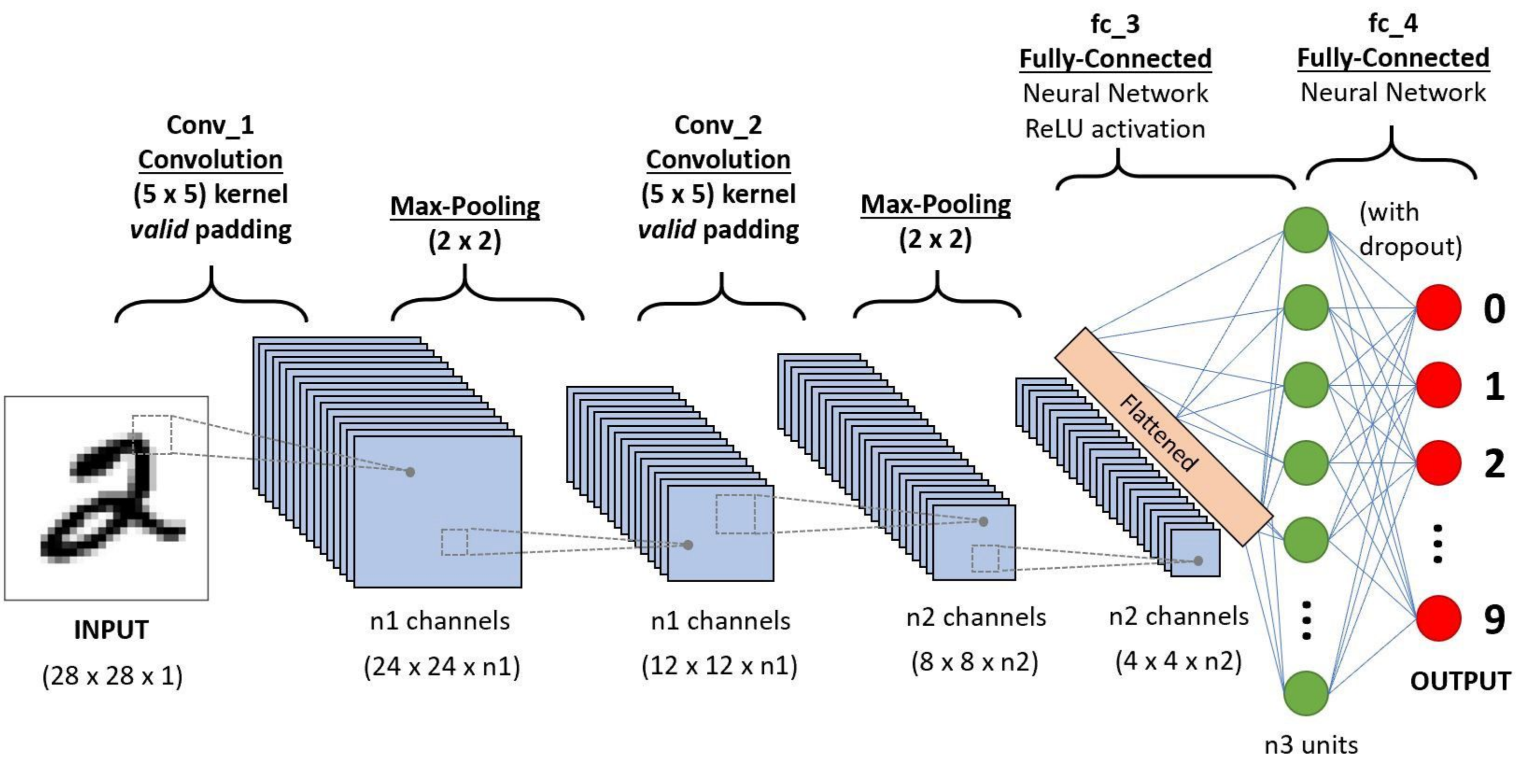
CNN Recipe

Recipe: ~~convolution~~ + **subsampling (pooling)** + hierarchy

Let’s go to section-2 in tutorial-1 to practice it!

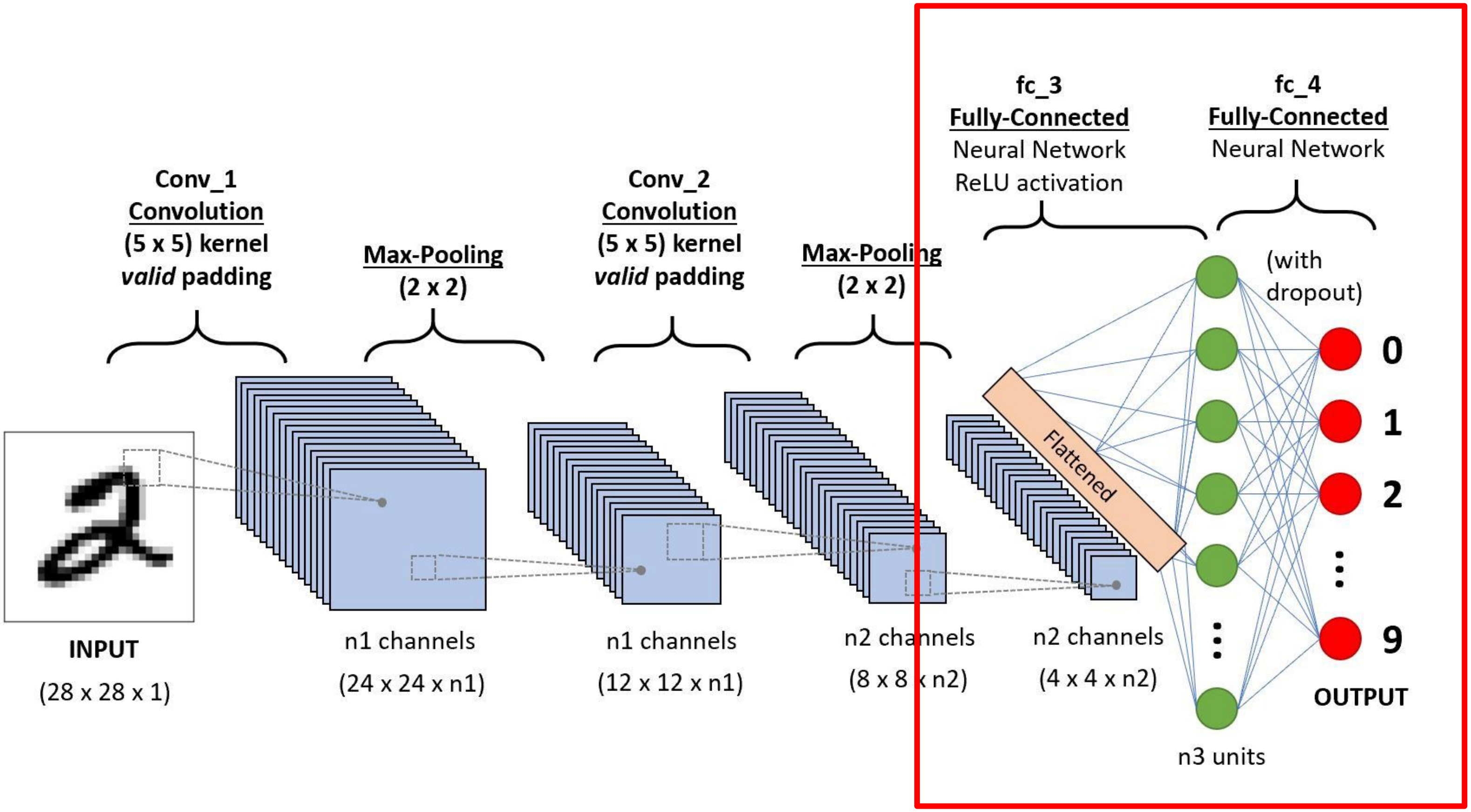
CNN Recipe

Recipe: ~~convolution~~ + ~~subsampling (pooling)~~ + **hierarchy**



CNN Recipe

Recipe: ~~convolution~~ + ~~subsampling (pooling)~~ + **hierarchy**



CNN Recipe

Recipe: ~~convolution~~ + ~~subsampling (pooling)~~ + **hierarchy**

Let’s put everything together in Section 3 of tutorial 1!!